Independent evaluation of Maths Champions in nursery settings to develop children's early numeracy: A two-armed cluster randomised controlled trial

Evaluation Protocol

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PROJECT TITLE	Independent evaluation of Maths Champions in nursery settings to develop children's early numeracy: A two-armed cluster randomised controlled trial
DEVELOPER (INSTITUTION)	National Day Nurseries Association (NDNA)
EVALUATOR (INSTITUTION)	University of York and Durham University
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TRIAL DESIGN	Two-armed cluster randomised controlled trial with random allocation at the nursery level
TRIAL TYPE	Effectiveness
CHILD AGE RANGE AND KEY STAGE	3-4 years at baseline (starting reception in September 2022)
NUMBER OF SCHOOLS	138 nursery settings
NUMBER OF CHILDREN	1380 children
PRIMARY OUTCOME MEASURE AND SOURCE	Maths attainment score (Assessment Profile on Entry for Children and Toddlers [ASPECTS])
SECONDARY OUTCOME MEASURE AND SOURCE	Practitioner confidence and beliefs (short survey adapted from Chen et al., 2014) Literacy/Language (reading and phonological awareness) score (ASPECTS) Child development at 2 years old (Ages and Stages Questionnaire) and correlation to ASPECTS at 3 and 4 years olds Child attainment at the end of Reception year at school (Early Years Foundation Stage Profile data (completed at the end of Reception) collected from National Pupil Database.)

Protocol version history

VERSION	DATE	REASON FOR REVISION
1.0	02 March 2020	N/A
2.0	02 November 2020	Addition of Outcome measures and Analysis sections relevant to the pilot study which were omitted from v1.0. Summary of changes to the pilot trial design as a result of COVID-19 section added. Addition of Research Question (RQ) 4 to the effectiveness trial to reflect collection of ASQ-3 data via NHS Digital database and it's correlation to ASPECTS at aged 3 and 4 years old. See the Effectiveness trial impact evaluation section. Clarification of setting types to setting level eligibility criteria for effectiveness trial. See the effectiveness trial Participants section. Addition of EYPP purposive sampling and changes to potential analysis to reflect this within the effectiveness trial. See the effectiveness trial Participants section. Addition of IPE RQ 7 to reflect data collection in relation to the impact of COVID-19 to the delivery of the MC programme within the effectiveness trial. See the Effectiveness trial Implementation and process evaluation section. Update to timeline to reflect that the pilot study was paused Mar 2020, with the view to restart in Oct 2020 with reduced evaluation activities, and the effectiveness trial was delayed by one year from 2020-21 to 2021-22. See Table 9. Update to the risks table to reflect potential impact of COVID-19 pandemic on the effectiveness trial. See Table 8. Update to trial diagram to reflect delay to the start of the effectiveness trial due to COVID-19. See Appendix A: Effectiveness Trial Diagram. Change of PI at Durham University from C. Torgerson to V. Menzies, effective October 2020.

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Study rationale and background

In England, the most recent Key Stage 2 assessments show that 21% of children do not meet the expected standard in maths at the end of primary school (Department for Education, 2019e). To help minimise attainment gaps, it is important to support children's early maths development, as maths skills at school entry are predictive of both later maths attainment and general educational attainment (Duncan et al., 2007; Watts et al., 2014). A recent report highlighted the importance of quality pre-school provision, with an enriching numeracy curriculum, to support children's maths development and long-term outcomes (Asmussen et al., 2018). Pre-school attendance and quality of pre-school provision, as well as pre-school effectiveness in promoting early number concepts, are predictive of children's maths and reading attainment at Key Stage 1 and 2 (Sammons et al., 2008, 2004), maths and science attainment at Key Stage 3 (Sammons et al., 2011), and even GCSE results (Sylva et al., 2014). Despite this, many nursery practitioners have a lack of training on maths provision and do not feel confident in their own maths skills (von Spreckelsen et al., 2019).

The National Day Nurseries Association (NDNA) developed the Maths Champions programme with the aim of building the confidence and knowledge of nursery practitioners to support the development of children's early maths skills. The EEF have previously commissioned an effectiveness trial evaluating NDNA's Maths Champions programme delivered to graduate practitioners in private, voluntary, and independent (PVI) nurseries during 2016-17 (Robinson-Smith et al., 2018). Here, children aged 3-4 years from nurseries randomly allocated to use the Maths Champions programme made the equivalent of two months additional progress in maths and language development (reading and phonological awareness), in comparison to children in the control group. This effect on maths development was not affected by children's eligibility for Early Years Pupil Premium, how many hours a child attended nursery, or gender. However, the findings should be viewed with caution, as the results were not statistically significant. Moreover, whilst the trial was well designed and conducted, it suffered from high attrition. Indeed, 36% children recruited into the trial were not included in the primary analyses; more than half of this attrition was attributable to children who were assessed at pre-test leaving the setting prior to post-testing. The level of attrition was a potential threat to the validity of the study's findings. Consequently, the EEF have funded a second effectiveness trial of NDNA's Maths Champions programme.

The first effectiveness trial of Maths Champions (Robinson-Smith et al., 2018) found that the programme was positively received by many nurseries, with 82% of settings being at least

minimally engaged with the intervention; however, some settings raised the burden on staff time to be a significant issue. Staff often reported that they had to complete activities for the Maths Champions programme within their own non-working time, particularly during the set-up phase, as settings lacked the financial resources to free staff from their normal day-to-day work commitments. Settings that shared the workload of the programme amongst staff, rather than just being the responsibility of the Maths Champion (MC), exhibited higher levels of engagement. A core component of the Maths Champions programme at the time was the completion of the Basic and Key Skill Builder (BKSB), which required practitioners to complete maths assessment at the start and end of the trial to assess maths skills, as well as relevant online modules in between. Only 52% of settings engaged with this core component and practitioner interviews indicated that this was a significant barrier to engagement, negatively impacted on staff confidence and, as a consequence, became a barrier to engagement and implementation of the programme.

In response to the results of the first effectiveness trial of the Maths Champions programme, NDNA have made a number of changes to the programme (summarised in Table **1**). The most significant changes are: the exclusion of the BKSB (a tool to assess levels of practitioners' maths capabilities and provide them with practical activities to develop their skills); the introduction of a Deputy Maths Champion (DMC); and a move from face-to-face initial training to online training. All these changes essentially aim to address the issue of staff burden reported by Robinson-Smith et al. (2018).

The removal of the BKSB is due to low engagement with this component of the programme as reported in the first Maths Champions trial. As a result, NDNA have adapted the programme to provide practitioners with a more comprehensive understanding of the main areas of early years maths. Webinars and online modules will help both the Champions and practitioners to gain a deeper understanding of the six main areas that collectively underpin children's early mathematical learning and provide the firm foundations for the maths that children will encounter as they go up the years in primary school. These six main areas include:

1. Cardinality and counting – the cardinal value of numbers so children know what the numbers mean in terms of knowing how many things they refer to. Counting is one way to establish how many things are in a group.

2. Comparisons – comparing numbers involves knowing which numbers are worth more or less than each other. However, this depends both on understanding cardinal values and numbers. This understanding helps underpin the mental number line which children will develop.

3. Composition – knowing numbers are made up of two or more other smaller numbers. Learning to see a whole number and its parts at the same time is key to development in children's number understating. Partitioning numbers into other numbers and putting them back together again underpins understanding of addition and subtraction.

4. Pattern – seeking and exploring patterns is at the heart of mathematics. Developing an awareness of pattern helps young children to notice and understand mathematical relationships and this can provide foundations of algebraic thinking.

5. Space and shape and measure – the existing programme provides firm foundations for children's development in this area, however improvements can still be made. The delivery team felt that the activities would benefit from some clearer links to early years' outcomes and provide some assessment pointers.

6. Number – this is well embedded in the existing programme, but would still benefit from slight improvement. There is very little around subsidising e.g. recognising numbers without counting, which is an effective way for children to gain number meaning.

The DMC role has a dual function, allowing settings to spread the programme's workload and continue with the programme should the MC be absent or leave the setting. These changes are to be piloted prior to moving to the second effectiveness trial. Indeed, this evaluation will be implemented in two phases: (1) the pilot study; and (2) the effectiveness trial.

Changes that have been made to the evaluation design between the previous and current effectiveness trials are also summarised in Table **1**. One change relates to who within the setting can be trained to be the MC. In the first effectiveness trial (Robinson-Smith et al., 2018), the inclusion criteria required nurseries to have at least one graduate practitioner within the setting who would be the nominated MC. Within this trial, the practitioner qualification requirements are lowered, so settings without a graduate practitioner can also participate. In this trial, practitioners qualified to at least Level 3 (A-level/NVQ Level 3 or equivalent) who are responsible for leading the quality of the Early Years Foundation Stage (EYFS) at their setting can receive training to become a MC. This is reflective of the changing landscape of early years practitioner qualifications. NDNA's (2019) annual workforce survey has demonstrated a reduction in the proportion of nursery staff with graduate qualifications in recent years. The Department for Education (2019d) reported that only 47% of private or voluntary early years settings had a graduate practitioner in 2019. Furthermore, while only 7% of staff in private or voluntary settings were graduate practitioners, 65% were qualified to Level 3 (Department for Education, 2019d).

As noted in Table **1**, another difference between this trial and the trial reported by Robinson-Smith et al. (2018) is that both PVI and school-based nurseries (including maintained nurseries) (SN) are to be recruited. This reflects national provision as, excluding childminders, SN settings make up 27% of early years providers in England (Department for Education, 2019a). This second effectiveness trial therefore seeks to understand whether the Maths Champions programme could also be effective in SN settings. To enable the inclusion of SN settings, the intervention period will be slightly longer in this trial compared to the previous trial, with settings receiving approximately 7-8 months of the intervention before post tests are conducted, rather than 6-7 months (see Table **1**).

A final point to note, in reference to policy changes within early years childcare, is that there has been a significant change to the government Free Early Education Entitlement (FEEE) scheme since Robinson-Smith et al. (2018). Since September 2017, FEEE has extended funded childcare from 15 to 30 hours per week (term-time only) for all eligible 3-4 year olds. In line with this policy change, we may see that children's average weekly attendance within nursery increases (children attended nursery approximately 24 hours per week within the first Maths Champions trial). If so, children will have greater exposure to the intervention within this trial.

Table 1: Changes since the previous evaluation

	Feature	Effectiveness trial I	Effectiveness trial II
Intervention	Intervention content	Completion of BKSB by practitioners One MC at each setting	No BKSB One MC and one DMC at each setting
	Delivery model	Face-to-face induction	Online induction
	Intervention duration	It was planned that settings would implement the Maths Champions programme for 6-7 months	Settings will be supported to implement the Maths Champions programme for approximately 7-8 months (to enable inclusion of school-based nursery (SN) settings)
Evaluation	Eligibility criteria	Setting level: PVI nurseries located in Local Authorities in areas of high deprivation (although recruitment was extended to other Local Authorities) Practitioner level: Requirement for a graduate practitioner to be the nominated MC	Setting level: PVI, maintained nursery schools or children's centres, and government funded infant or primary school-based nursery classes (SN) (no requirement for nurseries to be from deprived Local Authorities). Requirement for nurseries to have a minimum of 15 eligible children in the recruitment cohort. Requirement for settings to not currently be taking part in the evaluation of the Department for Education's Early Years Professional Development Programme. Practitioner level: Practitioners qualified to at least Level 3 (A-level/NVQ Level 3 or equivalent) can be the nominated MC in the absence of a graduate practitioner
	Outcomes and baseline	Nursery environment/ provision was measured at post-test using the Early Childhood Environmental	Nursery environment/ provision, measured pre- and post-intervention using the ECERS-3 and ECERS-E, will

	Rating Scales 3 (ECERS-3) and the Early Childhood Environmental Rating scale extension (ECERS-E) in all settings as a secondary outcome	only be assessed in a sample of four intervention settings for the IPE and will not be a secondary outcome for the impact evaluation.
Control condition	Business as usual plus £500 following the completion of post-testing.	Business as usual plus £250 after parent/carer recruitment prior to pre-testing and £250 following the completion of post testing.

Intervention

Table 2: Description of the programme using the Template for Intervention Description and Replication (TIDieR) checklist

TIDieR Item	Description
Brief name	Maths Champions
Why: Rationale, theory or goal of the elements essential to the programme	Maths Champions was developed in response to a number of challenges identified in the early years. • There is an attainment gap in EYFSP results between disadvantaged children and their peers (Asmussen et al., 2018). • Early Years (EY) practitioners have low confidence and professional understanding to support children's mathematical learning (All Party Parliamentary Group for Maths & Numeracy, 2014). • Research tells us that children who start behind, stay behind (Asmussen et al., 2018). The Early Intervention Foundation (Asmussen et al., 2018, p.149) conclude that enriching the maths curriculum in pre-school results in gains for low-income children; Frye et al. (2013) from the What Works Clearinghouse recommend embedding maths in daily routines and activities and using learning trajectories to monitor progress. The goals of the maths champions programme are to: • Reduce the attainment gap in EYFSP results between disadvantaged children and their peers. • Increase early years practitioners' confidence and professional understanding to support children's mathematical learning.

