

Nesta - Solving Together Fund

Boosting parent engagement in maths
through real-time app notifications

Final report

A collaboration between Eedi and
CLOO Behavioral Insights Unit.

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Executive summary

Eedi works with over a thousand schools in the United Kingdom. Eedi is a low-friction, formative assessment solution that identifies individual misconceptions to provide both pupils and teachers with personalised learning and instruction. Eedi has more recently developed a parent application, in order to help busy parents engage with their child's learning and wellbeing at school – regardless of their own subject knowledge or time.

This project aimed to test the impact of the parent app on the child's learning. We hypothesised that providing parents with simple actions to help their child plan their learning and overcome misconceptions would improve pupil effort and ultimately attainment. The project was a randomised controlled trial and included 9 schools and 1851 pupils across Year 7 and 8, assigned to either control or intervention groups. The trial ran from October 2019 to February 2020. The process evaluation included parent surveys pre- and post-trial and semi-structured parent interviews.

Pupils in classes that received access to the parent app did not achieve higher attainment in maths than pupils in control classes, as measured by quiz scores on the Eedi platform. Additionally, they did not attempt significantly more questions than their peers in control classes. In general, pupils eligible for Free School Meals showed lower effort and attainment, while those categorised as English as Additional Language showed higher effort and attainment regardless of condition. These findings do not provide conclusive evidence on the effectiveness of the parent app: only one fifth (20.6%) of parents assigned to the intervention group proceeded to sign up with their parent code. As such, a small number of parents (N = 192) received access to real-time information about their child's learning and simple actions to complete. Further, only 60 parents (around 6% of intervention parents) were classified as compliers, having opened the Eedi app at least 5 times. Because the vast majority of intervention parents never took part in the intervention, it is likely that the impact estimate is brought down by the observed non-participation. Further, the platform data shows that quiz completion varies strongly by teacher. Some teachers clearly enforce Eedi quiz completion, as evidenced by high average completion rates for

the whole class. As randomisation was performed at the classroom level, the teacher appears to have had a stronger effect on treatment estimates than parent app access.

The process and implementation evaluation similarly suffered from sample size restrictions. Parent survey completions were low, as well as sign-ups to the semi-structured phone interview. Nevertheless, the clearest emerging theme suggests that the implementation challenges seem to stem primarily from an imperfect implementation of the Eedi platform by participating teachers. Parent notifications delivered through the parent app or web functionality will be unlikely to benefit parents and pupils as long as the frequency and timing of the maths quizzes is irregular and suboptimal. A number of suggestions for app functionality improvements are offered in the final section of this report.

In conclusion, the trial recruitment and implementation challenges preclude us from being able to provide clear evidence on the effectiveness of the parent notifications. Future trials may benefit from randomisation at an individual level, as classroom-level implementation makes it difficult to disentangle the effect of the teacher on quiz completion rates from the effect of the parent app.

Background

On August 14th, 2019, NESTA awarded Eedi a grant from the Solving Together Fund, launched between Nesta and Tata, through the Maths Mission partnership. Nesta is a charity and makes available funding for research projects that help further a positive social impact objective.

Eedi and CLOO delivered and evaluated the parent engagement app designed by Eedi, to parents of Year 7 and 8 pupils in 9 schools in England in the academic year 2019/20. The app was piloted at small scale in 1 school in the academic year 2018/19, and the current research project aimed to further deliver pragmatic insight into boosting parent engagement with maths.

Eedi is a formative assessment platform that, through the use of Diagnostic Questions, identifies individual misconceptions and behavioural insights designed to make learning and understanding easier for teachers, parents and students. Teachers receive detailed insights into student misconceptions and are able to deliver more targeted support. With such individualised information, students achieve a deeper understanding of their own strengths and weaknesses and feel more confident in their own learning. For parents, Eedi sends actionable insights about their child's progress. These personalised insights give them the confidence to support them on a daily basis.

CLOO Behavioral Insights Unit is a specialist consultancy and research firm in the area of behavioural (public) policy. CLOO's mission is to address real-world challenges through a scientific understanding of human behaviour. CLOO supports Eedi in the delivery and evaluation of the parent app. CLOO led on the writing of the trial protocol, randomization, data cleaning, analysis, and final report write-up.

Theoretical motivation

Consistent parenting is not an easy task: multiple tasks may be competing for the parent's attention, and the returns of spending time with one's children are

only visible far into the future (Mayer et al., 2015). Parental involvement with the child's education declines as their child moves from primary to secondary education and beyond (Hoover-Dempsey et al., 2005). Two common challenges stand out: parents may (i) feel they do not have sufficient knowledge of the more advanced topics, or (ii) believe that they do not have the resources to help (Hoover-Dempsey et al., 2005).

What parenting behaviours are particularly beneficial to the development and wellbeing of children?

The social support literature suggests that it is especially important for parents to foster positive learning environments (Wentzel et al., 2016). Parents who take an interest in their child's education, participate in parents' evenings, communicate with their child about homework or school activities raise children who do better in school (Desforges & Abouchar, 2003; Fan & Chen, 2001). Such positive parenting behaviours can be stimulated. Jeynes (2005) conducted a meta-analysis of 52 studies and found that parental involvement programs lead to 0.36 of a standard deviation increase in grades and other measures of academic achievement. Beyond getting involved with school events and checking homework, parental beliefs and communication also appear to be of importance. For example, mothers' positive attitude towards and communication about maths and science positively predicts their adolescent children's' interest in these courses, as well as their actual subject choice (Hyde et al., 2017).

Supportive communication

What is the best way for parents to be involved in their children's education? While the answer may vary from child to child, the framework of self-determination theory (Ryan & Deci, 2017) can provide useful generalizations and guidelines. Self-determination theory identifies three basic psychological needs required for optimal motivation and well-being: autonomy, competence, and relatedness.

