Signs of potential: Affordable Maths Tuition

Intervention Developer	**Third Space Learning**
Delivery Organisations	Third Space Learning
Evaluator	NatCen Social Research
Principal Investigator	Julia Griggs and Robert Wishart
Protocol Author(s)	Robert Wishart, Kostas Papaioannou, Adam Gilbert, Julia Griggs
Type of Trial	Multi-site randomised controlled trial
Age or Status of Participants	Pupils who have had a social worker now or in the last six years, aged 10-11
Number of Participating Local Authorities	53
Number of Children	855 children (425 intervention, 430 control)
Primary Outcome(s)	KS2 Maths attainment [KS2_MATMRK]
Secondary Outcome(s)	Maths anxiety [mAMAS]
Contextual Factors	Covid-19

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Background and Problem Statement

Problem

Children who have had a social worker, either because they are or have been looked after, or because they have been identified as a Child in Need (CIN), have significantly lower attainment than their peers. It is therefore crucial to identify effective interventions that close the attainment gap in primary education to stop these pupils falling behind.

Just over half (51%) of Looked After Children (LAC) and CIN (48%) achieve the expected standard in maths at KS2, compared with four-fifths (79%) of non-looked after children (DfE, 2020). They also make less progress than their peers as they grow up (with average Progress 8 scores of -1.23 for LAC and -1.49 for CIN respectively, compared to -0.07 for non-looked after children) resulting in a wider attainment gap at KS4.

Theory of change - benefits of tuition

Previous research has indicated that one-to-one tuition can significantly improve academic attainment and act as a powerful educational tool.The Education Endowment Foundation (EEF) reports that one-to-one tuition can be highly effective, delivering, on average, five additional months' progress (EEF, 2020).

Theory of change - challenges of tuition as a tool close the attainment gap

However, one-to-one tuition is typically expensive and therefore not a realistic prospect for many pupils. In particular, disadvantaged pupils whose families have lower incomes are less likely to be able to access this form of tuition. This may in turn lead to disadvantaged pupils making less progress with their education compared to non-disadvantaged pupils for whom one-to-one tuition is more likely to be a possibility if needed. Over time, this can therefore lead to a widening of the attainment gap for disadvantaged pupils.

The cost and supply of tutors also makes tuition very hard for schools to use effectively. Research and best practice suggests that tuition should be directed by teachers to reinforce class teaching strategies to ensure the greatest academic benefit for each tutored pupil. Achieving this effectively across multiple students can add to the already high workload of teachers.

What is AMT?

The aim of the Affordable Maths Tuition (AMT) programme is to reduce the maths attainment gap for disadvantaged pupils, by recruiting and training specialist maths tutor in India and Sri Lanka to make online one-to-one tuition more affordable and accessible to children in English state schools. Importantly, the programme is specifically designed to make it easy and accurate for teachers to use online tuition within the school timetable to support their class teaching strategies.

The programme is delivered by Third Space Learning, which has provided tailored online maths tuition to over 60,000 pupils from over 2,000 schools since 2013. 55% of their pupils are eligible for Free School Meals.

Basis for study

An efficacy trial conducted for the EEF in 2014/15 concluded that pupils made no additional progress relative to their peers after 27 weeks tuition (Torgerson et al., 2016).

However, qualitative analysis highlighted that the majority of schools pointed to 'good or excellent progress' amongst pupils in the trial. Furthermore, re-analysis by What Works for Children's Social Care (WWCSC) found that, on average, pupils who have had a social worker who received AMT made three additional months progress relative to those who did not receive AMT (Sanders et al., 2020). The original study was not powered to detect an effect on this sub-group, making the analysis exploratory.

This evaluation aims to explore if scaling-up AMT is effective in improving maths attainment for children who have had a social worker.

How does AMT work?

The AMT programme aims to overcome the barriers to schools accessing one-to-one tuition, helping them to target the academic and social need that underpins the maths attainment gap in a format that is teacher-led; using one-to-one lessons to target learning gaps as they arise in class and thus reinforce class teaching strategies.

The one-to-one tuition takes place exclusively online. Online tuition lessons are scheduled within the school timetable with pupils accessing the online tuition at school, though most often not during maths lessons.[1]

Teachers are able to select the topic for each tutoring session, either manually or by selecting a curriculum strand for an online diagnostic assessment that the pupil sits at the beginning of the programme. The results of this assessment are then used to develop a personalised lesson plan for that pupil that the teacher is able to track. AMT has developed an online curriculum of over 400 lesson plans, covering mathematical content across KS1 and KS2, helping to ensure quality, structure and transparency for all tutoring lessons.

Pupils are provided with a headset along with a microphone to enable them to talk with their tutor within a secure virtual classroom. Both tutor and pupil also have access to a shared virtual whiteboard, which includes tools that enable the pupil to engage with the lesson's material, e.g. to answer questions or annotate content.

All AMT tutors are STEM graduates based in Sri Lanka and India who have been recruited and trained by Third Space Learning's Academic Centres in the region, to provide online tuition to pupils who live in the UK. Each tutor completes police and background checks, and undergoes a full-time three week training programme, supplemented by weekly development from a dedicated academic team manager. Every session is recorded for performance and safeguarding purposes.

Pupils receive one weekly 45-minute tutoring lesson. Each pupil is allocated to one tutor with all tutoring lessons taking place with this tutor. Lessons also take place at the same time each week for each pupil.

Schools each have their own online account with Third Space Learning, with teachers being given their own academic profile. Through this profile, the teacher can engage with the tutor and select the content of the pupil's lesson for the following week.

[1] For some pupils, the online tuition lessons can be accessed after school upon agreement with their tutors.

Furthermore, following each session, the online tutor provides session feedback to the pupil's teacher, allowing them to incorporate the feedback in their own teaching of the pupil and to guide them in selecting the following week's tailored session content.

Trial dosage and pandemic context

The trial was launched in July 2020, in the midst of unprecedented disruption to schools from the pandemic lockdown.