	• Provide children with the best start in mathematical development. In line with recommendations by the EEF (2020) to improve mathematics in the early years, these goals will be achieved by: • Increasing practitioners understanding of how children learn maths. • Increased understanding of pedagogy – e.g. embedding maths though the day through direct teaching and sustained shared thinking. • Champions will audit practice and practitioners' knowledge and develop and review plans of action that will result in an increase in children's achievement. • Champions will work with practitioners in nursery settings to develop mathematical understanding, skills and confidence. • Provide tools and resources to put learning into practice within their settings.
Who: Recipients of this programme	PVI, maintained and school-based nursery (SN) settings. A graduate or Level 3 practitioner will receive training and support for the role of Maths Champion (MC). Another practitioner at each setting, typically a room leader who is qualified to at least Level 3, will receive training and support for the role of Deputy Maths Champion (DMC). The MC and DMC will support other practitioners in their settings to develop their professional understanding and confidence through, for example, coaching to improve practice. The Maths Champions programme will work to improve maths provision and attainment in maths for all children in participating nursery settings. Nurseries may share resources/encouragement/communication with parents/carers regarding child's mathematical development.
What: Physical or informational materials used in the programme	MCs and DMCs will be provided with the following: • An online webinar induction (1 hour in duration) covering information about leading the programme in their nursery. • Information about the audit tools that MCs will use to evaluate early years maths teaching in their nursery, e.g. the quality of resources available in the nursery to support mathematical learning, staff use of mathematical language in discussions with children, planning

	opportunities for mathematical learning in play and activities.
	• Access to three online courses (approximately 2 hours in duration), made up of e-learning modules, which cover early years maths theory and how to support other staff in the nursery:
	  ○ Coaching as an Educational Lead Mathematical concepts in early years;
	  ○ Developing Mathematical Confidence in the Early Years: the big ideas of number sense;
	  ○ Developing Mathematical Thinking in the Early Years: shape space, measures and pattern – including Characteristics of Effective Learning and sustained, shared thinking.
	• Access to an online platform with over 700 resources including number songs and rhymes, outdoor maths ideas and links to useful websites and research (Requirement to use 10 mandatory resources from the platform, details below).
	• Access to optional monthly webinars. The focus of these webinars will be developed in response to setting's action plan themes, e.g. using outdoor play and snack time to develop children's mathematics and staff confidence.

What: Procedures, activities and/or processes used in the programme	• Use of the audit tool, comprised of a set of survey questions, development of action plan, review of action plan with NDNA throughout, review of action plan at end of support provided by NDNA. • Optionally track and monitor children's development, in line with EYFS, for 6 children on a termly basis[1]. Use of NDNA tracking tool is optional as settings may maintain their own tracking systems. • Use of 10 mandatory resources provided through online platform for 3-4 year olds: Build a maze, Number hunt, Delivering the post, Mud kitchen, Cars down a ramp, Patterns, Construction, Tidy up time, Snack time, Outdoor games. • Use of 10 mandatory resources provided through online platform for 2-3 year olds: Block play, Tidying up, Parachute games, Number rhymes, Snack time, Small world, Puzzles and shape sorters, 'Let's Picnic', Sand and water play, Care routines

[1] NDNA guidance for this step: "*The children you track should be carefully selected in order to show the best possible impact. We recommend selecting a range of children according to the composition of your setting. This could include; a mixture of boys and girls, children with SEND, children who attend AM or PM only, children who attend 15 hours or 30 hours etc"*

	• Maths Champions lead at NDNA provides one-to-one support to nurseries monthly, via telephone or video conference, to keep setting on track with the programme. • Case Study/Portfolio review completed by NDNA. This includes all steps settings must undertake to be compliant with the programme, with particular regards to the setting audit and following changes to tracked children's development (optional component).
Who: Programme providers/ implementers	The programme provider is NDNA. NDNA staff will provide MCs and DMCs with training and support. The MC (qualified in childcare to at least level 3) will run the programme within their nursery. With support from NDNA, their responsibilities will include: completion of online training, completing audits of maths teaching in their nursery; creating action plans for improving maths provision across the nursery; and working with other nursery staff to improve their practice and confidence in maths. The DMC (typically a room leader at level 3) will support the MC, to implement change and observe and track children. The DMC may replace the MC if the MC were to leave the setting. Alternatively, a new staff member may be trained up to replace the MC. The role of the DMC may be replaced, as appropriate, should the existing DMC take over the MC role. Practitioners within the setting, with support from the MC and DMC, will implement change and observe and track children with increasing confidence.
How? Mode of delivery	Training for MCs and DMCs will be delivered though online webinars and e-learning modules. NDNA will additionally provide MCs with one-to-one support, mainly through monthly phone calls or WebEx, if they need additional support.
Where? Location of delivery	The programme is available nationally. (For the purpose of this trial, recruitment will be geographically restricted to East and West Midlands, and may be extended to other areas if necessary). As noted above, training for MCs and DMCs will be online and support will be remote.
When and how much? Duration and dosage of the programme	Usually nurseries are supported for a minimum of 12 months. (N.B. in the context of this second effectiveness trial settings will be supported for 7-8 months, see the Study rationale and background section).
Tailoring? Adaptation of the programme	The audit will identify needs, the action plan that MCs put together to improve maths provision across their nursery will be tailored to their setting.

	NDNA will provide tailored one-to-one support to MCs throughout the year and particularly when putting together their action plans. Support will typically be remote (mainly monthly phone calls), but could include visits where necessary. MCs may request additional support phone calls or web calls if necessary. Attendance at optional webinars are dependent on audit and action plans.
How well (planned): Strategies to maximise effective implementation	In addition to the extensive training, resources, and support outlined in the sections above, the following strategies will be employed to maximise effective implementation: • The induction, used to gain commitment to programme, will take MCs and DMCs step-by-step through the process and will familiarise them with the early years development zone (online platform); • Handbook; • Usually phone calls rather than email, use of web calls; • Potential for face-to-face visits at nursery setting; to evaluate how revised resources are working in practice. Photographic evidence for future programmes. • No requirement for additional resources, as everything needed to implement the programme would be already available within the setting.

Logic model

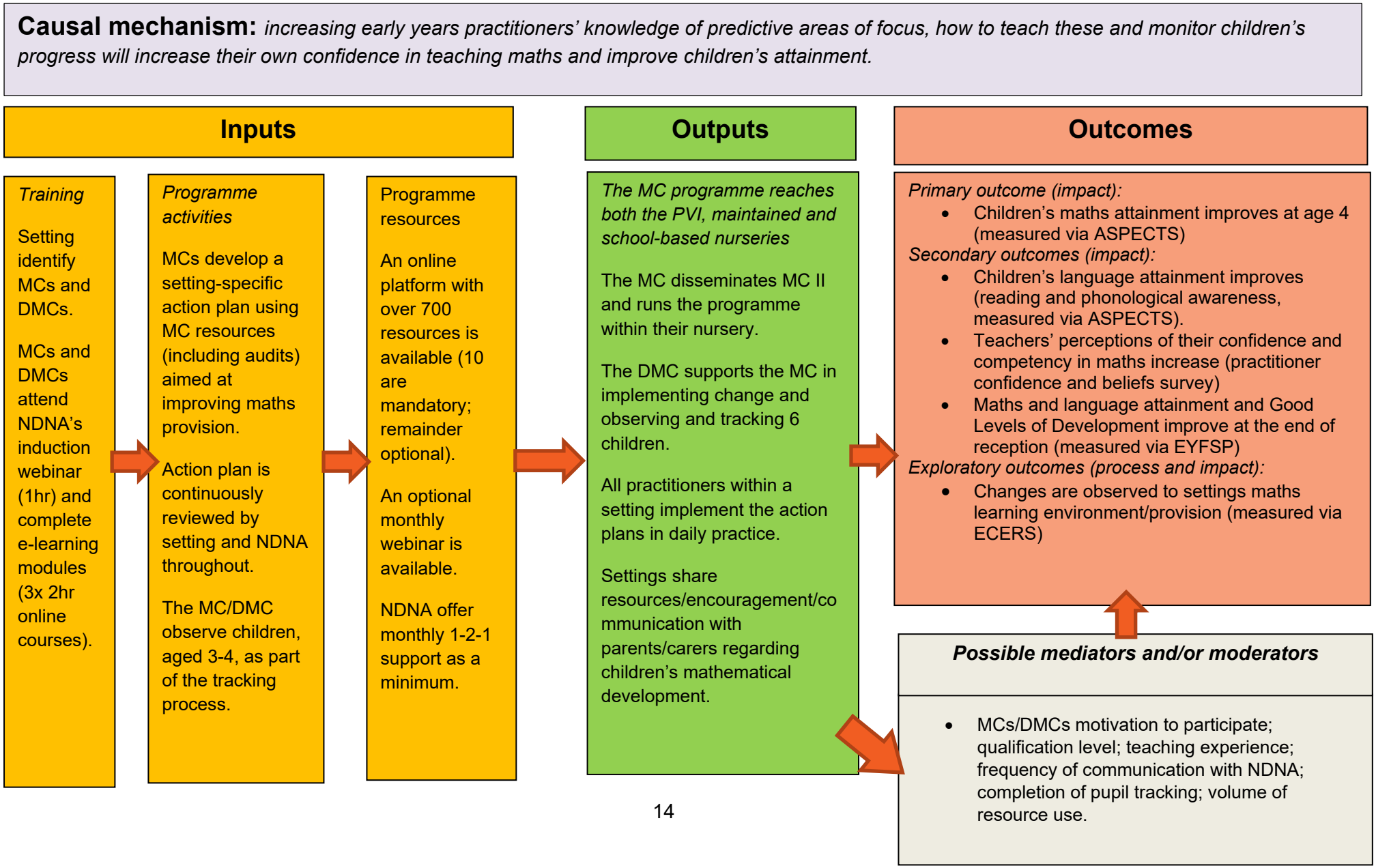
A detailed theory of change was originally developed by Evangelou and Mathers (2018) as part of the first Maths Champion's effectiveness trial. The Logic Model below was developed by the evaluation team on advice from the delivery team. The Logic Model below (see Figure 1) builds on the work of Evangelou and Mathers (2018), whilst considering key changes to the programme since the first Maths Champions effectiveness trial, e.g. removal of BKSB, move from face-to-face to online induction training and inclusion of a DMC. The logic model includes the core components in respect of inputs, outputs, outcomes and potential mediators and moderators.

The causal mechanism of the logic model is that ***increasing early years practitioners' knowledge of predictive areas of focus, how to teach these and monitor children's progress will increase their own confidence in teaching maths and improve children's attainment***.

The Early Intervention Foundation recognise the importance of creating high quality provision via high-quality training (Asmussen et al., 2018). They also identify that between the ages of 3-5 is the ideal time to rectify income related learning gaps in children's understanding of numbers. Pre-schools that helped children to understand early number concepts led to better outcomes in maths and overall later achievement (Mullis et al., 2012). The inputs of the Maths Champions programme aim to build confidence and professional understanding of teaching early years mathematics among practitioners, which are recognised issues within early years

teaching (All Party Parliamentary Group for Maths & Numeracy, 2014) .These inputs include the MC and DMC participating in relevant training (e.g. online induction, modules and webinars) which aim to equip the practitioners with a comprehensive understanding of the main areas of early years mathematical learning. Alongside this, practitioners implement programme tools including setting level action plan, trackers to monitor pupil progress, and online resources. These underpin the programme's outputs and enable the MC/DMC to evaluate existing practice, disseminate new learning to other practitioners within their setting and change current practice. Together these outputs aim to embed and increase the frequency and quality of maths routines, activities, exchanges and interactions in daily early years practice (Frye et al., 2013). At the child level, this will lead to improvements in children's maths attainment with spill-over effects into language (as practitioners use of mathematical language improve in complexity and frequency in relation to the programme). At the staff level, this will increase staff confidence in teaching early years maths, and improve maths provision and the learning environment. It is anticipated that engagement with the programme may depend on practitioner's qualifications and experience.

Figure 1: Maths Champions II Logic Model



Pilot study

Objectives

The objectives of the pilot study are to:

(1) Explore the most efficient way to deliver the Maths Champions trial within SN settings.

The first Maths Champions effectiveness trial recruited PVI settings only. Within the pilot we aim to determine the most efficient timeline for recruiting SN settings (includes maintained nursery schools or children's centres) and any changes to trial processes that may be required with the inclusion of SN settings.

(2) Understand if strategies to gain parental consent from children aged 3-4 are practical and effective.

We are aware of the challenges of recruiting children into research trials within the early years. Settings may self-select parents/carers to approach to take part in research, rather than offering the information to all who are eligible. Within the pilot, we will adopt strategies to maximise the number of consented children per setting in comparison to previous trials by requesting settings to provide the evaluation team with the total number of children who are eligible to participate, after which the evaluation team will send pre-made information packs to the nursery and request they distribute one to each parent/carer. Furthermore we will request that settings distribute an anonymous survey to parent/carers to complete and return, to the nursery, which gather perceived facilitators and barriers to recruitment. Data gathered via the anonymous questionnaire will inform recruitment strategies and materials within the effectiveness trial.