Autonomy refers to our sense of owning our own actions and feeling like they correspond to our interests and values; competence is the feeling of being able

to perform well at a given task, improve with practice, and, in general, navigate the world effectively; relatedness is our need to belong to social groups and have people in our lives who care about us and whom we care about. When these three needs are fulfilled, we function better, have more vitality, and are better able to integrate externally imposed regulations into our own value system—this last insight being particularly pertinent to the question of how best to motivate children to do what it takes to succeed in school.

How can parents be need-supportive while being involved in their child's education? Research within self-determination theory provides strategies for effective parental involvement in general (Grolnick & Ryan, 1989; Niemiec et al., 2014), and more recent research has focused on strategies especially well-suited for high quality parental homework involvement (Dumont et al., 2014; Moroni et al., 2015).

Two positive and one negative strategy stand out:

- Structure (positive) refers to parents organizing the child's environment (e.g., making sure they have a quiet environment and all the tools required to do homework) and setting clear guidelines and expectations for behaviour. Further, the consequences of not conforming to expectations should be clear and consistently applied.
- Control (negative) refers to negative forms of parental involvement such as those characterized by pressure, intrusiveness, and dominance. While consequences for noncompliance can be a useful part of providing structure, control involves more contingent and less predictable threats and rewards, used not to guide but to force the child to behave a certain way.
- Responsiveness (positive) refers to parents being available and responsive to their children's emotional and cognitive needs. While a controlling parent might check in on the child often to make sure that they are doing their homework well, a responsive parent might wait until the child asks for help instead of intruding on the child. Responsiveness also entails actively listening to the child and trying to take their

perspective first, refraining from giving immediate solutions to any and all problems voiced by the child.

With this background, CLOO proposed small changes to Eedi's existing parent notifications and suggested a few additional messages. The aim is to encourage parents to engage with their child in a responsive way by emphasising the provision of structure rather than the use of controlling tactics.

Intervention

This project tests if real-time notifications delivered to parents of Year 7 and Year 8 pupils can boost maths attainment and effort, as measured via the Eedi platform. The parent notifications inform parents of their child's learning on the Eedi quizzes. The quizzes are set by each class' teacher, depending on the school's scheme of work (SOW) and students complete the homework. Eedi recommends that teachers set on average two quizzes per week. Each quiz should take approximately 10-15 minutes to complete.

This project *does not* evaluate the effectiveness of the Eedi platform in itself,¹ as all pupils across control or treatment use the platform to complete their maths homework. The Solving Together trial complements the previously funded EEF project by providing a detailed and specific evaluation of the parent app element. It is important to note that these two trials do not intersect: all schools taking part in the EEF trial were excluded from participation in the present trial.

Both pupils and their parents learn about their misconceptions and effort. The parent notifications do not focus on in-depth maths concepts, but instead encourage parents to build a supportive home learning environment, as can be seen in Table 1. Parents can learn about:

¹ A large-scale RCT with 168 secondary schools in the UK currently tests if having access to Eedi can improve KS4 results. More information about this separate RCT can be found at: <https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/diagnostic-questions/>

1. **Misconceptions count.** The number of misconceptions their child uncovered in a particular topic, as a proxy for the level of difficulty they are experiencing;
2. **Missed assignment completion.** If a child was set a quiz, but did not complete it, the parent receives a notification encouraging them to ask the child when he/she is planning on completing it;
3. **Missed improvement opportunities.** If a child has misconceptions to resolve (i.e. answered quiz questions incorrectly), they can access their 'Improve' section where they can complete follow-up quizzes to help them overcome their misconceptions. Parents receive a notification if their child has not completed any 'Improve' questions.
4. **Upcoming assignment notification.** Quizzes get set each week; parents/carers receive a notification about upcoming quizzes.
5. **Non-login notification.** Parents receive a notification when their child has not logged into Eedi for a while, encouraging them to ask the child to log in and complete their quizzes.

Table 1: Example parent notifications

Topic	First message	Action (Second message)
Planning prompt	Sometimes children struggle to make good plans for their responsibilities.	Ask {{studentFirstName}} if they need your help to plan their homework or have everything under control.
Improvement prompt	{{studentFirstName}} did not review any results to questions they got wrong last week. This means they do not know where they went wrong 😞	Consider gently asking {{studentFirstName}} how they feel about using Eedi and whether there's anything they are struggling with.
Review prompt	{{studentFirstName}} reviewed none of the {{incorrectAnswersCount}} questions that they got wrong last week 😞	Explain to {{studentFirstName}} that reviewing mistakes is a great way to improve and ask whether they would

		prefer to do it alone or together with you.
Metacognition prompt	You can help {{studentFirstName}} develop strong 'thinking skills' by asking them to reflect on their maths learning.	Ask {{studentFirstName}} what they found difficult about the latest Eedi quiz, and what they will need to know next time. Self-reflection = learning!
Late completion notification	Having lots of overdue homework can make it hard to get back up to date 😞	Ask {{studentFirstName}} how they are doing on homework and if anything is getting in the way of their progress.
Performance notification (sent if student scored lower than group average)	{{studentFirstName}} scored {{correctAnswersCount}}/{{questionsCount}} on {{quizName}}	Ask {{studentFirstName}} if they know that they can resolve misconceptions in the Improve section on Eedi

Method

We tested the intervention in 9 schools, during the academic year 2019/20. The schools were spread geographically, with 2 located in the West Midlands, 2 in London, 1 in South East England, 1 in East England, 2 in North West England, and 1 in North East England.

The students in our sample were all Year 7 or Year 8 pupils. Once the schools had stable class lists (around week 3 of the Autumn term), we randomly allocated half of the classes to receive access to the app (the treatment group), while the pupils' parents in the remaining classes did not get an invitation to access the parent app (the control group). This trial was conducted as a class-level, or 'clustered' RCT. This minimises the risk of contamination (likely to be high if randomisation was to occur at the individual level), while preserving statistical power.