There is now a serious risk of the attainment gap further widening, thus reinforcing the need to trial new methods of closing the attainment gap, and hence our desire to persevere with the trial.

However, it is worth noting the material impact lockdown and school closure has had on the design and scope of the trial.

- The target for recruitment was 2,400 pupils (1,200 intervention; 1,200 control), but only 855 were recruited (425 intervention; 430 control).
- Dosage was intended to be 28 sessions, but most pupils are likely to receive less than 16.
- The timing of the trial and the impact of lockdown for schools in both summer term and the start of Autumn resulted in significant disruption to the normal on-boarding of pupils. This impacted on the attendance and experience of pupil's initial assessment and first sessions.
- The control group is likely to suffer from contamination due to the higher instance of tuition and other catch up investment across the wider pupil body, compared to "business-as-usual" in a typical academic year.

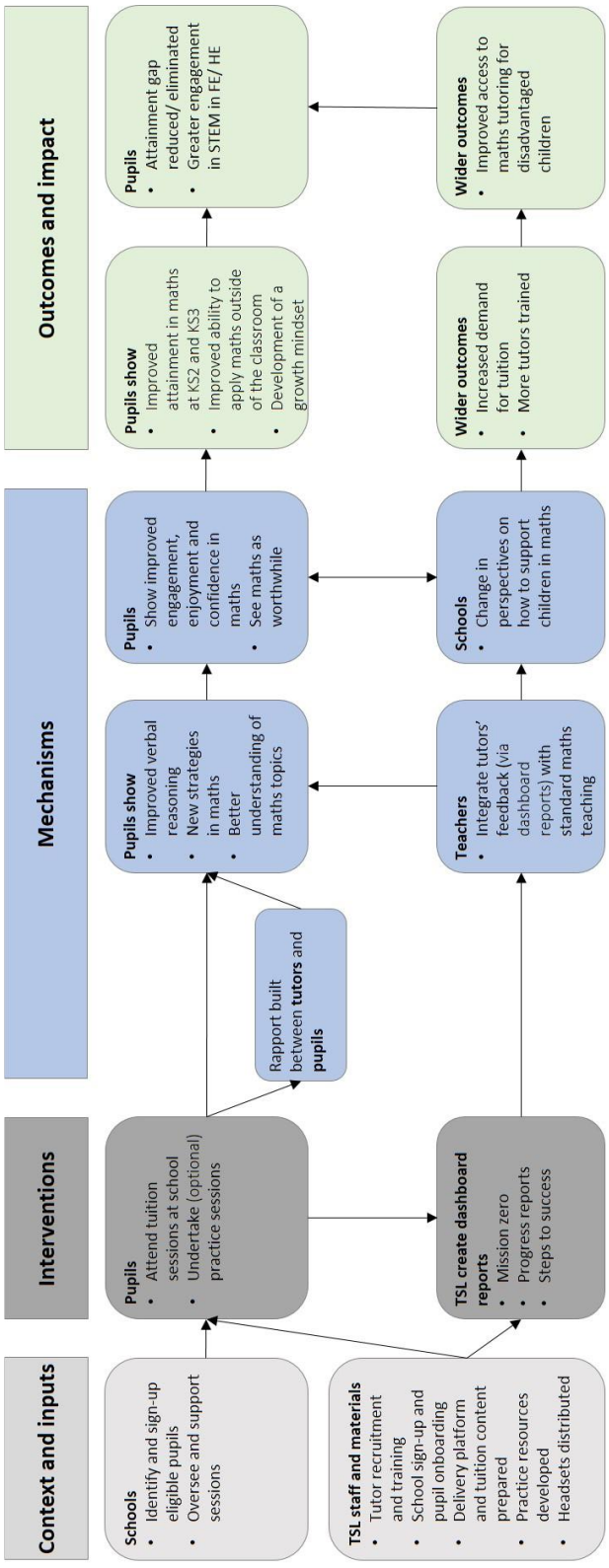
Our expectations are that this will reduce the impact of the intervention, and the measurement of progress versus the control group.

What Works for Children's Social Care

Trial Evaluation Protocol
Signs of potential: Affordable Maths Tuition

Evaluator: NatCen Social Research
Principal investigators: Julia Griggs and Robert Wishart

Logic model



Impact Evaluation

Research questions

Primary research question

- RQ1. What is the impact of *Affordable Maths Tuition* on children who have had a social worker on Key Stage 2 maths attainment?

Secondary research question

- RQ2. What is the impact of *Affordable Maths Tuition* on children who have had a social worker on maths anxiety in mathematical tasks?

Design

The evaluation is a two-armed randomised controlled trial with 855 pupils (in 235 schools and 53 Local Authorities). Participants will be assigned to receive AMT (intervention) or business as usual (control).

Following WWCSC statistical guidance, randomisation should be preferred at the lowest level possible for a given intervention. Thus, randomisation will occur at the child level, with children allocated to the intervention or to a 'business-as-usual' control group. To account for any differences between areas, stratification will occur at the level of Local Authority. School level stratification is impractical as we anticipate primary schools may have as few as one eligible pupil for the evaluation. LA stratification will ensure that there are roughly equal numbers of children within each Local Area in control and intervention groups. This method of evaluation will also enable the comparison of smaller effect sizes compared to what would be possible if randomisation were to occur at the school level.

The primary outcome will be Key Stage 2 maths attainment. Maths attainment at the end of intervention will be assessed using pupils' marks in KS2 maths as recorded in the National Pupil Database (NPD). The evaluation will also incorporate Key Stage 1 maths attainment as a baseline measure of maths attainment. Attainment will be assessed for all participating pupils.

The evaluation will also explore changes to pupils' confidence/anxiety in their own mathematical ability. This will be assessed using the Modified Abbreviated Maths Anxiety Scale (mAMAs). This will be issued at the end of the 2020/21 academic year after the intervention has ended. For this measure, a baseline assessment will not be included due to timeline impracticalities in arranging a baseline measure in addition to organising enumeration and randomisation before the intervention is due to begin. However, KS1 maths attainment, which is readily available in the NPD, could be predictive of maths anxiety (Smith, 2004). We therefore include KS1 maths attainment as a covariate in the secondary analysis. It is difficult for us to assume the power of the association between KS1 maths attainment and maths anxiety as we are unaware of any existing literature that could be used as an estimate.