(3) Explore if the intended strategy to reduce attrition is practical, feasible and cost effective.

As discussed earlier, the first Maths Champions evaluation suffered high attrition as many children (19%) left the nursery in-between pre- and post-testing. Within the pilot, we aim to explore strategies to mitigate this, specifically by gaining consent from parent/carers at the outset to provide the evaluation team with their child's new setting destination, should they leave before post-testing, to enable post-testing to be conducted at the child's new setting or other location where possible. As part of this strategy, parents will be contacted prior to the post-testing period to ascertain new setting destination data, if not already provided by the nursery, and the evaluation team will liaise with new settings to try to arrange a suitable testing date. Post-testing will be completed by a research assistant and new settings who accommodate post-testing will receive £100.

(4) Explore the feasibility of recruiting and assessing a 2-3 year old cohort.

As part of this pilot study, we will aim to gain parent/carer consent to assess a 2-3 year old cohort in order to calculate a correlation between the Ages and Stages Questionnaire (ASQ-3) and ASPECTS. This correlation can be utilised within future early years trials using ASQ-3 as a baseline measure. Currently the ASQ-3 is one of the only assessments that can be conducted by early years practitioners in settings to capture development in young children. It is also routine practice for health visitors to work with parents to complete the ASQ-3 when children are around 2 years old, the results of which are logged on an NHS Digital database (Public Health England, 2020, 2018). We aim to explore methods and the feasibility of

collecting ASQ-3 data for 2-3 year olds within the pilot. The eligibility and recruitment process for the 2-3 year old cohort is described below.

(5) To explore changes made to the Maths Champions programme since the first effectiveness trial and the usefulness and acceptability of these changes within settings.

Design

The pilot study will adopt a non-randomised study design where all participating settings (n=12) receive the Maths Champions programme. Two cohorts of children will be recruited into the pilot: 3-4 year olds (Cohort 1); and 2-year olds (Cohort 2). The recruitment of a 2-3 year old cohort is specific to this pilot study and will not be replicated within the effectiveness trial, further explanation is provided in the Participants section. The pilot study will commence in January 2020, and the findings will inform the main effectiveness trial. Pilot settings will have access to the Maths Champions programme for 12 months.

Participants

Nursery settings

The delivery team will lead on the recruitment of nursery settings for the pilot and this will be supported by the evaluation team. Recruitment will begin in November 2019 and recruitment activities will include: emails to settings and advertisements (e.g. in newsletters to NDNA members, information on the NDNA website, press releases, flyers distributed at events, and through social media).

Nursery setting eligibility criteria are as follows:

- PVI providers based on non-domestic premises, maintained nursery schools or children's centres, or government funded infant or primary school-based nursery classes (SN) providing nursery provision for 3 and 4 year olds (who will begin reception in September 2020).
- Settings who have a minimum of 15 children in the cohort who will begin reception in September 2020
- Settings that are not currently using the NDNA Maths Champions programme and have not done so in the past.
- Settings who are not currently taking part in the evaluation of the Department for Education's Early Years Professional Development Programme (see: https://www.suffolklearning.co.uk/suffolklearning_images/users/Early_Years_Team_CYP//2019-10-10-EYPDPInformationforsettings.pdf).
- Settings that agree to all requirements outlined in the Information for Nurseries and Memorandum of Understanding document.

Although it is not to be considered an essential requirement, we would encourage participation from settings providing provision for 2 year olds (who will start reception in September 2021 or September 2022) in order to explore the feasibility of recruiting and assessing this cohort.

Settings will receive a study Information Sheet and Memorandum of Understanding (MoU) which provides full details relating to a setting's involvement within the trial. Settings willing to participate are to return a completed and signed MoU to the delivery team who will forward on to the evaluation team. All nursery settings participating in the pilot will receive £250 (bank transfer from the delivery team) following parent/carer recruitment, prior to pre-

testing. This thank you payment should allow nursery staff time to be freed up for baseline testing. All nurseries will also receive £250 (bank transfer from the delivery team) after completing the outcome testing for cohort 1 in June 2020.

Children

Child eligibility criteria are as follows:

Cohort 1:

- Children, aged 3 to 4 years, who are due to start reception class in school in September 2020.
- Children who attend nursery for a minimum of 15 hours per week.
- Children whose parents/carers anticipate they will remain at the nursery for the duration of the pilot study (June 2020).

Cohort 2:

- Children aged 2 by 1st January 2020 or aged 3, who are due to start reception class in school in September 2021 or September 2022.
- Children who attend nursery for a minimum of 15 hours per week.
- Children whose parents/carers anticipate they will remain at the nursery for the duration of the pilot study (February 2021).

In January 2020, PVI and SN settings recruited to participate in the pilot will be asked to provide the number of children in their setting who meet all eligibility criteria. The evaluation team will then provide each setting with parent/carer information sheets and consent forms and ask for them to be distributed to the parents/carers of all eligible children at the setting. Settings will be required to obtain consent from at least 10 parents/carers of 3-4 year olds for their child to participate in the evaluation.

Parents/carers will be required to provide consent for their child to participate in the pilot, including the baseline and outcome testing, by completing a Parent/Carer Consent Form. On the consent form, parents/carers will be requested to consent for their child's nursery setting to provide the evaluation team with data regarding their child, including name, date of birth, gender, home postcode, Early Years Pupil Premium status, FEEE from 2 years of age, attendance at nursery per week, assessment reports, as well as their new setting destination if they leave before the outcome testing. Additionally, parents/carers will be asked to consent to be contacted for new setting destination data for their child should it be unavailable from the nursery.

Outcome measures

Cohort 1: The Assessment Profile on Entry for Children and Toddlers (ASPECTS), developed by the Centre for Evaluation and Monitoring (CEM) and hosted by Cambridge Assessment, will be used to assess children aged 3-4. Baseline assessments will be completed by a setting's own nominated early years practitioner, who will receive training from the evaluation team in February/March 2020. Trained research assistants will visit each setting to complete outcome assessments with the same children in June/July 2020. ASPECTS is discussed in detail in the effectiveness trial Outcome measures section.

Cohort 2: The Ages and Stages Questionnaire (ASQ-3) will be used to capture the skills and development of children aged 2-3 years old. The domains of the ASQ-3 include:

communication, gross motor, fine motor, problem-solving and adaptive skills. A score is assigned to each development. Within any screened domain, less than two standard deviations below the mean area score in considered a positive screen. The ASQ-3 is validated and standardised and has been reported to be accurate in detecting problems in healthy children. The ASQ-3 is usually completed by parents, but can be used by early years practitioners, taking no longer than 15 minutes to complete. Here, early years practitioners will be requested to complete the ASQ-3 for participating children early 2020. Settings will be provided with ASQ-3 training and materials by the evaluation team, and completed ASQ-3 questionnaires were to be returned via courier, arranged by the evaluation team. The same children will complete ASPECTS (as detailed above) with a Research Assistant once, in February 2021.

Analysis

Cohort 1: The purpose of conducting baseline and post-testing with this cohort is to pilot processes and procedures, as detailed above, prior to implementation within the effectiveness trial. Therefore, no formal analysis of ASPECTS will be undertaken for cohort 1; descriptive data will be provided relating to baseline and outcome assessment completion rates.

Cohort 2: ASQ-3 scores at 2 years old and ASPECTS scores at 3-4 years old will be summarised descriptively and the Pearson's correlation between the two will be presented with a 95% confidence interval.

Pilot implementation and process evaluation

The pilot implementation and process evaluation (IPE) has been designed to ensure adherence to the key principles for the design, conduct and reporting of the impact evaluation. The pilot will address the descriptive and experiential aspects of the pilot research questions, listed below. It will complement the quantified outcomes for the pilot impact evaluation and will be a combination of cross-sectional and longitudinal designs. The impact evaluation and IPE are fully integrated. Measures of compliance, fidelity and usual practice have been included in the impact evaluation, and these data will be complemented by pilot IPE data which will explain reasons underpinning levels of compliance and levels of fidelity within the context of usual practice.

The cross-sectional design will explore the perceptions and experiences of key stakeholders at the beginning of the pilot to provide snapshot descriptive data on perceptions about recruitment and towards the end of the pilot study period to provide snapshot descriptive data on perceptions about: barriers and facilitators to recruitment and retention; feasibility and acceptability of MC implementation and delivery; and acceptability and feasibility of undertaking the baseline and outcome assessments. Data collection will comprise a series of interviews/focus groups with key stakeholders: MCs, DMCs and NDNA staff. Four nursery settings (two PVI, two SN) will form the sample for the pilot IPE interviews.

The longitudinal design will provide quantified data on access to e-learning modules over the period of the pilot to measure engagement with the online training resources.

The IPE will link the perceptions of the key stakeholders to key process outcomes of the logic model to provide evidence of promise, see Table 3.

Pilot IPE Research Questions

Research Question (RQ) 1: What is the feasibility of evaluating MC within PVI and school nursery settings?

1.1. Is the intended timeline for recruiting PVI and school nursery (SN) settings feasible?
1.2. Are intended strategies to improve setting and child recruitment practical?
1.3. Is the intended strategy to reduce attrition practical and feasible?
1.4. Are intended outcome measures for pre- and post-tests effective and appropriate in terms of cost, administration and evaluation?

1.5. Is the content of baseline and endpoint surveys suitable for capturing necessary data?

RQ 2: What are the barriers to evaluating the MC programme in the pilot trial?

2.1. What are the barriers to recruiting children in the pilot study for pre- and post-tests?

2.2. How has COVID-19 impacted on the proposed delivery of the evaluation methods and what might the impact be of this for the effectiveness trial?

RQ 3: What is the feasibility of delivering MC within PVI and school nursery settings?

3.1. To what extent can NDNA deliver the MC programme and the support to MCs and DMCs as intended in the time allotted?

RQ 4: Is the MC programme implemented with fidelity within PVI and school nursery settings?

4.1. Are nominated staff (MCs, DMCs) accessing the available E-learning modules and the support as specified in the programme plan?
4.2. How effective and appropriate are the level of support and training (e.g. content, coverage, dosage and duration) for MCs and DMCs?
4.3. How is the MC programme disseminated within the nurseries to other staff?
4.4. To what extent do the MCs, DMCs and practitioners implement the MC programme into classroom practice?

RQ 5: What are the different stakeholders' viewpoints on the MC programme?

5.1. What are the perceived impacts of MC?
5.2. What is the perceived role of DMCs?
5.3. What are the perceived impacts of DMCs?

RQ 6: What are the barriers to delivering the MC programme in the pilot trial?

6.1. What are the barriers for MCs and DMCs to engage with induction and E-learning modules?
6.2. What are the barriers for MCs, DMCs and practitioners to implement MC in their classroom practice?
6.3. What are the barriers for MCs to disseminate MC to other staff in the classroom?

RQ 7: What appear to be the necessary conditions for the successful delivery of MC programme?

7.1. What are the necessary conditions for successful recruitment of settings, families and children?
7.2. What are the necessary conditions for MCs and DMCs to engage with the training and E-learning modules and the monthly one to one support?
7.3. What are the necessary conditions for practitioners to implement MC into practice?
7.4. What are the necessary conditions for reducing the attrition in the pilot trial?

RQ 8: How could the MC programme be improved?

RQ 9: How could the delivery of the MC programme be improved?

RQ 10: How has the delivery of the MC programme been impacted by the COVID-19 pandemic?