Table 2: Summary of trial design

Type of trial and number of arms	Randomised controlled trial, 2 arms
Unit of randomisation	Classroom
Stratification variables	School and year group
Primary outcomes	<p>Attainment, as measured by % correct (or later corrected) answers of total pool of assigned answers during trial period</p> <p>Effort, as measured by % of questions answered out of total pool of assigned questions during trial period</p>

Participant selection

The study was advertised by Nesta and Eedi. Eedi contacted schools directly via email, notifying them that a new research opportunity had come up. Schools were eligible to participate in the trial if they fit all of the following criteria:

1. Based in England
2. School type is one of the following:
 - a. State
 - b. Academy
3. Have Y7 classes
4. Year group total greater than 80
5. Teachers have experience in using Eedi
6. Classes regularly used Eedi in the previous academic year (2018/19)
7. FSM greater than 5%

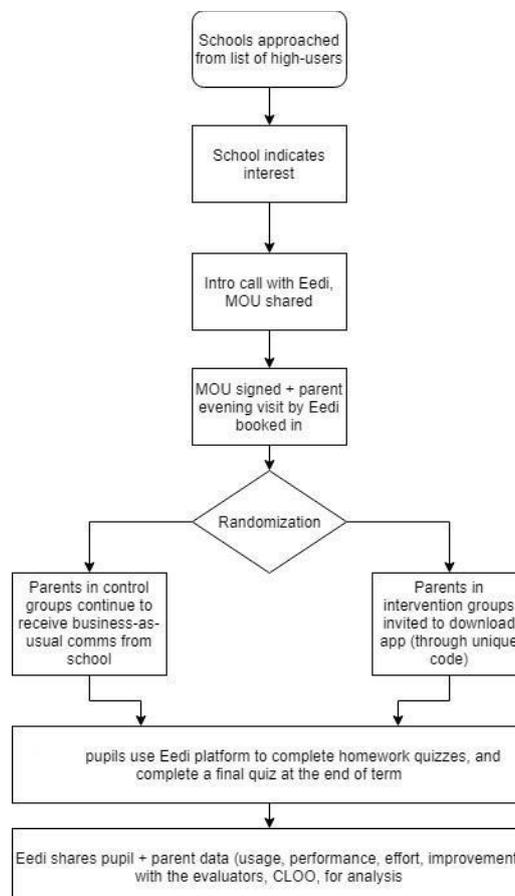
Eedi contacted an initial list of 300 schools. A total of 35 schools were interested in the trial. They were invited to book in an introductory phone call with the research team. A member of Eedi’s team conducted phone calls with a total of 19 schools, resulting in a total of 10 schools who signed both the Memorandum of Understanding (MOU) and Data Processing Agreement (DPA). Before randomisation, one school dropped out of the trial because the contact person moved jobs and was unable to allocate this project to her successor.

In conclusion, a total of 9 schools were randomised. Further detail about the randomisation strategy can be found in the next section.

Trial design

Year 7 and 8 classes in participating schools were randomised to conditions per-protocol: within each school and year level, 50% of classes were randomized to treatment and 50% to condition. When the number of classes was odd, the number of classes per condition differed by only 1 (e.g., out of 7 classes, 3 might be randomised to the experimental condition and 4 to the control, but never 2-5 or 1-6). This procedure was implemented in R (R Core Team, 2019), and the code is available in Annex A².

Figure 1: Trial design summary flowchart



² This code differs from the code provided in the Trial Protocol because small chunks were deemed unnecessary upon further inspection—the output of the two scripts is exactly the same.

Outcome measures

Primary outcomes

This trial sought to assess whether providing parents with the Eedi parent app and all its features would improve the **effort** students expend on the Eedi platform as well as their **attainment** in maths, as reflected in their use of the app. These constructs were operationalised through measures that could easily be extracted from Eedi's database and that proved comparable across students, classes, and schools:

- **Effort** was defined as engagement with the main purpose of the Eedi app: completing questions on assigned quizzes. Thus, for each student we collected (i) the number of maths questions assigned to the student through quizzes in a scheme of work for the duration of the trial (henceforth simply "assigned questions") and (ii) the number of questions the student answered (out of the assigned questions). This allowed us to compare the probability of answering an assigned question as a function of assignment to the treatment or control condition.
- **Attainment** on each question was defined as answering the question correctly, whether at first try or on a subsequent attempt. Thus, in addition to the measures above, we also collected (iii) the number of questions (out of the set defined in i) answered correctly at first try and (iv) the number of questions answered incorrectly at first try that were subsequently corrected. The two numbers were summed, allowing us to compare the probability of (eventually) answering an assigned question correctly as a function of assignment to the treatment or control condition.

Difference from trial protocol

Our original plan for the primary outcome focused solely on attainment and involved creating a maths score for each student. This score would be the number of correctly answered questions out of the X most recently answered questions (with X chosen such that each student had answered at least X questions). We had reasoned that this would create a comparable score between

students akin to a final quiz. Upon further reflection, and after consulting with Nesta about our decision, we altered the primary outcome to the one described above, for the following reasons:

- Some students did not answer any questions, bringing the “common denominator” we had based our measure on down to zero.
- Using the questions that were answered as a denominator to create an attainment score could bias our results and create challenges for interpretation. For example: a student who only answers questions they know the answer to (effectively quitting when a quiz gets difficult) would end up with an attainment score close to 100%. This score would neither reflect their true attainment nor the effort they put in.

Secondary outcomes

Through the Eedi database, we were able to collect additional measures to explore whether access to the parent app improved pupils’ engagement with the app. We chose three secondary outcomes:

- **Explanations** refers to the proportion of questions students answered with an explanation out of the assigned questions.
- **Long explanations** refers to the proportion of questions students answered with an explanation longer than 19 characters out of the assigned questions.
- **Review** refers to the proportion of incorrect answers a student took the time to review after completing a quiz, calculated as the number of incorrect answers reviewed divided by the number of incorrect answers (out of the assigned questions that the student answered).
- **Improve** refers to a student’s engagement with the improve section. For this variable, we took all the maths questions that the student resolved out of the improve section divided by the total number of maths questions in the improve section (that were either already there at the

beginning of the trial or were added during the trial as the student answered maths questions incorrectly).