Table 1 Study design		
Trial type and number of arms		Two-armed randomised controlled trial
Unit of randomisation		Child
Stratification variables **(if applicable)**		Local Authority
Primary outcome	Variable	Key Stage 2 maths attainment
	measure (instrument, scale)	Key Stage 2 maths mark [KS2_MATMRK]
Secondary outcome(s)	variable(s)	Maths anxiety
	measure(s) (instrument, scale)	Modified Abbreviated Maths Anxiety Scale (mAMAs)

Randomisation

Randomisation will occur at the child level, with children allocated to the intervention or to a 'business-as-usual' control group, blocked by the local authority (LA). Blocking ensures that there are both intervention and control cases within each block. We anticipate primary schools may have as few as one eligible pupil for the evaluation and therefore expect blocking by school to be impractical. However, blocking by LA should ensure a good spread of cases across areas, supporting the generalisability of the trial findings.

Randomisation will be conducted in Stata 16 SE by an independent analyst, blinded to the identity of LAs and pupils. Randomisation will take place in October, after the developer has completed the recruitment process and pupils have been enumerated. Intervention delivery can begin after the October half-term.

To facilitate intervention delivery, randomisation will be conducted in four batches whilst recruitment is ongoing:

- Batch one: all pupils recruited by 4th October
- Batch two: all pupils recruited between 5th and 11th October
- Batch three: all pupils recruited between 19th and 23rd October
- Batch four: all pupils recruited between 2nd and 6th November
- Batch five: all pupils recruited between 7th and 10th November

Participants

Eligible participants will be children in year 6 during the 2020/21 academic year who have been Children in Need, subject to a Child Protection Plan, subject to a Special Guardianship Order and/or Looked After in the past six years. Participating schools hold the relevant information

internally that can be used to identify eligible pupils. Participants will therefore be identified and recruited directly through their schools.

All primary schools within any Local Authority in England will be eligible to take part. As the tuition will be delivered online, there are no additional eligibility requirements for which LAs can participate (other than being within England).

Third Space Learning will lead on recruitment by liaising with LAs and Virtual School Heads (VSHs) within LAs. VSHs are in charge of promoting the educational achievement of all the children looked after by the LA they work for and are therefore well placed to approach individual schools on behalf of Third Space Learning for the purposes of recruitment. Additionally, Third Space Learning will be hosting webinars in September 2020 with eligible schools to encourage recruitment.

Sample size / MDES calculations

The evaluation is designed as a two-armed randomised controlled efficacy trial blocked at the local authority level (Level 2) involving 53 local authorities.

Table 2 Minimum detectable effect size calculation		**MDES (Proportion of a Standard Deviation)**
MDES		0.121
Baseline/Endline correlations	Child (Level 1)	0.60
	Family	n/a
	Local Authority (Level 2)	n/a
Intracluster correlations (ICCs)	Family	n/a
	Social Worker	n/a
	Local Authority	n/a
Alpha		0.05
Power		0.80
One-sided or two-sided?		2
Level of intervention clustering		Child (Level 1)
Average cluster size		1
Sample Size (children)	Intervention	425
	Control	430
	Total	855
Sample Size (families)	Intervention	n/a
	Control	n/a
	Total	n/a
Sample Size (Local Authority)	Intervention	53
	Control	53
	Total	53

The power calculations are informed by the trial design and were estimated using the PowerUp! tool (Dong and Maynard, 2013). Power calculations were estimated using the "2.2 BIRA2_1f" tab, which uses the appropriate power calculation formulae for a study with this design and we therefore do not account for clustering in the power calculations.

For the power analysis, we assume:

- A pre- and post-test correlation in attainment of 0.60. Prior attainment is included as it reduces variance in the outcome, increasing statistical power. This is informed by the EEF efficacy trial of AMT (Torgerson et al., 2016) and our recent evaluation of the Same Day Intervention (Davies et al., forthcoming).
- A type one error rate of 0.05
- A type two error rate of 0.20 (80% statistical power)
- A two-tailed significance test

We expect minimal attrition as the outcome and baseline data are sourced from the NPD.

Outcome measures

Primary outcome

The primary outcome will be pupils' KS2 maths attainment, recorded in the National Pupil Database (NPD) in June 2021. KS2 maths attainment was chosen as an appropriate outcome as it measures dimensions of math attainment that are closely linked to those addressed by the Affordable Maths Tuition programme. In addition, this measure was used in the efficacy trial conducted for EEF (Torgerson et al., 2016). KS2 math attainment is a continuous measure [KS2_MATMRK]. KS2_MATMRK raw score is derived by summing the scores on three KS2 maths assessments: Paper 1 (arithmetic, scored 0-40); Paper 2 (reasoning 1, scored 0-35) and Paper 3 (reasoning 2, scored 0-35), scored between 0 – 110. Baseline attainment will be assessed using KS1 maths grade, a categorical measure of attainment also recorded in the NPD [KS1_MATH_OUTCOME].

Secondary outcome

Confidence in maths will be measured by assessing pupils' anxiety when faced with a mathematical problem. This is known as 'maths anxiety'. The Maths Anxiety Trust define maths anxiety as "a negative emotional reaction to mathematics, leading to varying degrees of helplessness, panic and mental disorganisation that arises among some people when faced with a mathematical problem". Maths anxiety will be assessed using the Abbreviated Maths Anxiety Scale (mAMAS). mAMAS is a nine-item self-report questionnaire using a Likert scale from one (low anxiety) to five (high anxiety), leading to an overall score of 9 to 45. It has been psychometrically tested with British pupils aged 8 to 13, with high reliability (Cronbach Alpha: 0.85, Carey et al., 2017). We will collect this data using an online pupil survey conducted post-intervention at the end of the 2020/21 academic year.