Table 3: IPE Pilot Methods Overview

Feature	Research Method	Data collection methods	Participants/ data sources (type, number)	Research questions addressed	Implementation/ logic model relevance
Recruitment **Delivering MC to PVI and SN settings**	Cross-sectional	Semi-structured interview/ focus group	NDNA staff (n = 2)	RQ 1: 1.1; RQ 3: 3.1; RQ 4: 4.1 RQ 6: 6.1; RQ 7: 7.1; RQ 8; RQ 9	Feasibility; Fidelity; Context
Recruitment **Delivering MC to PVI and SN settings**	Cross-sectional	Semi-structured interview/ focus group	MCs (PVI n = 2; SN n = 2)	RQ 4: 4.2, 4.3, 4.4; RQ 6: 6.1, 6.2; RQ 7: 7.2; RQ 8; RQ 9	Fidelity; Context
Recruitment **Delivering MC to PVI and SN settings**	Cross-sectional	Semi-structured interview/ focus group	DMCs (PVI n = 2; SN n = 2)	RQ 4: 4.2, 4.3, 4.4; RQ 5: 5.1, 5.2; RQ 6: 6.1, 6.2; RQ 7: 7.2; RQ 8; RQ 9	Fidelity; Context
Recruitment **Delivering MC to PVI and SN settings**	Cross-sectional	Semi-structured interview/ focus group	Other practitioners (PVI n = 2; SN n = 2)	RQ 4: 4.3, 4.4; RQ 5: 5.2; RQ 6: 6.2; RQ 7: 7.3; RQ 8; RQ 9	Fidelity; Context
Role of DMC and other MC content change(s)	Cross-sectional	Semi-structured Interview/ focus group	MCs (PVI n = 2; SN n = 2)	RQ 5: 5.2, 5.3	Process outcomes (confidence and competence)

	Cross-sectional	Semi-structured interview/ focus group	DMCs (PVI n = 2; SN n = 2)	RQ 5: 5.2	Process outcomes (confidence and competence)
	Cross-sectional	Semi-structured interview/ focus group	Other practitioners (PVI n = 2; SN n = 2)	RQ 5: 5.2, 5.3	Process outcomes (confidence and competence)
Pilot trial data collection processes	Cross-sectional	Semi-structured interview/ focus group	Sample setting staff (n = 4)	RQ 1: 1.4; RQ 4: 4.4; RQ 6: 6.2; RQ 2: 2.1; RQ 7: 7.3	Feasibility; Fidelity
			NADA staff (n = 2)	RQ 5: 5.1, 5.3	Compliance;
	Longitudinal design	E-learning logs data	All settings (n = 12)	RQ 1: 1.2, 1.3, 1.4; RQ 2: 2.1; RQ 7: 7.4	Compliance; Context
Parental perceptions	Cross-sectional survey	Paper or Online surveys	Parents of eligible children in all settings (n = 12) are invited to complete the survey anonymously	RQ 1: 1.2, 1.3; RQ 2: 2.1; RQ 7: 7.1	Context; Feasibility
Baseline and end-point setting usual practice surveys	Cross-sectional (start and end of pilot)	Paper or online	Manager/head teacher in all control and intervention settings	RQ1.5	Feasibility; context
COVID-19	Cross-sectional	Semi-structure interview/ focus groups	All participants in all interviews/focus groups	RQ 10 RQ 2.2	Perceived impact of COVID-19 pandemic

Data collection

Data collection will use a combination of semi-structured interviews/focus group(s) (conducted using video conferencing software e.g. using Zoom or telephone), e-learning logs data and on-line and paper surveys. All data collection tools will be pre-specified and registered with the Ethics Committee providing ethical approval, thus ensuring transparency of the methods.

Analysis

IPE data will be analysed using a combination of inductive and deductive analyses. Emerging patterns in the data will be grouped thematically according to the research

questions. Results will be synthesised from the themes and presented as answers to each pilot IPE research question.

Summary of changes to the pilot trial design as a result of COVID-19

Due to COVID-19, the pilot study was paused in March 2020 and will resume in October 2020. Participating settings will receive another induction webinar and commence the MC programme. Settings will have access to the Maths Champions programme for 12 months, until September 2021. As a result, there will be a number of changes to the pilot study:

- Parents/carers of Cohort 1 children will not be asked to complete a questionnaire to gather perceived facilitators and barriers to recruitment. Strategies to gain parental consent will be explored with settings though IPE interviews.
- Cohort 1 will not complete outcome testing as they will have left the setting to start school by the time the pilot resumes in October 2020.
- Practitioners will not be asked to complete the ASQ-3 with Cohort 2 (children aged 2-3 years old) when the pilot restarts, settings will be asked if they routinely complete ASQ-3 and, if so, to provide any ASQ-3 data they already have for participating 2-3 year olds, to gain information about routine use of the ASQ-3 and the feasibility of collecting this data from settings.
- Cohort 2 children will be followed-up to explore the feasibility of completing ASPECTS in their current or new setting in February 2021. Doing so allows us to develop the strategy for locating and assessing children in a new setting which will be useful for reducing attrition in the effectiveness trial (a process originally planned to take place with children in Cohort 1 in the pilot study). It may not be possible for Cohort 2 outcome assessments to be carried out as planned in February 2021 (depending on restrictions in place due to COVID-19) but it allows the evaluation team the opportunity to liaise with current and new settings to explore how receptive they would be for a research assistant to visit and complete post-testing with the participating child, with the view of offering a £100 thank you payment for accommodating post-testing. It also offers the opportunity to gauge settings' perspectives on measures that may need to be put in place due to COVID-19 to carry out assessments in settings, prior to the effectiveness trial starting. It is important to note that the proportion of children who have moved settings may not be representative of what would be normally expected. This is because some settings closed during the peak of the pandemic for a period of time whilst others remained open to children of keyworkers. Subsequently, participating children of keyworkers may have needed to relocate settings, meaning a greater proportion of children may have moved settings, than in usual circumstances,
- IPE interviews/focus groups will likely reduce in number and be conducted online via zoom and/or TEAMS, in line with the capacity of participating settings.

A revised timeline is provided in a Table 9.

Effectiveness trial impact evaluation

Research questions

RQ 1. What is the impact of the Maths Champions programme, in comparison to usual early years setting provision, on the maths skills of pre-school children aged 3-4? [Primary outcome]

RQ 2. How effective is the Maths Champions programme at improving nursery practitioners' confidence in supporting children's maths development in comparison to usual early years setting provision? [Secondary outcome 1]

RQ 3. What is the impact of the Maths Champions programme, in comparison to usual early years setting provision, on the development of language (reading and phonological awareness) of pre-school children aged 3-4? [Secondary outcome 2]

RQ 4. What is the feasibility of accessing ASQ-3 data completed when children were 2 years old from NHS digital and how does this data correlate to maths and language development at 3 and 4 years old (measured using ASPECTS).

Design

Table 4: Trial design

Trial design, including number of arms		Two-armed cluster randomised controlled trial
Unit of randomisation		Nursery setting
Minimisation factors		Nursery type (2 levels: PVI; SN and maintained settings); Nursery size (2 levels: < median number of children leaving for primary school in 2022 at participating settings; ≥ median number of children leaving for primary school in 2022 at participating settings); Number of staff at the nursery, holding a degree qualification in early years (2 levels: 0 graduates; ≥ 1 graduate)
Primary outcome	variable	Child Maths attainment after 7 months intervention exposure
	measure (instrument, scale, source)	ASPECTS maths attainment score, 0-29, Centre for Evaluation and Monitoring (CEM) at Cambridge Assessment
Secondary outcome(s)	variable(s)	Practitioner confidence and beliefs after 7 months intervention exposure; Child Language attainment after 7 months intervention exposure; Child attainment at the end of Reception year at school Child development at 2 years old and its correlation to child development at 3 and 4 years old

	measure(s) (instrument, scale, source)	Practitioner confidence and beliefs survey subscales: Beliefs About Nursery Aged Children and Maths, 8-40; Confidence in Helping Nursery Aged Children Learn Maths, 11-55; Confidence in Own Maths Abilities, 9-45; survey adapted from version developed by Chen *et al*. (2014). ASPECTS Language (reading and phonological awareness) score, 0-53, CEM at Cambridge Assessment. Early Years Foundation Stage Profile data (completed at the end of Reception) collected from National Pupil Database. Ages and Stages Questionnaire (ASQ-3) at 2 years old, data gathered via NHS digital and its correlation to ASPECTS (described above).
Baseline for primary outcome	**variable**	Child maths attainment
	measure (instrument, scale, source)	ASPECTS maths attainment score, 0-29, Centre for Evaluation and Monitoring at Cambridge Assessment
Baseline for secondary outcome	**variable**	Child Language attainment
	measure (instrument, scale, source)	ASPECTS Language (reading and phonological awareness) score, 0-53, CEM at Cambridge Assessment

Randomisation

A statistician at York Trials Unit (YTU), who is not involved in nursery recruitment, will randomise nursery settings to either the intervention or control arm, using a 1:1 allocation ratio and minimisation to ensure balance across the trial arms on nursery type, nursery size, and the number of graduate staff (see Table 4 for the levels of each minimisation factor). A dedicated computer program, MinimPy (Saghaei and Saghaei, 2011), will be used for randomisation. If necessary, randomisation will be completed in batches following setting's pre-test completion to prevent any delay to NDNA delivering the programme. Nursery settings allocated to the intervention arm will receive the NDNA Maths Champions programme, whereas settings allocated to the control arm will continue with usual nursery provision. The trial statistician will not be blind to group allocation.

Settings will be randomised after child recruitment and baseline data collection has been completed. Randomisation may be carried out in batches to avoid delays in programme induction and to maximise programme delivery for as many settings as possible. All settings will be informed of their random allocation via a letter emailed to the setting contact.

Participants

Nursery settings

The delivery team will lead on the recruitment of nursery settings, supported by the evaluation team. NDNA will cease promotion and marketing of the Maths Champions

programme to new settings not taking part in the trial, to ensure capacity to support the trial. Recruitment began in January 2020, but was paused between March and December 2020 due to the COVID-19 pandemic and will recommence in January 2021. Planned recruitment strategies include: a dedicated page on NDNA's website for the trial; emails to settings in recruitment areas; marketing through social media channels; promotion via sector press and public relations work; promotion at NDNA member events in targets recruitment areas and at NDNA's annual conference; working with contacts in targeted local authorities and providing them with recruitment materials to push at a local level; and working with Early Education to promote the trial.

Nursery setting eligibility criteria are as follows:

- PVI providers based on non-domestic premises, maintained nursery schools or children's centres, or government funded infant or primary school-based nursery classes (SN) settings providing nursery provision for 3 and 4 year olds (who will begin reception in September 2022).
- Settings who have a minimum of 15 children in the cohort who will begin reception in September 2022.
- Settings that are not currently using the NDNA Maths Champions programme and have not done so in the past.
- Settings who are not currently taking part in the evaluation of the Department for Education's Early Years Professional Development Programme (see: https://www.suffolklearning.co.uk/suffolklearning_images/users/Early_Years_Team_CYP//2019-10-10-EYPDPInformationforsettings.pdf) or taking part in any other trials funded by the EEF.
- Settings that agree to all requirements outlined in the Information for Nurseries and Memorandum of Understanding document.

The recruitment areas for this trial will be focussed on the East Midlands and West Midlands, as at the time of set-up no other EEF trials are currently recruiting or running in these areas, but nurseries from others areas may be considered for participation. Approximately 138 nursery settings (69 in each of the intervention and control arms; approximately 96 PVI and 42 SN settings, soft targets) will be recruited to take part in this trial. This represents 70% PVI and 30% SN and is in line with national provision as, excluding childminders, SN settings make up 27% of early years providers in England (Department for Education, 2019a).

Settings will receive a study Information Sheet and Memorandum of Understanding (MoU), which provides full details relating to a setting's involvement within the trial. Settings willing to participate are to return a completed and signed MoU to the delivery team who will forward on to the evaluation team. All nursery settings (i.e. both intervention and control) will receive £250 (bank transfer from the delivery team) after parent/carer recruitment, before pre-testing. This thank you payment should allow nursery staff time to be freed up for baseline testing. All nurseries will also receive £250 (bank transfer from the delivery team) after completing the outcome testing.

Children

Child eligibility criteria are as follows:

- Children aged 3 to 4 years, who are due to start reception class in school in September 2022.

- Children who attend nursery for a minimum of 15 hours per week.
- Children whose parents/carers anticipate they will remain at the nursery (i.e. they do not foresee they will leave the nursery) for the duration of the trial (until June 2022).
- Children who complete the trial pre-test.

Children are not eligible to take part in the trial if practitioners consider them to have significant Special Educational Needs or Disabilities or English as an Additional Language where an extreme language barrier exists which would prevent them from accessing the ASPECTS assessment and/or would be distressed through completing the assessment.

In the summer term of 2021, recruited PVI and SN settings will be asked to provide the number of children in their setting who meet the first three eligibility criteria. The evaluation team will then provide each setting with parent/carer information sheets and consent forms and ask for them to be distributed to the parents/carers of all eligible children at the setting. SN settings may choose to begin the parent/carer consent process prior to the start of the academic year, contacting parents/carers of children who are on the school's pre-registration lists. In current EEF trials (e.g. PACT), parent/carer consent has taken place during 'home' school visits prior to the child starting at the school. For schools where this does not take place, or in PVI settings where they have new starters aged 3, they will be requested to gather parent/carer consent during the first two weeks of term. As detailed above, setting level eligibility criteria requires settings to have at least 15 children who meet the eligibility criteria. Settings are then required to obtain consent from at least 10 parents/carers agreeing for their child to participate in the evaluation. Settings must receive parent/carer consent for a minimum of 10 children to continue their participation in the trial. Settings who recruit between 7 and 9 children will be placed in 'reserve' and will progress to participation in the trial in the event that the desired level of recruitment of settings/pupils is not met and/or saturation within setting-level recruitment is met.