Analytical strategy

All analyses were conducted in programming language R (R Core Team, 2019) within the RStudio (RStudio Team, 2019) environment. For our binomial primary outcomes our main analysis was an intention-to-treat analysis: we analysed student outcomes as a function of their treatment assignment irrespective of their parents' compliance with the intervention.³ Generalized linear mixed models were fit using R package `lme4` (Bates et al., 2015, version 1.1.21), and statistical inference was performed by extracting p -values using the `base::summary` function and comparing them with the standard Type I error threshold of 5% as well as by inspecting the 95% confidence intervals. Our model estimated the effects of condition on the relevant outcomes (our comparison of interest) with and without statistical control for several possible confounding variables, while taking into account the nested structure of the data (students nested within classes nested within schools). We fit our models with a function call of the following general form:

```
lme4::glmer(cbind(Successes, Failures) ~ Condition + Covariates +  
(1|SchoolId/ClassId), data, family = "binomial")
```

This function produces a model with estimates as log-odds. To extract confidence intervals and convert the estimates to odds-ratios, we used the `stats::confint` function and the innate `exp` function, as well as the `lme4::fixef` function to extract only the fixed effects. The code was of the general form⁴:

```
model %>%  
  confint(parm = "beta_") %>%
```

³ Unfortunately, and as described further in the Main Findings section, relatively few parents signed up to the Eedi app and showed meaningful levels of engagement with it.

⁴ Including pipe (`%>%`) operators available through the set of `tidyverse` (Wickham, 2017) packages.

```
cbind(oddsratio = lme4::fixef(model)) %>%  
exp()
```

Intracluster correlation coefficients (ICC) were calculated for level one units (students) within level 2 (classrooms) and for level 2 units within level 3 (schools) using the `insight` package (Lüdtke et al., 2019, version 0.8.2.)

By including an interaction between condition and FSM6 status in the covariate-adjusted models, we were able to perform subgroup analyses and test whether the intervention was more or less effective for students who had been eligible for free school meals within the past 6 years.

Further exploratory analyses—including a compiler average causal effect (henceforth CACE) analysis—are also described in the Main Findings section.

Impact evaluation

Sample characteristics

Our final sample consists of 1851 pupils, from 9 distinct schools and 79 classes. Of these classes, 59 are in year 7, while 20 are in year 8. Of all classes 41 were in the experimental condition, while 38 were in the control condition. The below figure follows the CONSORT guidelines in reporting of randomised controlled trials and details the sample size across control and treatment groups.

Figure 2: Sample selection flowchart

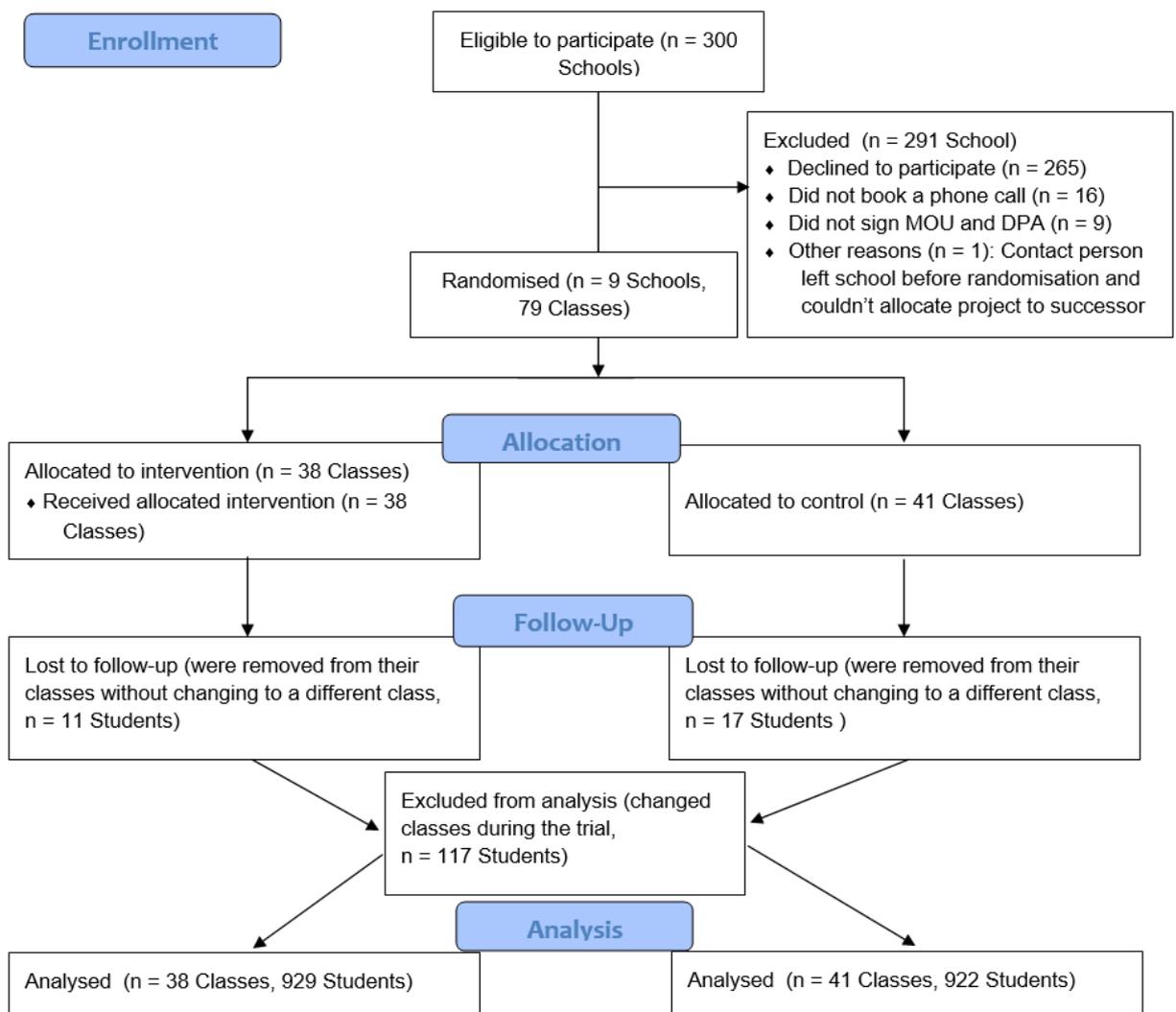


Table 3 describes the pupil-level characteristics of our final sample.