Analysis plan

Primary Outcome Analysis:

The evaluation of the Affordable Maths Tuition programme aims to estimate the impact of the programme on KS2 maths attainment of Year 6 pupils in England, using an intention-to-treat approach. The trial is designed as a multi-site two-armed randomised efficacy trial with random allocation at the individual level, blocked by local authority.

There are three levels of clustering in this trial: pupils (level one), nested in schools (level two) and within LAs (level three). Clustering of pupils within schools will be accounted for with fixed effects. A single dummy variable will be used as a fixed effect for pupils that are the only eligible pupil within their school (i.e. these pupils will be grouped together).. Local Authority is used as the blocking variable in randomisation (rather than school), and we control for these with fixed effects.

Following WWCSC statistical analysis guidance for multi-site trials, the primary analysis will be conducted on an intention-to-treat basis using an OLS regression model. The dependent variable will be KS2 maths scores and the independent variables will be: (1) an indicator of allocation (intervention or control), (2) KS1 attainment [KS1_MATH_OUTCOME], (3) School fixed effects and (4) Local Authority fixed effects.

The full model notation is as follows:

$$KS2\_MATMRK_{ijk} = \beta_0 + \beta_1 Intervention_{ijk} + \beta_2 KS1\_MATH\_OUTCOME_{ijk} + \beta_3 School_j + \beta_4 Local\ Authority_k + u_{ijk}$$

Where children (i) are nested within schools (j) within local authorities (k). The error term is represented by u_{ijk}. Robust (Huber-White) standard errors will be estimated to account for heteroscedasticity. Following WWCSC statistical analysis guidance (WWCSC, 2019), the effect estimate will be presented as a ***Glass' Delta*** *(∆)* effect size, using 95% confidence intervals. Full effect size formulae are presented in the Effect Size Estimation section.

Compliance

We will also estimate the Complier Average Causal Effect (CACE) as we expect some non-compliance if the intervention were to be offered in a real-world scenario. This estimation will not be part of the primary analysis we will conduct, but it will be in place to assess the degree of non-compliance with the programme.

The evaluation design aimed to recruit, randomise and set-up tuition for pupil allocated to the intervention by the end of September 2020. This would give pupils a real-world experience of Third Space Learning with a total of 26 sessions. The minimum advised sessions is 16. In practice, recruitment and randomisation took longer than expected. Consequently, it is likely that many pupils will receive fewer than 16 tuition sessions.

We will consider a pupil to be compliant if:

- They have completed 'Mission Zero' - the initial diagnostic assessment;
- They have attended sixteen or more of all tuition sessions; and,
- That 80% or more of those attended tuition sessions had acceotable technical set-up, measured by good quality audio.

This data will be collected by TSL and supplied to NatCen and a binary indicator of compliance will be derived, based on these three conditions being satisfied. The individual components will be explored descriptively as part of the IPE.

We will estimate the Complier Average Causal Effect using the Bloom adjustment (Bloom, 2006). Assuming one-sided non-compliance, this is estimated by dividing the intention-to-treat (ITT) estimate by the proportion of compliers in the intervention group:

$$CACE = \frac{ITT}{Pr\ (Compliers)}$$

Dosage

We will also assess the relative importance of the number of sessions attended (dosage). The number of sessions delivered to pupils in the trial will vary based on a number of factors, such as the date they were randomised (and subsequently onboarded) as well as their own attendance to sessions. It is worth noting that pupils randomised in the final batch will only be able to attend a maximum of twelve tuition sessions before sitting their SATs and this is lower than typical delivery of AMT. In some rare instances, pupils that were already receiving AMT were randomised (as their receipt of tuition was unknown at the point of randomisation) and these pupils will also have higher dosage relative to their peers. We will assess the impact of AMT for pupils that have had:

- Fewer than twelve tuition sessions;
- Twelve or more tuition sessions, but less than sixteen tuition sessions; and,
- Sixteen or more sessions.

We will assess dosage using instrumental-variables, two-staged least squares regression to estimate the Average Causal Response with Variable Treatment Intensity (Angrist and Pischke, p181, 2009). The first stage equation is as follows:

$$Dosage_{ij} = \propto + \beta_1 Treati_j + \varepsilon_{ij}$$

The predicted values of dosage $\widehat{Dosage}_j$ will then be used in the estimation of the second stage model, as follows:

$$Y_{ij} = \propto + \beta_1 Treat_j + \beta_2 \widehat{Dosage}_j + \beta_3 KS1\_MATH\_OUTCOME_{ij} + \beta_4 Local\ Authority_{ijk} + \omega_{ij}$$

Secondary outcome analysis

The secondary analysis will use a similar specification to the primary analysis. The dependent variable will be the mAMAS score at endline, with independent variables for random allocation, fixed effects for schools and LAs.

The model will take the following form:

$$MathsAnxiety_{ijk} = \beta_0 + \beta_1 Intervention_{ijk} + \beta_2\ KS1\_MATH\_OUTCOME_{ijk} + \beta_3 School_j + \beta_4 Local\ Authority_k + u_{ijk}$$

Where children (i) are nested within schools (j) within local authorities (k). The error terms is represented by u_{ijk}. Robust (Huber-White) standard errors will be estimated to account for heteroscedasticity. Following WWCSC statistical analysis guidance (WWCSC, 2019), the effect

estimate will be presented as a *Glass' Delta (Δ)* effect size, using 95% confidence intervals. Full effect size formulae are presented in the Effect Size Estimation section.

Missing values

We will consider missing data analysis for both the primary and secondary outcome. As we are using administrative data for the primary outcome analysis, we do not expect large proportions of missing outcome or covariate data. We expect missing data could arise in two scenarios; 1) if pupil data cannot be linked to the NPD, and 2) if NPD data has missing outcome or covariate data. We are collecting at least five pupil and school identifiers to minimise the risk of losing pupil observations during the data linkage process. Based on our prior experience of NPD data we also expect the proportion of missing data to be low (less than five percent).