Parents/carers will be required to provide consent for their child to participate in the evaluation, including the baseline and outcome testing, by completing the Parent/Carer Consent Form. On the consent form, parents/carers will be requested to consent for their child's nursery setting to provide the evaluation team with data regarding their child, including name, date of birth, gender, home postcode, Early Years Pupil Premium status, FEEE from 2 years of age, attendance at nursery per week, assessment reports, child's school destination, as well as their new setting destination if they leave before the outcome testing. Additionally, parents/carers will be asked to consent to be contacted should school or new setting destination data for their child be unavailable from the nursery, and also to consent for long-term tracking of their child's educational outcomes through the National Pupil Database for the purposes of the evaluation. Parents/carers will receive two copies of the consent form; one to complete and return to the setting and one to keep for their own records. Parents/carers must indicate their willingness for the child to participate by ticking or writing their initials against all statements listed on the consent form, and providing necessary signatory. In cases where settings gain consent from more than 10 parents/carers, then a sample of 10 children will be selected for baseline and outcome testing. Where possible, we want to include at least one EYPP pupil per setting to have adequate power to conduct analyses in the EYPP subgroup (see the Sample size calculations section below). Therefore, we will randomly select up to three eligible children with EYPP status (or all of them if there are three or less eligible; including more than one, where this is possible, which allows for some attrition at follow-up), then randomly sample from the remaining, unselected children (EYPP and non-EYPP) to make up the 10.

Parents/carers will be provided with an additional brief information sheet and consent form seeking permission for the evaluation team to access their child's ASQ-3 data completed at 2-years old stored in an NHS Digital database, and to use this data to assess the correlation between their child's ASQ-3 score and their ASPECTS score at 3 and 4 years old. We will also ask parents/carers to consent to the setting providing the evaluation team with ASQ-3 data should they hold it. These are planned to be separate study documents as they will require review by NHS Research Ethics Committee.

Sample size calculations

We make the following assumptions: a setting-level intra cluster correlation of 0.17; 10 children per setting with a baseline and outcome testing correlation of 0.59; and 1:1 allocation at nursery setting level. Based on 138 nurseries (i.e.1380 children), we would have 80% power to show an effect size of 0.20 of a standard deviation between the control and the intervention groups, allowing for 15% attrition at the child level.

We will conduct a subgroup analysis for the primary outcome in EYPP pupils. Owing to the proposed sampling strategy of eligible children to participate in the trial, we hope to have at least one EYPP pupil from each setting included in this analysis. If most nurseries only have one EYPP pupil who contributes to this analysis, then the analysis for this will be conducted at the setting level, aggregating child outcomes by taking the mean for eligible EYPP children in that setting. Assuming a baseline and outcome testing correlation of 0.59 (no design effect assumed since at setting-level), with 138 nurseries we would have 80% power to show an effect size of 0.38 of a standard deviation between the control and the intervention groups in the EYPP subgroup.

If, however, more than half the settings have two or more eligible EYPP pupils that contribute to the analysis and the average number per setting is ≥2, we may conduct this analysis at the pupil-level, and account for the clustering by setting. Assuming an ICC of 0.17; an average of 2 children per setting with a baseline and outcome testing correlation of 0.59; and 1:1 allocation at setting level, we would have 80% power to show an effect size of approximately 0.30 of a standard deviation between the control and the intervention groups in the EYPP subgroup.

Table 5: Sample size calculations

		OVERALL	EYPP
Minimum Detectable Effect Size (MDES)		0.20	0.30-0.38
Pre-test/ post-test correlations	level 1 (child)	0.59	0.59
	level 2 (nursery)	0.59	N/A
Intracluster correlations (ICCs)	level 2 (nursery)	0.17	N/A/0.17
Alpha		0.05	0.05
Power		0.8	0.8
One-sided or two-sided?		Two	Two
Average cluster size		10	1/2
Number of nurseries	Intervention	69	69/138
	Control	69	69/138

		OVERALL	EYPP
Total		138	138/276
Number of children	Intervention	690	69
	Control	690	69
	Total	1380	138

EYPP = Early Years Pupil Premium

Outcome measures

Primary outcome

The Assessment Profile on Entry for Children and Toddlers (ASPECTS), developed by the Centre for Evaluation and Monitoring (CEM) and hosted by Cambridge Assessment, will be the primary baseline and outcome measure. ASPECTS has been specially designed for children aged 3-5 years old (36-60 months) and is aligned with the crucial elements of the EYFS Prime and Specific areas of Leaning and Development. Early maths skills that are assessed include digit identification, counting, shapes, number problems, and ideas about maths; each of these areas are targeted by the Maths Champions programme, which provides a holistic approach to improving maths attainment. The early maths skills component of ASPECTS formed the primary outcome measure within the first Maths Champions trial (Robinson-Smith *et al*. 2018) which will allow a comparison of results. Participating children will be assessed using ASPECTS at baseline at the start of the 2021-22 academic year (before their nursery is randomised) and again at the end of the 2021-22 academic year for outcome testing. We aim to assess 10 children, for whom parent/carer consent is received, at baseline and again at the outcome time point. The evaluation team will liaise with nursery settings to arrange convenient times for the baseline and outcome testing. Where possible, baseline assessment dates will be booked in advance prior to the start of the 2021-22 academic year.

ASPECTS is a child-friendly, computer-based assessment, designed to be used on a one-to-one basis with children aged 3-4 years. The programme asks children to compete a series of activities and an adult submits the child's responses on the computer. At first, the child is asked to write their name and this is scored by the practitioner against examples. The software then plays an audio recording of a story to the child and asks a number of questions. While all children hear the same story, ASPECTS adopts an adaptive design whereby the questions asked are dependent on the child's responses (e.g. more challenging questions are provided when a child answers a question correctly). ASPECTS uses Rasch measurement to estimate the item difficulties. All items are categorised and more difficult items from each category are no longer presented once the child has made a certain number of mistakes in that category. The early maths subscales of the measure, which take approximately 10-12 minutes per child, will be used at baseline and outcome testing. The maths score (range 0 to 29) will be the primary baseline and outcome measure, a higher score indicates greater attainment.

At baseline, where possible, a practitioner from within each PVI setting who is familiar with the children will be asked to complete ASPECTS with participating children. There is provision for a research assistant to complete baseline assessments in 20% of participating PVI settings who are unable to complete assessments within the agreed timeframe. . As the timeframe for baseline testing is likely to be shorter for SN settings (as all children will not be

present in the setting until the beginning of the academic year), a research assistant will visit all SN settings to complete the baseline testing with children, unless the school request to complete these themselves (baseline scores will be adjusted for within the primary outcome statistical model, which will account for any differences hypothetically caused by type of assessor at baseline). As children will be very young at baseline (typically 3 years), having a familiar adult administer the assessment with children should help them to perform to the best of their ability and minimise missing data. At least one practitioner per nursery will receive training in how to set-up and administer ASPECTS via an online, pre-recorded webinar delivered by the evaluation team lasting no longer than 30 minutes. The evaluation team will send a research assistant to any setting that requests help to conduct baseline assessments.

At the time of outcome testing, ASPECTS will be administered in all settings by independent, blinded, research assistants (RAs), who will have received training from the evaluation team. All research assistants will have an enhanced DBS check and undergo relevant safeguarding and data protection training. We will advise settings that a child's key worker or familiar staff member should be available to chaperone the assessment conducted by the research assistant to ensure the child feels comfortable. In cases where children have moved to a new setting before outcome assessment, we will seek to follow up such children and assess in new settings (this will include gaining agreement from new settings). The proportion of children for whom this strategy is employed will depend on the numbers of children identified as having moved to new settings. The aim will be to ensure an adequate level of attrition overall, weighed with the cost implications of assessing in new settings. New settings who facilitate the outcome assessment will receive £100.

In the event RAs are unable to attend settings to complete baseline and/or outcome due to continuing COVD-19 restrictions, the protocol will be updated with a revised testing strategy.

Secondary outcomes

The literacy/language score from ASPECTS, carried out at baseline and outcome time-points, will be a secondary outcome. Early literacy skills that are assessed include reading and phonological awareness. This is scored from 0 to 53, where a higher score indicates greater attainment. The Maths Champions programme aims to increase the frequency of use of maths terminology between practitioners and children in all interactions; therefore there is potential for intervention spill-over effects in the domain of literacy/language. The literacy/language component of ASPECTS formed a secondary outcome measure within the first Maths Champions trial (Robinson-Smith et al., 2018) which will allow a comparison of results.

Practitioner confidence and beliefs, assessed using a short online survey adapted from Chen et al. (2014), will be a secondary outcome. Increasing practitioner's confidence in using maths is a key focus of the Maths Champions programme. We will request for the survey to be completed by all practitioners in each setting who work with children aged 3 years or older, including the nominated MC and DMC in intervention settings and comparable staff in control settings. The survey will be completed at post-intervention only and consists of three subscales: Beliefs about Nursery Aged Children and Maths (8 items); Confidence in Helping Nursery Aged Children Learn Maths (11 items); and Confidence in Own Maths Abilities (9 items). Practitioners will be asked to rate their agreement with each item on a Likert scale, from strongly disagree to strongly agree. Each item is scored from 1 to 5, with some items reverse scored. Scores for items in the subscales will be summed to

produce three summary scores (Beliefs about Nursery Aged Children and Maths: scored from 8 to 40; Confidence in Helping Nursery Aged Children Learn Maths: scored from 11 to 55; Confidence in Own Maths Abilities: scored from 9 to 45). As the three subscales represent three different constructs, they should not be combined into a total score and will be analysed separately. Practitioner confidence using the Chen et al. survey formed a secondary outcome measure within the first Maths Champions trial (Robinson-Smith et al., 2018) which will allow a comparison of results.

The Ages and Stages Questionnaire (ASQ-3) is used to capture the skills and development of children at 2 years old. The domains of the ASQ-3 include: communication, gross motor, fine motor, problem-solving and adaptive skills. A score is assigned to each development domain. Within any screened domain, less than two standard deviations below the mean area score is considered a positive screen. The ASQ-3 is validated and standardised and has been reported to be accurate in detecting problems in healthy children. The ASQ-3 is used routinely by health visitors who request parents complete the questionnaire as part of a health check when their child is 2 years old, taking no longer than 15 minutes to complete. The data from the questionnaire is stored, and accessed, via NHS digital (Public Health England, 2020, 2018). The evaluation team will seek parental consent to access participating children's ASQ-3 scores from NIHS Digital, assess the feasibility and coverage of ASQ-3 data held within NHS Digital and determine if a correlation exists between ASQ-3 scores at 2 years old and ASPETS scores at 3 and 4 years old which are being collected as part of the effectiveness trial.

Compliance

Compliance and fidelity will be measured at the nursery setting level. Each setting in the intervention arm will be assessed for their implementation fidelity and compliance (the extent to which the critical ingredients of the Maths Champions programme are delivered to, received and implemented by the target participants). This will be measured by NDNA who will rate each setting on compulsory and optional aspects of the programme. A working rating scale is provided below but will be confirmed a priori and detailed in the Statistical Analysis Plan.

NDNA will rate each setting on aspects of the programme on a scale of: 2 = very engaged ('green'), 1 = partially engaged ('amber'), and 0 = not engaged ('red'). This will result in possible scores of 0-16 for core components, with an additional 10 points for optional components. The definitions are outlined in Table 6.

Current EEF guidance for IPE evaluations (Education Endowment Foundation, 2019a) defines compliance and fidelity in the following way:

> Compliance: the extent to which the critical ingredients of the programme are delivered to and/ or received by the target participants.
>
> Fidelity: the degree to which the programme is delivered as intended or prescribed.

For the purposes of this rating scale, in this particular trial, we are not differentiating between compliance and fidelity, but seeking to capture information on both compliance and fidelity within one rating scale. Other elements of the IPE will seek to comment and explore compliance and fidelity as separate constructs where possible.