Table 3: Pupil-level demographic characteristics and outcomes by condition

Demographic Variables	Intervention group		Control group	
	n/N(missing)	Percentage	n/N(missing)	Percentage
Categorical				
Female	451/929(0)	48.5%	438/922(0)	47.5%
FSM6: Yes	278/918(11)	30.3%	248/912(10)	27.2%
EAL: Yes	91/927(2)	9.8%	89/920(2)	9.7%
Continuous	n(missing)	Mean(SD)	n(missing)	Mean(SD)
Age	916(13)	12.18(0.52)	911(11)	12.19(0.53)
Maths KS2 Score	858(71)	101.22(12.03)	866(56)	102.16(11.02)
Outcome Variables (proportions)	n(missing)	Mean(SD)	n(missing)	Mean(SD)
Effort	929(0)	0.54(0.37)	922(0)	0.63(0.37)
Attainment	929(0)	0.29(0.25)	922(0)	0.33(0.25)
Explanations	929(0)	0.15(0.26)	922(0)	0.16(0.27)
Long explanations	929(0)	0.10(0.20)	922(0)	0.11(0.21)
Review	810(119)	0.37(0.31)	821(99)	0.35(0.30)
Improve	867(62)	0.05(0.17)	829(63)	0.04(0.14)

Density of treatment for each school was calculated based on the number of weeks between the first parent of that school signing up and the end of the trial on February 29, 2020. The longest density was 21 weeks, and the shortest was 5 weeks. All schools with the exception of one were treated for more than 11 weeks.

Main findings

Analyses of primary and secondary outcomes are undertaken on an ‘intention to treat’ basis: all pupils for which there is available data are included in the estimation of the effect size, regardless of whether the parent proceeded to download the Eedi parent app. As described above, we see a low parent-take up of the Eedi app/web notifications. Only 20.6 % of the parents who were offered the opportunity actually proceeded to take it up. Of the parents who signed up, only 60 (about 31.3%, or about 6.5% of the total eligible parents) opened the mobile app at least 5 times and were considered compliers. Our treatment estimates will therefore be lower-bound estimates of impact. We present now the findings of the statistical analyses of primary and exploratory analyses.

Primary outcomes

Without covariate-adjustment

All of the estimates in this subsection were based on 1851 observations, since we had complete outcome data. Statistical models and the software packages used to implement them are described in the Analytical Strategy section.

Effort

A generalized linear mixed model was fit using condition as a predictor for effort (a binomial outcome) and specifying random effects of class nested within schools. The following table displays the results:

Table 4: Primary results, effort

	Estimate	Standard Error	z-value	p-value
(Intercept)	0.322	0.386	0.834	.404
Condition	-0.398	0.309	-1.288	.198

The ICC for students within classrooms was estimated at 0.453, and the ICC for classrooms within schools was estimated at 0.316. For ease of interpretation,

odds-ratios were obtained by exponentiating the estimates and confidence intervals were calculated.

Table 5: Odds-ratios and 95%CI for primary results, effort

	Odds-ratio	95% CI
(Intercept)	1.38	0.601, 3.078
Condition	0.671	0.363, 1.239

Given these results, we cannot conclude that our intervention had an effect in either direction. Our best estimate is that those in the experimental condition were only 67% as likely as those in the control condition to answer assigned questions ($p = .198$), but plausible values (95% CI) range from 36% to 124%. Figure 3 below shows a histogram of student effort across conditions, while Figure 4 shows histograms for each condition.