The secondary outcome will be collected using an online pupil survey and consequently there is a greater risk of missing data. Missing data may arise from 1) survey non-response and 2) linking collected survey data with the NPD and other trial data. The online survey will use unique access codes for pupils, to minimise the risk of missing data. It is also possible covariate data (namely KS1 maths attainment sourced from the NPD) may also be missing.

If lower than five percent of the intention-to-treat sample are missing the primary or secondary outcome, a complete case analysis will be estimated, as we would expect this to yield unbiased estimates of all coefficients including the treatment variable for the full sample. If less than five percent of the intention to treat sample are missing covariate data, we will use the missing indicator method to account for missing data.

If greater than five percent of the intention-to-treat sample are missing the primary or secondary outcome it is likely that missingness may impact the results of the evaluation. As a first step, we will assess patterns of missing data can be predicted using observed characteristics using a 'drop-out' model. The dependent variable (primary or secondary outcome) will be a binary indicator of whether the observation is missing outcome or covariate data, with all available covariates included as independent variables.

If these models find statistically significant associations (a p-value less than 0.05) between observed characteristics and the dependent variable, we will assume that data is missing at random (MAR) and conduct multiple imputation.[2] Multiple imputation by chained equations (MICE) will be conducted in Stata 16.1 using the *mi* suite of commands to impute missing outcome and covariate data. The first 200 observations will not be used ('burn in') to ensure that a stable distribution has been reached. In total, 75 datasets will be imputed. The imputed values will be used in the matching model by using the *mi estimate* command.

If there are no statistically significant associations with observed characteristics, we will assume that data is missing completely at random (MCAR). If this missing data is solely due to missing covariate data, we will re-estimate the primary analysis without covariates (regressing the outcome on the binary indicator of treatment allocation only), otherwise we will conduct complete case analysis, with missing covariate data accounted for using the missing indicator method..

Subgroup analyses

[2] By definition, it is not possible to assess if there are associations with unobserved characteristics. If there were associations with unobserved characteristics, the data would be described as missing not at random (MNAR). In this case, both the primary analysis and multiple imputation would produce biased estimates. A full description of types of missing data and their consequences are available in the WWCSC statistical analysis guidance.

We do not plan on conducting subgroup analysis.

Intra-cluster correlations

We intend to calculate intra-cluster correlation (ICC) coefficients to inform future trials, as we anticipate stratification of trials at a higher than the school level (e.g. Local Authorities) and with similar outcomes (e.g. KS2 maths attainment). To calculate the ICCs , we will run a multilevel model that will include a binary term for treatment allocation as the sole covariate and random effects for Local Authorities.

Following WWCSC statistical guidance, the ICCs will be estimated with the post-test estimation command *estat icc* in Stata 16.1 using the following formula:

$$\boldsymbol{\rho_{LA}} = \frac{\boldsymbol{\sigma^2_{BLA}}}{\boldsymbol{\sigma^2_{BLA}} + \boldsymbol{\sigma^2_{BS}} + \boldsymbol{\sigma^2_{WS}}} = \frac{\boldsymbol{\sigma^2_{BLA}}}{\boldsymbol{\sigma^2_{WT}}}$$

$$\boldsymbol{\rho_{S}} = \frac{\boldsymbol{\sigma^2_{BS}}}{\boldsymbol{\sigma^2_{BLA}} + \boldsymbol{\sigma^2_{BS}} + \boldsymbol{\sigma^2_{WS}}} = \frac{\boldsymbol{\sigma^2_{BS}}}{\boldsymbol{\sigma^2_{WT}}}$$

Where σ^2_{BLA}, is the between-LA variance, σ^2_{WLA} is the within-LA variance (between and within school variance use the S subscript). Values of ρ range from zero to one, where values closer to zero implies that the within-cluster variance is much greater than the between cluster variance.

Effect Sizes (ES)

In line with WWCSC guidance, estimates for the primary outcome, KS2 maths score, as well as the secondary outcome, maths anxiety, will be reported as Glass' Delta effect sizes (Smith and Glass, 1977), using the following formula:

$$\Delta = \frac{\underline{Y_t} - \underline{Y_c}}{SD_c}$$

The observed outcomes in the intervention ($\underline{Y_t}$) and control ($\underline{Y_c}$) groups will be divided by the standard deviation of the control group (SD_c). The effect size will be estimated using the *esize* command in Stata 16 SE-64.

Contextual Factors Analysis

The use of Affordable Maths Tuition by schools for this cohort of pupils is likely to be different to typical delivery. The COVID-19 pandemic has caused significant disruption to schools, and will likely cause further disruption in the 2020-21 academic year. This may include higher than usual pupil and staff absence and remote learning, which may vary from one bubble to the next. Adapations to the delivery of Affordable Maths Tuition may include:

- Sessions being delivered at home, rather than at school
- Sessions at school may not be delivered in a separate, quiet IT room (as is advised by TSL) because of bubbling within classrooms
- Fewer staff may be available to support tuition sessions, which may result in more sessions being missed, and lower dosage overall
- Pupil absence may be higher, also contributing to lower attendance and dosage

To some extent, the complier and dosage analyses will capture some of the likely difference in impact that arises from adaptions to the progamme. Nevertheless, it is unlikely that the

quantitative estimates will be able to account fully for the impact of the pandemic on the effectiveness of Affordabel Maths Tuition. The implementation and process evaluation wil assess programme fidelity and adaptations made to the programme in delivery for this cohort of pupils. This information will be used in interpretation of the impact estimates, along with the wider context of COVID-19 and its impacts on education.

Delivery of other tuition programmes and support for pupils may also make it harder to detect an effect. For example, in June 2020 the Department for Education announced a National Tutoring Programme (NTP) as part of their COVID-19 catch-up plan for pupils. All trials run the risk of confounding from other interventions but given the scale of the NTP, it is highly likely to involve children that are part of the AMT trial. There are logistical challenges and ethical concerns about denying the 'business-as-usual' control group access to the NTP. We recommend that these pupils should be able to access the NTP. We also recommend that the intervention group should have access to the NTP, as this will allow us to assess the impact of AMT versus 'business-as-usual' rather than the relative effectiveness of one tutoring programme against another.