Table 6: Compulsory/Optional Components Compliance and Fidelity Rating

Criteria	Core/ Optional	Description	RAG rating
Identification of suitable Maths Champion (MC; graduate or Level 3 practitioner)	Core	MC with graduate qualifications	Green = 2
		MC with Level 3 qualifications	Amber = 1
		MC with no level 3 qualifications or no MC identified	Red = 0
Identification of suitable Deputy Maths Champion (DMC; qualified to at least Level 3)	Core	DMC with Level 3 qualifications or higher	Green = 2
		DMC with no level 3 qualifications	Amber = 1
		No DMC identified	Red = 0
MC and DMC complete induction	Core	MC and DMC complete induction	Green = 2
		Only MC or DMC complete induction	Amber = 1
		Neither MC or DMC complete induction	Red = 0
Completion by the MC of 3 courses: Developing Mathematical Confidence in the Early Years: the big ideas of number sense; Coaching as an Educational Lead Mathematical concepts in early years; Developing Mathematical thinking in the Early Years: shape space, measures and pattern – including Characteristics of Effective Learning and sustained, shared thinking.	Core Coaching module optional if MC already has coaching training	All done and completed (n=3). Or 2 completed and already hold coaching training.	Green = 2
		At least 1 completed	Amber = 1
		None completed	Red = 0
Use of audit tool	Core	Audit Tool used and audit completed	Green = 2
		Audit Tool used but audit not completed	Amber = 1
		Audit Tool not used	Red = 0
Completion and continued use of an action plan	Core	Action plan done and used as working document throughout	Green = 2
		Action plan done, started to be used but then not implemented	Amber = 1
		Action plan not done/not used	Red = 0
Use of 10 mandatory resources provided through online platform: 3-4 year olds: Build a maze, Number hunt, Delivering the post, Mud kitchen, Cars down a ramp, Patterns,	Core	Use of 10 mandatory resources	Green = 2
		Use of at least 5 mandatory resources	Amber = 1
		Use of 4 or less mandatory resources	Red = 0

Construction, Tidy up time, Snack time, Outdoor games			
Engagement with one-to-one support provided by NDNA	Core	Setting always receptive to support from NDNA	Green = 2
		Setting sometimes receptive to support from NDNA	Amber = 1
		Setting never receptive to support from NDNA	Red = 0
Possible Total Score Core Components			**16**
Track and Monitor development of 6 children on termly basis.	Optional	All done and evidence uploaded	Green = 2
		Some done but needed support	Amber = 1
		None done	Red = 0
Monthly webinars	Optional	Attend all	Green = 2
		Attend one or more	Amber = 1
		Attend none	Red = 0
Completion by the DMC 3 courses: Developing Mathematical Confidence in the Early Years: the big ideas of number sense; Coaching as an Educational Lead Mathematical concepts in early years; Developing Mathematical thinking in the Early Years: shape space, measures and pattern – including Characteristics of Effective Learning and sustained, shared thinking.	Optional	All done and completed (n=). Or 2 completed and already hold coaching qualification.	Green = 2
		At least one completed	Amber = 1
		None done	Red = 0
Reflection and completion of case study based on outcomes of action plan	Optional	Case study submitted demonstrating impact of change as a result of the programme	Green = 2
		Case study started or planned	Amber = 1
		Case study not started or planned	Red = 0
Compliance review via online platform – note: this is the portfolio review.	Optional	Case study submitted demonstrating impact of change as a result of the programme	Green = 2
		Case study started or planned	Amber = 1
		Case study not started or planned	Red = 0
Possible Total Score Optional Components			**10**
Possible Total Score Core and Optional Components			**26**

Dosage is defined as the length of time (in weeks) a nursery setting is delivering the Maths Champions programme. In this effectiveness trial, the intended duration of programme delivery is 7 to 8 months. This will start on the day NDNA make contact with the setting to begin the Maths Champions programme and end when post-testing occurs, or when the setting expresses a desire to no longer implement the Maths Champions programme or when NDNA withdraw their support, whichever is sooner. During this active implementation period, we would expect some evidence of core and/or optional elements of the Maths Champions programme being implemented.

Two potential Complier Average Causal Effect (CACE) analyses (Dunn, Maracy and Tomenson, 2005) for the primary analysis, will be conducted and the following definitions will apply (defining compliance of the nurseries as a dichotomous variable):

- Settings engaging at least **minimally** with the programme (defined as the nursery being rated amber score of 1 or green score of 2, in at least one of the core aspects of the programme, total core component score of at least 1 out of 16), vs setting received **no intervention** at all (control nurseries plus all intervention nurseries for whom all core components of the programme were rated red, score of 0); and

- Settings who deliver the programme with **good fidelity** (defined as the nursery being rated amber score of 1 or green score of 2 in all of the core aspects of the programme (minimum score of 8 and all components scoring at least 1) vs settings who deliver **no intervention or deliver with poor fidelity** (control nurseries plus all intervention nurseries for whom at least one core component of the programme is rated red score of 0).

A CACE analysis treating compliance as a continuous outcome will also be considered and detailed in the statistical analysis plan.

Analysis

Analysis will follow the EEF's (2018) most recent guidance and will be detailed in a Statistical Analysis Plan (SAP), produced within three months of randomisation of nurseries to the effectiveness trial. A summary of the proposed analyses is presented below.

All analyses will be conducted on an intention to treat basis, using two-sided significance at the 5% statistical level. A CONSORT diagram will be produced to show the flow of settings and children through the trial.

The number of children identified as eligible for the evaluation, the number for whom parental consent was received, the number selected to take part in the evaluation, and the numbers actually tested for ASPECTS at baseline and outcome assessments will be reported with reasons for non-participation given where available. Setting, practitioner, and child-level baseline data will be summarised by arm and presented descriptively, as randomised, and as included in the primary analysis (if different). This will include considering the proportion of children who have a 'positive screen' on the ASQ-3 domain scores, defined as scoring less than two standard deviations below the mean area score. No formal comparison of the baseline data will be undertaken, except for a comparison of the difference in prior attainment (ASPECTS scores and ASQ-3 domains) between the groups, reported as the Hedge's g effect size, with a 95% confidence interval (CI).

The pairwise correlation between baseline and outcome measurements for and between ASPECTS and ASQ-3, as appropriate, will be presented. The observed ICC for ASPECTS

scores associated with setting (both baseline and outcome testing) will be presented with a 95% CI. All outcome data will be summarised descriptively by trial arm. Effect sizes based on the difference between the groups at the outcome testing will be presented as Hedges' g with 95% CI.

Numeracy attainment for children in the intervention group and those in the control group will be compared using a linear mixed model at the child-level. Group allocation, baseline ASPECT numeracy score, and setting-level minimisation factors will be included as fixed effects in the model, and setting as a random effect.

Subgroup analyses looking at gender, the average number of hours the child attends the nursery setting, eligibility for Early Years Pupil Premium, whether a child was eligible for FEE at 2 years old and whether the child was pre-identified to be tracked and monitored as part of the programme will be considered and detailed in the SAP. Gender will be explored using subgroup analysis as there are differences in maths attainment between genders during the early years, with a higher proportion of girls achieving the expected level of development in mathematics than boys (Department for Education, 2019b). We include EYPP and FEEE within the subgroup analyses as measures of deprivation. Whilst EYPP is considered a 'traditional' identifier of deprivation, uptake of EYPP is low within early years. There are believed to be two reasons for this: (1) providers lack of understanding regarding differential Local Authority defined eligibility criteria, and (2) the fact that the responsibility of making applications for EYPP rests with parents, rather than providers (Roberts, Griggs and Robb, 2017). In comparison to EYPP, FEEE at 2 years old may be a better identifier of disadvantage within early years trials. Research has shown that once aware of the scheme, parents/carers are sufficiently self-serving to approach providers for a place (Paull et al., 2017), with a 72% take-up among eligible families in 2018 (Albakri et al., 2018).

A Complier Average Causal Effect (CACE) analyses will be considered to account for compliance/engagement of the nurseries with the programme.

The language score from the ASPECTS will be analysed in the same way as the primary outcome. Responses to items in the practitioner confidence survey will be summarised descriptively by trial arm. The three subscale scores will be compared between the two arms using separate linear regression models, adjusting for the setting-level minimisation factors and highest qualification in mathematics of the respondent as fixed effects, and setting as a random effect.

Longitudinal follow-ups

The longitudinal analysis will involve accessing participating children's Early Years Foundation Stage Profile (EYFSP) data via the National Pupil Database. This longitudinal follow-up will enable us to determine if the Maths Champions programme, administered to nursery children (aged 3-4 years old), had any longer-term effects at the end of Reception (4-5 years old). To do so, this longitudinal analysis will focus on relevant EYFSP early learning goals which align to the outcomes of the effectiveness trial and the logic model. The analysis will follow the EEF's (2019b) most recent published guidance on longitudinal analysis of EEF trials. The analysis will consider mathematics, literacy, and readiness for school.

Key research questions

RQ 1. What is the impact of the Maths Champions programme, in comparison to usual early years setting provision, on the mathematical development of children at the end of reception, as measured by the mathematical early learning goal of the EYFSP?

RQ 2. What is the impact of the Maths Champions programme, in comparison to usual early years setting provision, on the literacy of children at the end of Reception, as measured by the literacy early learning goal of the EYFSP?

RQ 3. What is the impact of the Maths Champions programme, in comparison to usual early years setting provision, on children's overall development and school readiness, as measured by whether the child achieved a good level of development in the EYFSP?

Outcome measures

The EYFSP is an observational measure completed by teachers when children are in the summer term of Reception year (Standards and Testing Agency, 2018). Teachers rate each child's learning and development against 17 early learning goals using a 3-point achievement scale (1 = emerging, 2 = expected, or 3 = exceeding), according to extent to which the child has met the expected level of development. For any of the early learning goals, a score of 'A' may be reported to indicate that a child has not been assessed.

It should be noted that the EYFSP is currently undergoing revision, with the aim to use the new framework on a statutory basis from September 2021 (i.e. the year the effectiveness trial cohort will be recruited; Department for Education, 2019c). There has been a pilot of new EYFSP content (Husain et al., 2019) and the Department for Education (2019c) have recently published a consultation to seek views from stakeholders on the proposed changes. One of the proposed changes is to drop the 'exceeding' rating option (Department for Education, 2019c). This longitudinal analysis will align to the EYFSP content at the time.

Mathematics is a specific area of learning measured in the EYFSP. Currently included within this area are the following early learning goals: numbers; and shape, space and measure (Standards and Testing Agency, 2018). In the revised EYFSP, these early learning goals may change to: number; and numerical patterns (Department for Education, 2019c). The sum of the early learning goals will be taken to produce a summary score for mathematics. This will be analysed as a continuous outcome.

Literacy is another learning area measured by the EYFSP, currently consisting of the following early learning goals: reading; and writing (Standards and Testing Agency, 2018). In the revised EYFSP, these early learning goals may change to: comprehension; word reading; and writing (Department for Education, 2019c). Again, a summary score will be produced by adding together the scores for all literacy early learning goals. This will be analysed as a continuous outcome.

Additionally, as defined in the current and proposed EYFSP (Standards and Testing Agency, 2018; Department for Education, 2019c), children are defined as achieving a 'good level of development' if they achieve at least the expected level of development for the following:

- The prime areas of learning: personal, social and emotional development; physical development; and communication and language;
- The specific areas of mathematics and literacy.

‘Good level of development’ is a dichotomous variable (Yes/No) pre-calculated and provided as a single variable in the National Pupil Database.

Participants

We shall request National Pupil Database data for randomised children only, provided their parents/carers gave consent for their child’s data to be accessed.

Analyses

Analyses will be conducted on an intention-to-treat basis, using two-sided significance at the 5% level. Outcome data will be summarised descriptively for the two groups. We will consider the correlations between EYFSP and measures collected as part of the main phase of the trial (ASPECTS and ASQ-3). The primary outcome for this longitudinal analysis is the summary mathematics EYFSP score (RQ 1). This will be analysed via a multilevel mixed-effect linear regression model at the child level. Group allocation, baseline Core Mathematics Standard Score and the minimisation factor of number of children with parent/carer agreement to participate within the setting (in its continuous form as included in the analyses performed for the effectiveness trial) will be included as fixed effects in the model. Setting will be included as a random effect.

The secondary outcome of summary score for literacy will be similarly analysed (RQ 2). Effect sizes based on the difference between the groups at the outcome testing post-intervention will be presented as Hedges’ g with 95% confidence intervals (CI). The intra-cluster correlation coefficient (ICC) at outcome testing will be presented. The Pearson correlation coefficient between baseline Core Maths/Literacy Standard Score and these two EYFSP summary scores will be reported.

The secondary, dichotomous outcome of good level of development will be analysed via a mixed-effect logistic regression model, adjusted as for the primary model specified above (RQ 3). The treatment effect expressed as an odds ratio will be reported with a 95% CI and p-value.

In line with the effectiveness trial analyses, subgroup analyses will consider children that were eligible for the Early Years Pupil Premium, FEEE at 2 years old and gender. This will only be undertaken for the primary outcome of mathematics.

Effectiveness trial Implementation and process evaluation

Research questions

The purpose of the IPE is to address the following questions:

RQ 1: Is the Maths Champion (MC) programme delivered to MCs and DMCs with fidelity within both PVI and school nursery settings?

1.1. Are nominated staff (MCs, DMCs) accessing the available E-learning modules and the support as specified in the programme plan?
1.2. How effective and appropriate are the level of support and training (e.g. content, coverage, dosage and duration) for MCs and DMCs?
1.3. What are the barriers for MCs and DMCs to engage with the E-learning modules?
1.4. What are the necessary conditions (facilitators) for MCs and DMCs to engage with the E-learning module and the one to one support?

RQ 2: To what extent is the MC programme implemented as planned within nursery settings?

2.1. Do MCs and DMCs adhere to their roles as specified in the programme?
2.2. Do nursery practitioners implement the agreed action plans in their daily practice?
2.3. What are the barriers for MCs, DMCs and practitioners to implement MC in their classroom practice?
2.4. What are the necessary conditions for nursery practitioners to implement MC into practice?

RQ 3: What are the different stakeholders' viewpoints on the MC programme?

3.1. What are the perceived impacts of MC programme on nursery practitioners' classroom practice in general?
3.2. What are the perceived impacts of MC programme on nursery practitioners' math-related classroom practice?
3.3. What are the observed impacts on children's maths attainment?
3.4. How can the MC programme be improved?
3.5. What are the observed impacts of MC programme on nursery practitioners' math-related classroom practice?