Figure 3: Effort across conditions

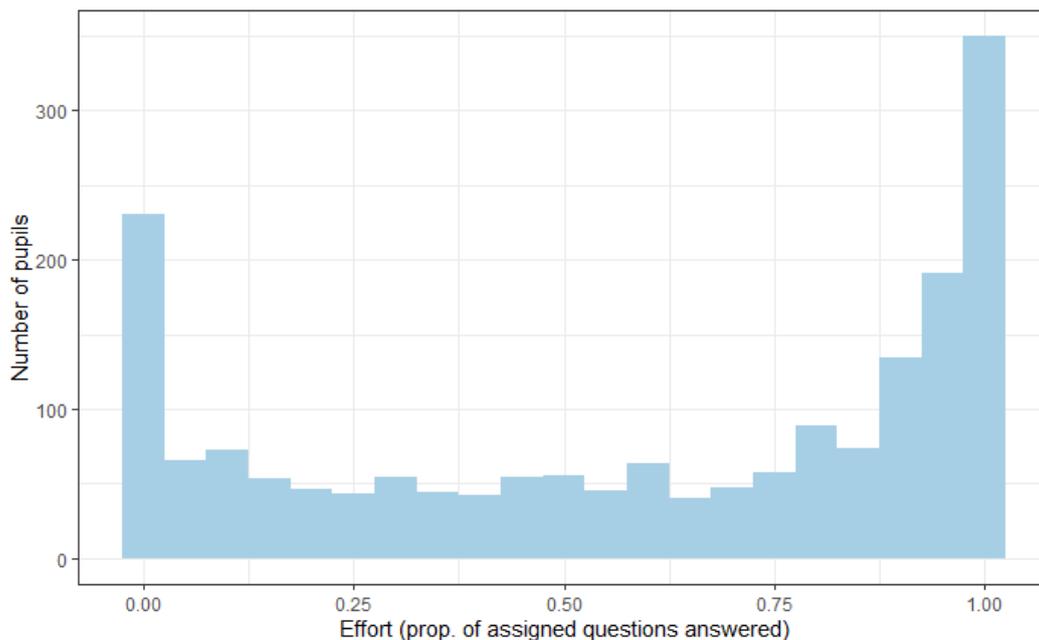
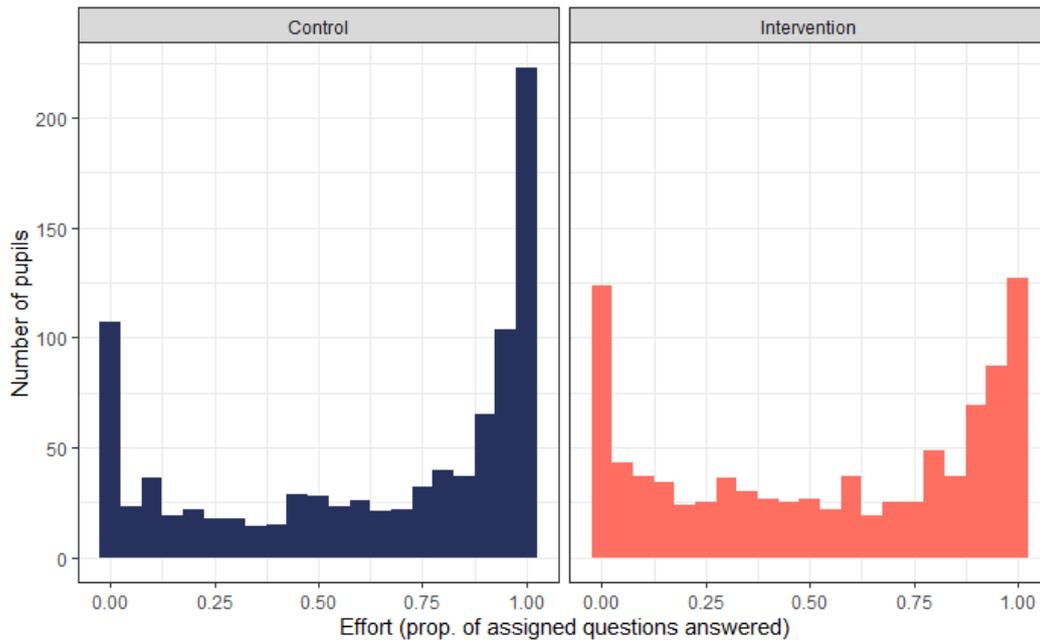


Figure 4: Effort by condition



Attainment

A generalized linear mixed model was fit using condition as a predictor for attainment (a binomial outcome) and specifying random effects of class nested within school. The following table displays the results:

Table 6: Primary results, attainment

	Estimate	Standard Error	z-value	p-value
(Intercept)	-1.215	0.289	-4.204	< .001
Condition	-0.166	0.262	-0.634	.526

The ICC for students within classrooms was estimated at 0.347, and the ICC for classrooms within schools was estimated at 0.233. For ease of interpretation, odds-ratios were obtained by exponentiating the estimates and confidence intervals were obtained.

Table 7: Odds-ratios and 95%CI for primary results, attainment

	Odds-ratio	95% CI
(Intercept)	0.297	0.161, 0.539
Condition	0.847	0.503, 1.424

Given these results, we cannot conclude that our intervention had an effect in either direction. Our best estimate is that those in the experimental condition were 85% as likely as those in the control condition to eventually answer assigned questions correctly ($p = .526$), but plausible values (95% CI) range from 50% to 142%. Figure 5 below shows a histogram of student attainment across conditions, while Figure 6 shows histograms for each condition.