We are exploring the possibility of cross-referencing the AMT trial sample against pupils receiving support through NTP. If pupil data on NTP participation is available for all pupils in our sample, we will conduct an additional analysis using an interaction model. This analysis would explore whether receiving NTP tuition affects the impact AMT tuition using an interaction model. As the sample of pupils receiving AMT and NTP are likely to be small, we anticipate that this analysis will have low power. The model has the following notation:

$$KS2\_MATMRK_{ijk} = \\ = \beta_0 + \beta_1 Intervention_{ijk} + \beta_2 KS1\_MATH\_OUTCOME_{ijk} \\ + \beta_3 Tuition\ Partners_{ijk} + \beta_4 Tuition\ Partners_{ijk} * Intervention_{ijk} + \beta_5 School_j \\ + \beta_6 Local\ Authority_k + u_{ijk}$$

The coefficient $\beta_4$will be interpreted as the difference between the impact of the intervention for pupils receiving tuition from NTP and the impact of the intervention on pupils who did not receive tuition from NTP.

Implementation and process evaluation

The purpose of the implementation and process evaluation (IPE) is to explore delivery of the AMT programme. Findings will provide important information in which to contextualise and understand the results of the impact analysis. Specifically, the IPE aims to build a detailed understanding of the intervention and to help explain any identified intervention effects.

The IPE addresses its aims by capturing data (beyond the outcomes explored by the impact analysis) directly from those involved in the delivery of the programme, as well as the recipients. This provides a direct perspective on the delivery of the intervention as well as its perceived effectiveness.

Research questions

The IPE brings together multiple strands of work including quantitative and qualitative data collection to answer a number of key research questions. These questions are set out in the first column of the table below (grouped by aspect of implementation). The second column details the evaluation activities we will use to address each set of questions.

Research questions	Evaluation activities
Fidelity: • How has AMT been implemented in schools? • Are schools/ teachers administering the programme as prescribed (i.e. is there intervention fidelity)? • Is AMT being delivered consistently by tutors?	• Telephone interviews with maths leads/ teachers • Follow-up telephone interviews with maths leads/ teachers • Observation of tutor training • Observation of recorded tuition sessions • Online interviews with tutors
Programme differentiation: • What types of 'business as usual' are offered by participating schools • Are schools providing other forms of (maths) tuition to pupils/ specific groups of pupils?	• Telephone interviews with maths leads/ teachers • Follow-up telephone interviews with maths leads/ teachers • Survey with pupils • Interviews with pupils
Adaptation: • Have schools needed or chosen to adapt the intervention in any way? • What does this adaptation look like? • What level of adaptation is acceptable?	• Telephone interviews with maths leads/ teachers • Follow-up telephone interviews with maths leads/ teachers • Observation of tutor training • Observation of recorded tuition sessions
Acceptability: • What is the experience of schools/ teachers and pupils involved with the intervention? • What are the facilitators and challenges of implementing AMT? • Do teachers and pupils feel AMT is the right response to problems with attainment/ lack of confidence in maths?	• Telephone interviews with maths leads/ teachers • Follow-up telephone interviews with maths leads/ teachers • Survey with pupils • Interviews with pupils
Mechanism: • Do stakeholders (teachers/ pupils/ tutors) feel that the intervention has had an impact on pupil outcomes as set out in the logic model?	• Telephone interviews with maths leads/ teachers • Follow-up telephone interviews with maths leads/ teachers • Interviews with pupils • Survey with pupils • Online interviews with tutors
Costs: • What resources have teachers/ school leaders needed to contribute to the running of the intervention?	• Follow-up telephone interviews with maths leads/ teachers • Collection of cost data from teachers (cost pro-forma)

IPE methods

The design for the IPE brings together a number of different research components, employing both qualitative and qualitative methods, in order to better understand and assess how AMT has been implemented. These research components are discussed in turn below, and (where relevant) the subsections include details about sampling, data collection methods and timing.

Observations of tutor training and tuition sessions

The IPE begins with a review of tutor training materials and one observation of an online training session for AMT tutors. Training materials will be shared by TSL with NatCen early in the intervention period. The review of training materials and observations will take place between September and November 2020.

The team will also use observation methods to explore how the tuition is delivered in practice: ten recorded tuition sessions will be reviewed from across the intervention period. We will analyse the videos and use an observation pro-forma to collect qualitative data on pupil participation, engagement and understanding. The sessions used for observation and analysis will be selected by the evaluation team. Sampled sessions will include three from early in the intervention period (November-December 2020), four from the middle (January-February 2021), and three from the end (March-April 2021). They will be selected from schools with larger numbers of pupils (two or more) in the intervention group. The sessions will include a minimum number of pupils and tutors who meet particular sampling characteristics (see table below). Setting quotas on key characteristics will ensure that particular groups are represented in our analysis.

Table 3 Pupil and Tutor sampling characteristics	
Pupils	
CIN in the last 6 years	Min. 2
CPP in the last 6 years	Min. 2
LAC in the last 6 years	Min. 2
Male	Min. 3
Female	Min. 3
Tutors	
New tutor (started this year)	Min. 3
Experienced tutor (delivered AMT previously)	Min. 3
Female	Min. 2
Male	Min. 2

Qualitative interviews with maths leads/ teachers

Telephone interviews will be conducted with 20 maths leads/ teachers based within participating primary schools, located in different LAs and with different school characteristics. As above, the sample will be selected to ensure it includes maths leads/ those teaching in schools with different characteristics (see table below). Minimum quotas will be placed on certain key characteristics to ensure a range of schools are represented in the analysis.