RQ 4: To what extent does the MC programme impact evaluation process adhere to the plan?

4.1. Do nursery MCs and DMCs meet the specified recruitment criteria for the MC programme?
4.2. Does children and family recruitment process adhere to the recruitment strategy?
4.3. Do baseline and outcome test administrators (teachers or independent research assistants) effectively and appropriately evaluate children's maths attainment?
4.4. Any there any sample attrition effects and how that might affect the estimates of the impact of MC programme?

RQ.5: **What is 'usual practice' in all settings?**

RQ 6: What maths-related professional development (PD) opportunities do staff have in control group settings?

6.1. What are the perceived impacts of these maths-related PD opportunities on nursery staff's maths-related classroom practice?
6.2. What are the perceived impacts of these maths-related PD opportunities on children's maths attainment?
6.3. What other maths-related PD opportunities are nursery staff looking for?

We anticipate that the research questions, design and methods for the effectiveness trial IPE may be refined following the completion of the pilot IPE. Any changes made to the effectiveness trial IPE following completion of the pilot IPE will be fully documented, with reasons and any impact on overall results.

RQ 7: What is the perceived impact of COVID-19 pandemic on the delivery of the MC programme?

Research design, methods of data collection and analysis

The effectiveness trial IPE has been designed to ensure adherence to the key principles for the design, conduct and reporting of IPEs. The effectiveness trial will address the descriptive and experiential aspects of the effectiveness trial research questions. The research design and methods of data collection and analysis will be finalised following the results of the pilot IPE. Results from the pilot IPE will be summarised in an internal report in August/September 2020, which will be included in the final reported when published. The effectiveness trial IPE will complement the quantified outcomes for the effectiveness trial impact evaluation and will be both cross-sectional and longitudinal in design. It will explore the perceptions and experiences of key stakeholders towards the end of the effectiveness trial study period to provide snapshot descriptive data on perceptions about: barriers and facilitators to MC programme implementation and delivery; and adherence to the evaluation protocol. The impact evaluation and IPE are fully integrated. Measures of compliance, fidelity and usual practice have been included in the impact evaluation, and these data will be complemented by effectiveness trial IPE data which will explain reasons underpinning levels of compliance and levels of fidelity within the context of usual practice.

Data collection will comprise surveys with all MCs and DMCs (via the usual practice survey) and a series of interviews or focus groups with all key stakeholders: MCs, DMCs and NDNA staff. The usual practice surveys will be used to establish baseline and post-intervention practices within settings and to monitor settings to determine longitudinally whether any changes to the planned practice were made in the control settings over the course of the trial.

At least 11 (nursery settings (9 PVI; 2 SN) will form the sample for the effectiveness trial IPE interviews (unless saturation is reached with a lower sample size, i.e. unless emerging patterns in the data no longer include new insights). The sample will be a combination of randomly sampled intervention settings to provide the full range of delivery and settings selected by NDNA to provide examples of ‘best practice’ (i.e. settings which have engaged particularly well with the programme).

For the full sample, some interviews will be conducted during implementation (e.g. to gauge perceptions on the training) and some will be conducted towards the end of the effectiveness trial, after implementation. The effectiveness trial IPE will also provide longitudinal quantified data on the access to e-learning modules over the period of the effectiveness trial. It will link the perceptions of the key stakeholders to key process outcomes of the logic model to provide evidence of promise.

All data collection for the IPE will follow best practice ethical guidelines in terms of fully informed consent to participate.

The Early Childhood Environment Rates Scales-III (ECERS-3) and the ECERS-E which has a specific focus on maths quality provision will be collected, at baseline (October 2021, after randomisation) and at outcome testing (June/July 2022) within four intervention settings. These ECERS data will be collected by external providers, A+ Education Ltd, who will also provide settings with ECERS feedback following the outcome period in June 2022. These ECERS data will be descriptively incorporated within the IPE to provide insight and clarity to the results of the impact evaluation, and the impact, if any, of the Maths Champions programme on the quality of maths provision within settings.

Please see Table 7 for information linking design and data collection processes to research questions and to the logic model.

Table 7: IPE design and methods of data collection and analysis overview

Research methods	Data collection methods	Participants/data sources (type, number)	Data analysis methods	Research questions addressed	Implementation / logic model relevance
Cross-sectional design	Semi-structured Interview/focus group	NDNA staff (n=2)	Combination of inductive and deductive analysis with analyses grouped thematically according to RQs	RQ 1: 1.1; RQ 3: 3.4; RQ 4: 4.1; RQ 7	Fidelity; Context
Cross-sectional design	Semi-structured Interview/focus group	MCs (PVI n=9; SN n=2)		RQ 1: 1.2, 1.3, 1.4; RQ 2: 2.1, 2.2, 2.3, 2.4; RQ 3: 3.1, 3.2, 3.4; RQ 7	Fidelity; Process outcomes (confidence and competence)
Cross-sectional design	Semi-structured Interview/focus group	DMCs (PVI n=9; SN n=2)		RQ 1: 1.2, 1.3, 1.4; RQ 2: 2.1, 2.2, 2.3, 2.4; RQ 3: 3.1, 3.2, 3.4; RQ 7	Fidelity; Process outcomes (confidence and competence)
Cross-sectional design	Semi-structured Interview/focus group	Other practitioners (PVI n=9; SN n=2)		RQ 2: 2.2, 2.3, 2.4; RQ 3: 3.1, 3.2, 3.3, 3.4; RQ 7	Fidelity; Process outcomes (confidence and competence)
Longitudinal design	Log data of E-learning module attendance	MCs and DMCs (PVI n=9; SN n=2)	frequency counts; regression	RQ 1: 1.1	Compliance; Context
Longitudinal design	Setting practice observation (ECERS-3 & ECERS-E)	PVI n=9; SN n=2	Descriptive analysis;	RQ 3: 3.5	Context; Outcomes
Longitudinal design	Baseline and endpoint setting usual practice surveys	All control and intervention settings	Frequency. Counts; Descriptive/thematic analysis	RQ.5; 6; 7	Context

Data collection

Data collection will use a combination of semi-structured interviews or focus groups (telephone/Zoom/TEAMS and face-to-face), e-learning logs data and on-line and paper surveys. All data collection tools will be pre-specified and registered with the Ethics Committee providing ethical approval, thus ensuring transparency of the methods.

Analysis

IPE data will be analysed using a combination of inductive and deductive analyses. Emerging patterns in the data will be grouped thematically according to the research questions. Results will be synthesised from the themes and presented as answers to each IPE research question.

Cost evaluation

The cost analyses will follow the 'ingredients method' (Levin et al., 2017) to account for the costs of the implementing the Maths Champions programme at *all* stages. Cost data will be collected from relevant staff members by the evaluation team at different time-points throughout the trial via cost-specific surveys and during planned IPE interviews. MCs and DMCs will be requested to complete two, short, cost-specific online surveys (during December 2021/January 2022) and February/March 2022. Cost-specific questions will also be included within the end-point survey for intervention settings. A summary of the content of these surveys is provided below:

- December 2021/January 2022 – this survey will capture the amount of time (staff working hours) spent completing the relevant **training components** of the programme (e.g. the online induction, 3 x2 hour e-learning training modules and development of setting-specific action plan), any start-up, pre-requites costs (e.g. computer or internet connectivity), unexpected or hidden costs associated with training.

- February/March 2022 **and** June 2022 – these surveys will capture the amount of time (staff working hours) involved in continuing to deliver the programme (e.g. the time spent attending monthly online webinars, planning to implement core resources into practices, monitoring pupil progress and reviewing setting action plans, participating in 1-2-1 support from NDNA), any recurring implementation costs (e.g. materials, print outs, resources), unexpected or hidden costs.

A random sample of 20% of PVI settings and 20% of SN settings managers/head teachers will be requested to provide the full hourly cost (including wages, national insurance payments, benefits, cost of recruiting new teachers, among others) for each relevant staff member e.g. MC and DMC. This will allow us to capture the approximate costs of delivering the programme among staff at different levels of seniority (e.g. Level 3 practitioner vs. graduate practitioner). Setting managers/head teachers will also be requested to indicate the cost of staff cover, if applicable.

The total cost per school for a programme as implemented over three consecutive years, and the cost per-pupil-per-school-years will be presented. Sensitivity analyses will account for differences in costs of running the programme, e.g. PVI versus maintained and SN settings; MC being a graduate versus Level 3.

Ethics and registration

- Ethics approval has been granted from the University of York, Health Sciences Research Governance Committee on 29th November 2019
- School of Education Ethics Committee at Durham University will be informed of the study.
- NHS ethical approval will be sought for seeking access to children's ASQ-3 data only.
- A Memorandum of Understanding signed by nursery settings will cover the requirements of the project.
- Data Sharing Agreements will be put in place between the University of York and participating nurseries.
- Participating nurseries will also be required to sign an agreement with Centre for Evaluation and Monitoring (CEM) at Cambridge Assessment to cover the use of the ASPECTS software.
- An ISRCTN Registration Number will be applied for.

Trial monitoring

Trial Management Group

The evaluation team will form a Trial Management Group, the decision making body who will be responsible for the day-to-day running and management of the trial. Led by the joint principal investigators (Robinson-Smith and Ainsworth) at YTU and the principal investigator at Durham University (previously C. Torgerson, from Oct 2020 V. Menzies), it consists of all members of the evaluation team. The Trial Management Group will meet on a regular basis. Regular meetings will be held with the delivery team and representatives from the EEF as appropriate.

Trial management

The trial will be sponsored by the University of York. The day-to-day management of the trial will be co-ordinated through YTU. YTU Standard Operating Procedures (SOPs) will be followed where applicable and the research team will be trained as appropriate. The University of York, for YTU, will obtain and hold public liability insurance cover for legal liabilities arising from the trial.

Child safeguarding

In the very rare circumstance that a child safeguarding issue is suspected, for example during data collection a set procedure will be followed which will include contacting the trial principal investigators (Robinson-Smith and Ainsworth). The child nursery setting and parents/carers will be informed accordingly and the nursery setting's usual safeguarding policy will be followed.

Complaints

Nurseries and parents/carers will be provided with the principal investigator's contact details, should they wish to make a complaint about the conduct of the trial. Complaints will be dealt with by the principal investigators and the Trial Management Group will be informed.

Declaration of interests

The principal investigators (Robinson-Smith and Ainsworth) declare no competing interests.

Access to data

The final anonymised trial dataset will be available to all trial team members/investigators if a formal request describing their plans is approved by the Trial Management Group. To ensure confidentiality, data dispersed to trial team members will be blinded of any identifying participant information.

Appropriate datasets will be provided to the EEF data archive manager and the Office for National Statistics for archiving and long-term follow up purposes.

Publication and dissemination policy

The results of this trial will be submitted in a final report to the EEF, who will publish the report on their website. Articles for educational journals may be written and presentations given at relevant conferences.

Data protection

The University of York will be the Data Controller who also processes data. Data subjects are the participants in the evaluation, which includes children in participating nurseries and staff members in participating nurseries.

Personal data will be processed under Article 6 (1) (e) (*Processing necessary for the performance of a task carried out in the public interest*) and Special Category data under Article 9 (2) (j) (*Processing necessary for ... scientific ... research purposes)* of the General Data Protection Regulation (GDPR; 2018).

All participant data will be treated with the strictest confidence and will be stored in accordance with the GDPR. Identifiable information about participants will be shared by the evaluation team, with the Department for Education, the EEF's archive manager and, in an anonymised form, with the Office for National Statistics and potentially other research teams. Matching to the National Pupil Database and other administrative data may take place during this and subsequent research. There will be no international data transfers outside of the EU.

Parents/carers will be informed about the research though an information sheet sent on behalf of the evaluation team by nurseries to parents/carers. Parents/carers will be asked to return a signed consent form if they are willing for their child to be included in the evaluation.

For the purposes of the research, the following details about participating children will be collected from participating nurseries, parents/carers and the National Pupil Database: child full name, date of birth, gender, home postcode, Early Years Pupil Premium status, FEEE from 2 years of age, attendance at nursery per week, ASQ-3 and ASPECTS assessment data, EYFSP data, child's school destination, as well as new setting destination should children leave participating nurseries before outcome testing.

Nurseries will transfer personal data directly to YTU on an encrypted spreadsheet of participant details, via the University of York's secure file transfer service (DropOff).

A unique trial identification number (Trial ID) will be generated for each participant when their details are entered into the trial management system. ASPECTS data is collected and stored

online via CEM's (Cambridge Assessment) servers. YTU will have access to setting's ASPECTS accounts so that assessment data can be downloaded and stored securely. In order to provide the ASPECTS assessment, CEM will collect child name, date of birth, gender, year group, and class.

The trial management systems and trial data will be held on secure University of York servers with access limited to specified members of YTU staff. The dataset for statistical analysis will hold anonymised data. No nurseries, staff members, or children will be identifiable in the report or dissemination of any results.