Figure 5: Attainment across conditions

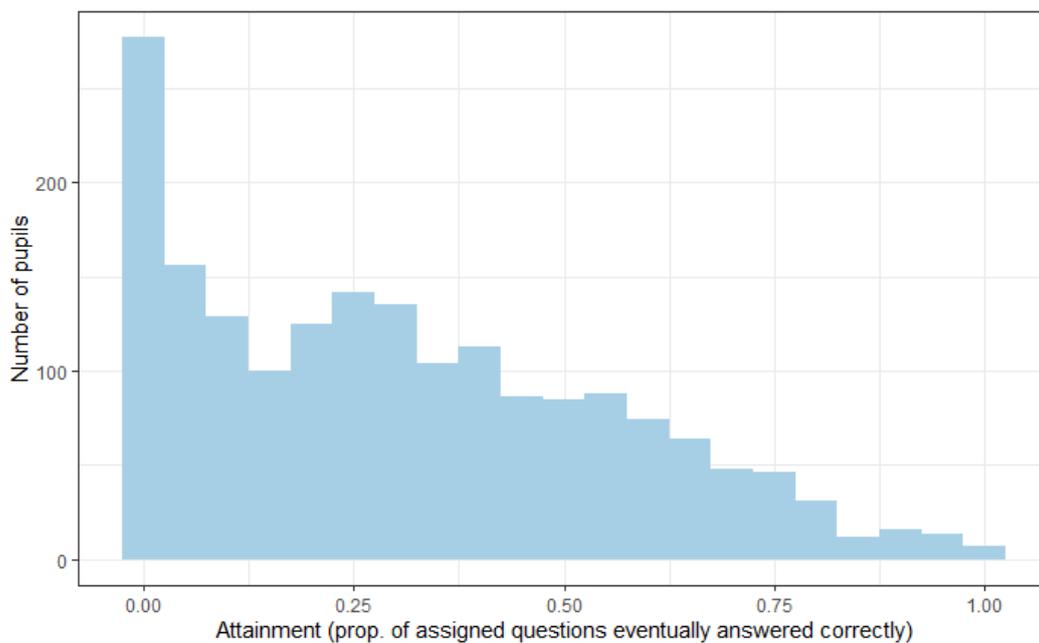
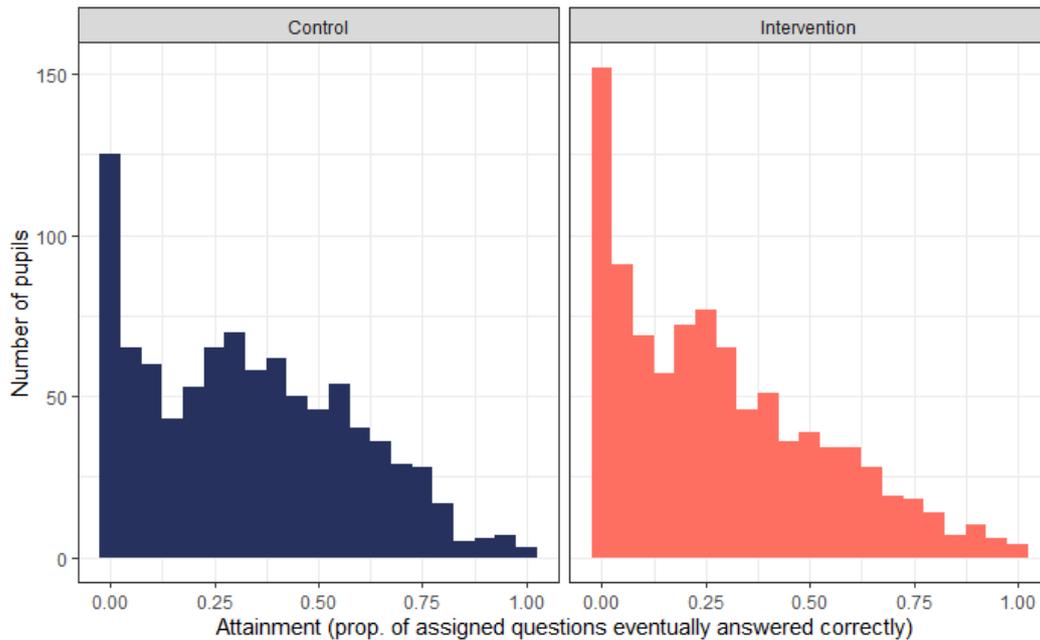


Figure 6: Attainment by condition



With covariate-adjustment

The analyses described above were rerun using the following variables as covariates: FSM6 status, EAL status, gender, a normalized KS2 score, Year group, age, and a condition-by-FSM6 status interaction. In neither analysis did the inclusion of these covariates render the effect of condition significant. However, we did find the following highly significant effects ($p << .001$):

- **Students with a positive FSM6 status scored lower** on effort and attainment than those without FSM6 status;
- **Students with a positive EAL status scored higher** on effort and attainment than those for whom English was the first language;
- **Boys scored lower** on effort and attainment than girls;
- **Students with a higher KS2 score scored higher** on effort and attainment those with lower KS2 scores;
- **Older students scored higher** on effort and attainment than younger students.

Statistical details for the covariate adjusted models for effort and attainment can be found in Annex B.

Subgroup analysis: Effects by FSM6 status

Further, we found significant ($p < .05$) interactions between condition and FSM6 status for effort and attainment with practically negligible effect sizes. Using the `ggeffects::ggpredict` (Lüdtke, 2018, version 0.14.3) function, we can extract predicted proportions and 95% CI. We present these values illustratively for effort in Table 8 below. In general, we can see that students with positive FSM6 status responded to fewer of their assigned questions, and that this relationship is slightly stronger for students in the experimental condition.

Table 8: Predicted proportions of effort as a function of condition and FSM6 status [and 95% CI in brackets]:

	Condition		Diff. in perct. points
	Control	Intervention	
FSM6 Status: Yes	58% [40%, 74%]	47% [30%, 65%]	11 pp
FSM6 Status: No	70% [53%, 83%]	61% [43%, 77%]	9 pp
Diff. in perct. points	12 pp	14 pp	2 pp

CACE analysis

While our intention-to-treat analysis estimated the effect of being assigned to a condition on student effort and attainment, Eedi are arguably more interested in knowing whether parents actually using the app reflects positively on their children. To test this idea, we performed a complier average causal effect (CACE) analysis, following the instrumental variables approach.

The primary purpose of this analysis was to better understand treatment effects for pupils whose parents received a meaningful dosage of the parent app. In other words, this secondary analysis explored what the treatment effect is for parents who downloaded Eedi's parent app and used it at least five times. This analysis is of importance for understanding the potential impact of the parent

app, as the ITT estimate only looks at whether parents are assigned to receiving access. Since the sign-up rate within intervention classrooms was low, the treatment effect may have been diminished considerably. This statistical technique focuses on the subgroup of participants who would always have complied with their treatment allocation (Gerber & Green, 2012, p. 147).

The validity of this analysis relies on a set of strong assumptions:

- **The relevance assumption:** This assumption states that the instrument has a causal effect on treatment.
 - ◆ In our case, it is very clear that being assigned to receive treatment has a causal effect on being treated, as long as some parents sign up to the trial and use the app.
- **The exclusion restriction:** This assumption states that the instrument affects the outcome only through its effect on treatment.
 - ◆ In this case, we could imagine that being assigned to receive treatment might prompt parents to engage more with their child’s education even if they never sign up to the app, thus influencing student outcomes. This scenario would violate the exclusion restriction. In order to interpret the CACE results, we must assume that this effect does not exist, or is so small as to be negligible.
- **The independence assumption:** This assumption states that the instrument and the outcome do not share common causes.
 - ◆ Since we randomly assign subjects to the instrument (remember, the instrument is “treatment assignment”), there is no outside cause for the instrument, and there cannot be common causes between instrument and outcome. This assumption is, in our case, true
- **The no-defiers assumption:** This assumption states that there are no participants who would always receive the opposite treatment to the one assigned to them.
 - ◆ For our trial, we exclude students who moved from a control class to a treatment class, and we satisfy the no-defiers assumption.