Table 4 Maths leads/teachers sampling characteristics

Ofsted rating	
Outstanding	Min. 2
Good	Min. 2
Requires improvement/ inadequate	Min. 2
Number of eligible pupils	
1-3	Min. 5
4 plus	Min. 5
Disadvantage	
Low disadvantage (<=18%[3] FSM)	Min. 5
High disadvantage (>18% FSM)	Min. 5

These interviews will be conducted at two time points: 1) during the 2020 autumn term (baseline), and 2) towards the end of the 2021 summer term (endline). The baseline interviews will be used as an opportunity to explore school staff's expectations and early experiences of the intervention. The endline interviews will encourage staff to reflect on prior expectations and perceived outcomes for pupils, as well as collecting feedback on any issues with implementation and information on resource requirements for the school.[4]

Interviews will also include a discussion of 'business-as-usual', including any other tuition being delivered to pupils (possible confounders). Questions will be included in the topic guide to ensure sufficient information is captured about what usual maths teaching looks like at each school, and any additional support provided for pupils in the control group, the intervention group or both. In addition, the pro-forma used to determine delivery costs administered to teachers at the end of the intervention will ask for high level information about other support provided to pupils across the different trial groups.

Qualitative interviews with pupils

The IPE will use paired and grouped interviews with pupils in the intervention group to explore their perceptions of the maths tuition they received and its effectiveness. Grouping pupils for the interviews may help them to feel more relaxed in an interview setting, and to stimulate discussion about the intervention. Care will be taken to ensure topics such as maths attainment and lack of confidence in maths are handled sensitively. Should pupils express a desire to be interviewed individually, then this is something the team will accommodate. The interviews will be conducted face-to-face in the 2021 summer term and will last up to 60 minutes.[5]

[3] 17.6% of nursery and primary school pupils were eligible for FSM in the 2019/20 academic year - https://lginform.local.gov.uk/reports/lgastandard?mod-metric=2173&mod-period=2&mod-area=E92000001&mod-group=AllRegions_England&mod-type=namedComparisonGroup

[4] This will be supplemented by an online proforma sent to all maths leads involved in the intervention to collect cost data.

[5] If possible, interviews will be conducted face-to-face, but should restrictions on conducting fieldwork continue into the 2021 academic year, interviews with pupils may need to be conducted online using video-conferencing software.

The evaluation team will speak to a total of 24 pupils across 10 or more data collection points. Where possible, interviews will include pupils working with maths leads taking part in the IPE (i.e. teacher interviewees). Should the selected schools (i.e. those where maths leads/ teacher interviewees are based) include a large number of participating pupils, we will work to ensure the sample includes children from across the different LAC/ CIN/ CPP groups and the attainment spectrum. Pupils will be encouraged to discuss their experience of AMT, assess perceived impacts on their confidence and attainment in maths, and describe any other tuition they received.

Pupil survey

In addition to qualitative data collection, the IPE will include a ten-minute online pupil survey. The survey will take place at the end of the intervention period (in June-July 2021), and will be used to collect data on the secondary outcome of maths anxiety (discussed above), as well as confidence, perceived ability and enjoyment of maths. It will also gather information on any other tuition received (including through the NTP programme). The questionnaire will include a small number of open questions to collect tailored feedback on the tutoring sessions from pupils. The survey will be delivered to pupils in both the intervention and control groups, with named contacts at each school (collected during the recruitment phase) supporting the administration of the survey.

Qualitative interviews with tutors

Data collection with teachers and pupils will be supplemented by online interviews with tutors. Where possible, the research team will select tutors who have either a) worked with pupils interviewed as part of the IPE or b) who's tuition session was included in the observations. The sample will be selected to include those with different levels of experience delivering AMT (i.e. those who started as a tutor this year, and those who have delivered AMT previously), as well male and female tutors. As with the qualitative data collection with pupils, interviews will be conducted towards the end of the intervention period (May-July 2021), allowing tutors to reflect on how the intervention was operationalised (including any training and support received) and its effectiveness on pupils' comprehension, confidence and attainment in maths.

Analysis

Individual and group interviews will be recorded (with respondents' permission) and transcribed. Observations of tutoring sessions will be recorded using detailed fieldnotes entered into a tailored observation pro-forma. We will use Framework in NVivo to facilitate thematic analysis of qualitative data. In the Framework approach data from each interview is summarised within an analysis matrix (where columns represent the key sub-themes or topics and the rows represent participants), so the data are ordered systematically and grounded in participants' accounts. Analysis will look for patterns, consistencies and inconsistencies in data collected from different respondents and across schools in order to help answer the research questions.

The team will manage and analyse pupil survey data using SPSS.

We will triangulate and synthesise IPE data according to our research questions and implementation domains. This will enable us to provide a comprehensive assessment of implementation, report findings against the finalised logic model and contextualise/ explain results from the impact evaluation.

The following steps will be taken to ensure rigor in the analysis and reporting of qualitative data:

- Confidence that the findings are an accurate reflection of participant experience will

be ensured through presentation of examples of participant responses using quotes, and triangulation between different participants and data collection methods.

- The degree to which findings are transferable to other contexts will be considered through description of contextual factors, and collection of data from participants with different characteristics to gather a range of perspectives.
- Transparent reporting of the research and analysis process will ensure the study methods are clear and repeatable.
- When interpreting findings, consideration will be given to contrasting and inconsistent accounts.

Cost evaluation

The EEF funded efficacy trial estimated the cost of AMT to be £378 per pupil for 27 weeks of tuition, based on the service fees of the intervention (Torgerson et al., 2016). They also found some small costs associated with staff time to oversee tuition. We will estimate the cost based on the current service fees for AMT and delivery costs for schools. Delivery costs will be collected from each school; the teacher will be provided with pro-forma to complete online in Summer 2021 covering the different types of costs incurred in the last twelve months. This will assign costs to different categories, such as staff costs, fixed costs, marginal costs and set-up costs (where appropriate).

More specifically, this online pro-forma will request schools to assess prerequisites for intervention delivery (such as having a suitable IT equipment and classroom availability) and required staff time (such as setting up online tuition accounts and supervising children whilst they receive online tuition).