Electronic data and paper documents including identifiable personal child data will be securely archived and disposed of by YTU 5 years after the end of the study (2028). Identifiable personal data about adult data subjects (e.g. nursery staff) will be kept for 5 years after the end of the study (2028). Anonymised electronic data and paper documents will be kept indefinitely.

Data sharing agreements will also be put in place with participating nurseries before data transfer.

The University of York's data protection policy is publicly available at: https://www.york.ac.uk/records-management/dp/

Personnel

Evaluation team

Dr Lyn Robinson-Smith, York Trials Unit, University of York

Lyn Robinson-Smith is a research fellow (trial manager) with experience of leading and delivering large trials, particularly in the early years. She is the joint principal investigator and will be responsible for the oversight of the trial. Lyn will also be responsible for providing training for the baseline and outcome testing.

Hannah Ainsworth, York Trials Unit, University of York

Hannah Ainsworth is an experienced education and health care trial manager. She is the joint principal investigator and will be responsible for the oversight of the trial.

Professor Carole Torgerson, Department for Education, University of York

Professor Carole Torgerson is an expert in RCT design and conduct and has been the principal investigator or a co-investigator on over 25 RCTs. Carole was Principal Investigator at Durham University until October 2020, before moving to University of York. She will contribute to the overall design and conduct of the impact evaluation and will lead the IPE

Professor David Torgerson, York Trials Unit, University of York

Professor David Torgerson is the director of York Trials Unit and has worked on numerous RCTs, including many in education and the social sciences. He will support the design and conduct of the trial.

Professor Catherine Hewitt, York Trials Unit, University of York

Professor Catherine Hewitt is a senior trial statistician and deputy director of York Trials Unit, with experience working on numerous RCTs including educational trials. She will provide input into the statistical analysis.

Louise Elliott, York Trials Unit, University of York

Louise Elliott has worked on a large number of EEF trials and has been involved in trial coordination, data management and coordinating testing. She will be responsible for the data management aspect and testing on the trial.

Caroline Fairhurst, York Trials Unit, University of York

Caroline Fairhurst is a senior statistician, currently supporting a number of trials, including several EEF-funded trials, within York Trials Unit. She will oversee and undertake the statistical analysis and take responsibility for archiving data with the FFT.

Kalpita Joshi, York Trials Unit, University of York

Kalipta Joshi is a trainee statistician, currently supporting a number of trials, within York Trials Unit. She will undertake the statistical analysis.

Dr Katie Whiteside, York Trials Unit, University of York

Katie Whiteside has worked on a number of RCTs evaluating education and health care interventions. Katie will act as a trial coordinator for the evaluation and will contribute to writing the final report.

Dr Xiaofei Qi, Durham University

Dr Xiaofei Qi is an assistant professor at Durham University and an associate of the Cambridge Psychometrics Centre. Her substantive area is early years and she will provide expertise in assessment and will conduct elements of the IPE.

Vic Menzies, Durham University

Vic Menzies is an experienced education trial coordinator and researcher with a particular focus on maths development and learning. She will contribute expertise to the design and conduct of the evaluation, particularly the IPE. Vic will be Principal Investigator at Durham University from October 2020.

Delivery team

Stella Ziolkowski, National Day Nurseries Association

Stella Ziolkowski is Director of Quality and Training at NDNA. She has overarching contract responsibility for the delivery of outcomes and milestones, reporting to EEF, final approval of deliverables, processes and procedures in relation to the trial.

Sue Gifford, Roehampton University

Sue Gifford is a Specialist Maths Adviser and will provide mathematical advice for programme content.

Paula Dunn, National Day Nurseries Association

Paul Dunn is the Maths Champions lead and is responsible for providing settings with their induction to the programme and continued one-to-one support for Champions.

Freya Roper, National Day Nurseries Association

Freya Roper is a Project Manager with contract management responsibility for the day to day delivery of the trial, including milestones tracking, the recruitment process and financial monitoring.

Kathryn Moses, National Day Nursery Association

Kathryn Moses is a Project Officer and will assist with programme coordinating and recruitment, record keeping and tracking mandatory outcomes for delivery.

Fiona Bland, National Day Nurseries Association

Fiona Bland is an Early Years Advisor who will be the Maths Champions support adviser within the trial and will cover for staff absences.

Risks

Table 8: Risks

Risk	Detail/Preventative measure	Likelihood
Insufficient settings recruited	• The evaluation team will work closely with the delivery team to support recruitment. • Long period of effectiveness trial recruitment. • Recruiting PVI, and SN settings. • No requirement for nurseries to have a graduate. • Financial recruitment incentives provided to participating settings (£250 after parent/carer recruitment but before pre-testing and £250 after outcome testing).	Medium
Insufficient children recruited	• Request settings to provide the total number of children who are eligible to participate and distribute information packs to parents/carers of all eligible children (rather than self-selecting parents/carers to approach). • Provide guidance and support to nominated nursery staff so that they feel confident speaking to parent/carers about the trial. • Provide parents/carers with transparent information about the trial/Maths Champions programme and assure parents/carers of confidentiality of data and their own and their child's anonymity in trial reports (via user-friendly information sheets). • The first setting incentive payment (£250 after parent/carer recruitment) should allow nursery staff time to be freed up to support parent/carer recruitment. • Evaluate parent/carer recruitment strategies in the pilot to inform the effectiveness trial.	Medium
Missing baseline data	• Baseline measures selected to involve minimal burden on settings. • Some nurseries (particularly PVI) may experience barriers to baseline data collection using ASPECTS, such as insufficient staff resource or lack of technology (e.g. laptops/computers, access to Wi-Fi). In these circumstances, laptops could be couriered to settings to use or the evaluation team will arrange for a research assistant to visit the setting to collect the data, if possible. • The first setting incentive payment (£250 before pre-testing) should allow staff time to be freed up for baseline assessments. • Setting characteristics, current practices survey, participating child details, and completion of child	Medium

Risk	Detail/Preventative measure	Likelihood
	baseline assessments will be required as a condition to be randomised.	
Independent research assistants unable to complete baseline assessments in settings due to COVID-19	• The baseline and outcome child assessment measure (ASPECTS) is computer based and suitable for settings to complete themselves. • It is planned that all PVI settings will complete baseline assessments themselves and training materials are in place for this. • All SN settings will be given the option of completing baseline themselves and this may be necessary if sending research assistants is not possible. Provide financial incentive to any setting struggling to complete baseline ASPECTS, the incentive could be used to pay for additional staff to complete this part of the evaluation. This would be negotiated with EEF.	High
Unable to complete in person semi-structured interviews/ focus groups due to COVID-19 pandemic	• Offer zoom/TEAMS interviews/focus groups to minimise burden and maximise convenience in data collection for pilot and, if necessary, main phase data collection. •	High
Tight timeline for setting randomisation	• Due to the tight timeline between baseline assessments and randomisation needing to take place, randomisation will take place in batches (of settings who have completed baseline assessments), to adhere as close as possible to the timeline.	Medium
MC Programme unable to be delivered as intended due to COVID-19	• NDNA may need to adapt Maths Champions programme to enable delivery if COVID-19 restrictions continue.	Medium
Short staffing at settings due to COVID-19 / setting staff turnover	• Recruitment in PVI settings, and SN settings where possible, will start in the summer term 2021 to relieve the pressure of recruitment in September 2022. • For intervention settings, in the event that the trained MC leaves the setting during the trial, or takes a leave of absence, the DMC may take over the MC role to prevent the disengagement from the programme. Alternatively, another nursery practitioner may be trained to replace the MC, with support from the DMC. The delivery team will provide support and training, as appropriate, to the new MC or DMC. The role DMC may be replaced should the existing DMC take over the MC role. • Having a MC and DMC (i.e. two practitioners trained in the programme) at each intervention setting should	High

Risk	Detail/Preventative measure	Likelihood
	help to mitigate the impact of staff absences on programme delivery, compared to just having a MC. • Evaluate in the pilot IPE (e.g. in setting interviews) how the research team can alleviate pressure on settings due to short staffing in terms of programme delivery and evaluation activities.	
High attrition among settings (not due to COVID-19)	• The randomised controlled trial model will be explained to settings during effectiveness trial requirement. • The value of control nurseries will be explained in initial discussions and during data collection points. • Aim to over recruit in the effectiveness trial to allow for some attrition. • Delivery team and evaluation team to develop good relationship with settings through regular contact. • EEF prepare a letter to setting managers to encourage them to remain in the trial, in the event of withdrawal requests.	Low
Complete setting closures due to COVID-19	• Aim to over recruit in the effectiveness trial to allow for some attrition.	Medium
Missing outcome data / high attrition among children	• The second setting incentive payment (£250) will be paid after the completion of outcome data collection. • Mop-up research assistant visits will be arranged, if possible, to collect data from children who were absent during first assessment visit. • Request parent/carers in the information sheet and consent form to agree for the evaluation team to request new setting details from the child's nursery/parents/carers, should they move nurseries prior to outcome testing. New settings will receive a £100 incentive to allow outcome testing. The feasibility of this approach will be explored in the pilot study.	High
Cross-over	• Children may move from an intervention setting to a control setting or vice versa. Children's data will be analysed as per the original assignment (ITT) and cross-over considered within a CACE analysis.	Low

Timeline

Table 9: Timeline

Date	Activity	Staff responsible/ leading
12th Jul 2019	Set Up Meeting 1	EEF, ET, DT
2nd Sep 2019	Set Up Meeting 2	EEF, ET, DT
10th Oct 2019	IDEAs Workshop	ET, DT
Sep - Nov 2019	Protocol development	ET
Nov 2019	Ethics application for pilot study	ET
Dec 2019 - Jan 2020	Ethics application for effectiveness trial	ET
Pilot Study		
Nov - Dec 2019	Recruit nurseries	DT (support from ET)
Jan 2020	Recruit parent/carers	ET
Jan - Feb 2020	Pilot baseline assessments with children; nursery setting usual practice survey	ET
Feb 2020	Pilot nurseries commence MC programme (support and resources provided for 12 months)	DT
Mar 2020	Pilot study programme delivery and evaluation activities with settings paused due to COVID-19	-
Apr 2020	IPE interviews (with NDNA only)	ET
Activity suspended due to COVID-19	Pilot outcome assessments with cohort 1 children; practitioner confidence and beliefs survey	ET
Sept 2020	Submission of pilot study interim report.	ET
Oct – Nov 2020	Restart delivery of MC programme to pilot settings (support and resources provided for 12 months)	DT
Oct - Nov 2020	Collect current setting destination for cohort 2 children	ET
Jan - Feb 2021	IPE interviews with settings and DT	ET
Feb 2021	Outcome assessments with cohort 2 children (COVID-19 dependant)	ET
Jun - Jul 2021	IPE end-point setting/staff surveys	ET

Effectiveness trial		
Jan - May 2021	Recruit settings	DT (support from ET)
Jan – May 2021	Ethics Application for NHS REC for access to ASQ3 data in NHS digital.	
June - Sep 2021	Recruit parent/carers; schedule baseline assessments; baseline assessment training	ET
2nd Sep 2021	Autumn term begins	-
Sep - Oct 2021	Baseline assessments with children; nursery setting usual practice survey	ET
Early Oct 2021	Batch randomisation begins	ET
Early Oct 2021	ECERS baseline within identified IPE intervention settings	A+ Education Ltd (ECERS only, external providers)
25th-29th Oct 2021	School half-term	-
Mid Oct 2021 - Jun 2022	Delivery of MC programme (support and resources provided for 7-8 months)	DT
Jan 2022	Complete SAP	ET
Sep 2021 - Aug 2022	IPE interviews	ET
Jan 2022-May 2020	Application to NHS digital for ASQ3 data	ET
Jun - Jul 2022	Outcome assessments with children (including conducting outcome assessments with a sub-sample of children who have moved to new settings); practitioner confidence and beliefs survey; ECERS post-intervention within identified IPE intervention settings	ET and A+ Education Ltd (ECERS only, external providers)
23rd Jul - 31st Aug 2022	School summer holidays	-

Aug 2022	IPE DT interview	ET
Sep - Dec 2022	Confirmation of 'school destination of children' collected via settings/parents/carers to enable matching to National Pupil Database.	ET
Sep - Oct 2022	Data analysis and report writing	ET
Nov 2022	Submit impact and IPE draft report for pilot and effectiveness trial	ET
April 2023	Submission of final edited EEF Report, submission of data to the EEF data archive and updating the ISRCTN trial registry with results. Submission of interim statement of spend to date.	ET
Long term follow up		
Nov 2023	Submission of National Pupil Database request for Early Years Foundation Stage Profile data (completed at the end of Reception)	ET
Nov 2023 - Jan 2024	Report addendum analysis and writing	ET
Feb 2024	Submit addendum long-term follow up	ET
April 2024	Submission of long-term data to EEF archive and updating of ISRCTN trial registry with results. Submission of final statement of spend to EEF.	ET

EEF = Education Endowment Foundation; ET = Evaluation Team; DT = Delivery Team; ECERS = Early Childhood Environment Rating Scale

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Appendix A: Effectiveness Trial Diagram