Ethics & Participation

Ethical clearance was sought from NatCen's ethics committee in August 2020. Ethical approval was granted on 15 September 2020. Some of the key considerations for our ethics application are outlined below.

The children selected for the study are especially vulnerable because they have been considered a Child in Need, subject to a Special Guardianship Order, subject to a Child Protection Plan, and/or Looked After in the past six years. Care will be taken to ensure that children are given opportunities to give explicit consent to primary data collection activities (i.e. the survey and interviews). Consent will be treated as continuous: the children will be able to opt-out at any point before, during, and immediately after data collection.

Researchers will be thoroughly briefed before interviews. The briefing will include sufficient coverage of managing interviews with vulnerable participants. It will also include information on the NatCen disclosure policy, to make sure they are clear on the process to follow in the event of disclosure.

The team are aware of the ethical challenges of randomisation, particularly for vulnerable children, when it means withholding a potentially beneficial intervention. However, there is genuine uncertainty about the effectiveness of this intervention with this population when scaled up (equipoise). It should also be noted that children in either group may be able to access other forms of government-funded tuition (e.g. the NTP) as part of the government response to the Covid-19 crisis and we do not preclude pupils from accessing this support as a condition of their participation in the AMT evaluation.

Participation

Recruitment will take place between August and November 2020 and will be carried out by the developer, Third Space Learning (TSL). As the developers of the AMT programme, TSL are best placed to recruit schools and pupils to the trial as they already have existing contacts with schools who have registered to participate. TSL are also best placed to explain what the AMT programme is. Expectations around recruitment are set out in a contract between TSL and the funder WWCSC.

Once schools are recruited, they need to sign an MOU to formally register their interest. The MOU will be drafted by NatCen with input from TSL. It provides full details on what participation entails and sets out schools' commitments for evaluation activities. The MOU will be delivered to schools by TSL, who will work with NatCen to collect signed MOUs, giving their written consent to participate in the trial.

It will be made clear in all communications from NatCen and Third Space Learning that all participation in the AMT programme and evaluation is voluntary and can be withdrawn at any time. Consent for maths leads'/teachers' and maths tutor participation in the programme and its evaluation will be established through informed verbal consent.

Participating schools hold the relevant information internally that can be used to identify eligible pupils. In this case pupils must be in Year 6 and recorded, in the past six years, as:

- a Child in Need;
- subject to a Special Guardianship Order;
- subject to a Child Protection Plan; or,
- have been Looked After.

NatCen will send an **opt-out** letter to **parents/carers** via the school, to request their permission for their child's involvement in the intervention and evaluation, including **NPD data linkage**. Opt-outs will come to NatCen (a NatCen email address/Freephone number will be provided). Parents/ carers will be required to return the opt-out slip to the school if they do not wish their child to take part. If they do this, they will be opting out of the evaluation which means that the school does not have permission to share their child's data for NPD-matching purposes and their child will not be asked to take part in the survey, or an interview.

Registration

The final version of the protocol, which will include full details of the analysis, will be published on Open Science Framework (OSF). NatCen's evaluation team will make sure that the trial registry is updated with all outcomes at the end of the project.

Data protection

NatCen will be both a data controller and a data processor on this evaluation.

TSL will be data controllers for the data they provide for the impact evaluation, whilst NatCen will be a data processor. It is the responsibility of the data controller to decide on the legal basis for data sharing. At this stage we anticipate that the legal basis for data sharing is "legitimate interests" with special category personal processed for scientific research purposes.[6]

[6] General Data Protection Regulation (GDPR) Article 6(1) and Article 9(2[j]).

NatCen will be data controller for personal data collected as part of the implementation and process evaluation (IPE). For all data collection encounters we conduct, we will provide detailed information on what participation entails and we will invite people to participate in the study with their fully, informed consent. All participants will be given a copy of the privacy notice which will provide further information on how we will use the data we collect for the IPE, what their rights are as research participants and how they can withdraw their data from the study if they wish.

A Data Sharing Agreement (DSA) has be signed between NatCen and TSL. We have issued a privacy notice to all concerned parties on the Affordable Maths study page of the NatCen website.

Personnel

Table 4 Delivery team		
Name	**Title**	**Role**
Thomas Hooper	CEO and Founder	Project sponsor
Bryan Tookey	COO	Operations lead
Sam Stagg	CTO	Technology lead
Jenna King	Project Manager	Internal and external project delivery
James Gregson	Head of New Schools	School recruitment
Candida Crawford	Head of Academic Standards	Curriculum design, tutor training design
Ellie McCann	Senior Product Manager	Platform & reporting design and implementation
Jenni Hoy	Head of Customer Support	School onboarding, customer experience and safeguarding lead

Table 5 Evaluation team		
Name	**Title**	**Role**
Dr Julia Griggs	Research Director, Children and Families	Principle investigator and IPE lead
Robert Wishart	Research Director, Evaluation	Impact evaluation lead
Dr Chris Grollman	Senior Researcher, Children and Families	IPE
Dr Kostas Papaioannou	Senior Researcher (Analyst), Evaluation	Impact evaluation

Ben Stocker	Researcher (Analyst), Evaluation	Impact evaluation
Emily Roberts	Researcher, Children and Families	IPE
Harriet Read	Research Assistant	IPE

Timeline

Table 6 Timeline		
Dates	Activity	Staff responsible/ leading
August – September 2020	Project set-up, protocol prepared and published, materials prepared	Julia Griggs
September – October 2020	Pupil enumeration, randomisation	Robert Wishart
October 2020	Intervention delivery starts Baseline interviews with maths leads/ teachers	Julia Griggs
May 2021	NPD data request	Robert Wishart
May – July 2021	IPE endline data collection: interviews with pupils, interviews with maths leads/ teachers and interviews with tutors	Julia Griggs
June – July 2021	Endline pupil survey, cost data collection	Robert Wishart
October 2021	Delivery of short interim report (summary of findings from the IPE)	Julia Griggs, Robert Wishart
January – March 2022	Impact analysis and delivery of final report	Julia Griggs, Robert Wishart

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