We performed these analyses separately for effort and attainment using the `ivtools::ivglm` function (Sjolander et al., 2020), using treatment assignment as our instrumental variable and compliance status as our exposure, and using age, gender, FSM6 status, EAL status, KS2 score, and year group as covariates. This analysis uses two-stage estimation and takes clustering by classroom into account. However, the full nested structure of the data (students within classrooms within schools) is not represented by the model, so results should be interpreted with caution. Table 9 presents the final results for effort, and Table 10 presents the final results for attainment.

Table 9: CACE analysis results, effort

	Estimate	Standard Error	z-value	p-value
Intercept	-6.971	0.0007	-9531	<.001*
Compliance status	-0.067	0.00009	-788	<.001*
FSM6 (Yes)	-0.829	0.00006	-14916	<.001*
EAL (Yes)	-0.298	0.00008	-3639	<.001*
Gender (Male)	-0.003	0.00003	-9938	<.001*
KS2	0.047	0.000005	9837	<.001*
Year (Year 8)	0.428	0.0001	3503	<.001*
Age	0.238	0.00005	5257	<.001*

* all $<2 \times 10^{-16}$

Exponentiating the estimate for compliance status, we can conclude that children of compilers were about 93.5% as likely to answer an assigned question in the experimental group.

Table 10: CACE analysis results, attainment

	Estimate	Standard Error	z-value	p-value
Intercept	-7.190	0.0007	-9877.8	<.001*
Compliance status	0.043	0.00006	731.6	<.001*
FSM6 (Yes)	-0.791	0.00004	-17834.1	<.001*
EAL (Yes)	-0.253	0.00006	-4277.8	<.001*
Gender (Male)	-0.213	0.00002	-9285.6	<.001*
KS2	0.051	0.000006	8930	<.001*
Year (Year 8)	0.085	0.00008	1087.3	<.001*
Age	0.119	0.00003	3584.8	<.001*

* all $<2 \times 10^{-16}$

Exponentiating the estimate for compliance status, we can conclude that children of compliers were about 104.4% as likely to eventually answer an assigned question correctly in the experimental group.

However, and as highlighted above, special caution in interpreting these results is warranted for two reasons: (i) the function employed could not take the full clustering of the data into account, and (ii) our analysis was based on a very limited number of compliers. We thus refrain from interpreting these results further, instead suggesting that the true effect of using the Eedi parent app be tested in a larger sample before more definite conclusions are drawn.

Exploratory analyses

We explored whether performance on our secondary outcome measures was different between condition. We did not find strong evidence either way.

Students did not seem to differ by condition in the proportion of incorrect answers they reviewed, the proportion of questions they answered with an explanation, or the proportion of questions in their improve section they resolved.

However, one exploratory analysis proved insightful. Looking at histograms for our primary outcomes for each class, a suspicion arose that performance varied mostly as a function of teacher rather than condition—it was clear that classes could show very similar distributions despite being in different conditions. We thus filtered our data to only include teachers who had at least one class in each condition, plotting the histograms from our outcome variables for each teacher and condition. The results below (see Figure 7 for effort and Figure 8 for attainment) clearly indicate that, indeed, engagement with the Eedi app is much more similar within classes taught by the same teacher than within classes belonging to the same condition. Notably, this pattern persists when we distinguish between different year levels.

Figure 7: Effort by teacher, condition, and year group

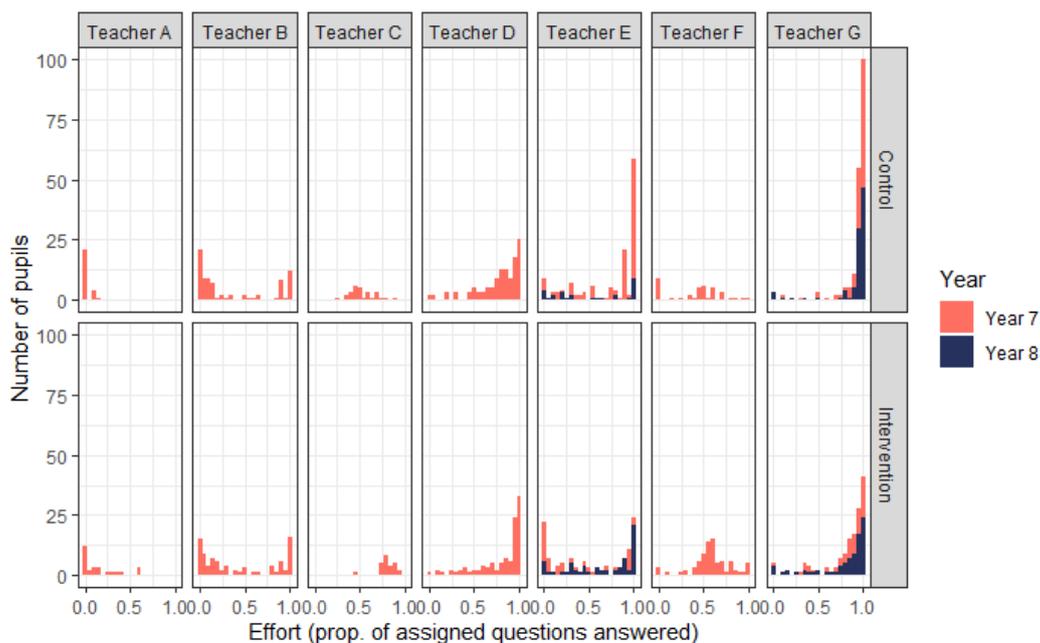
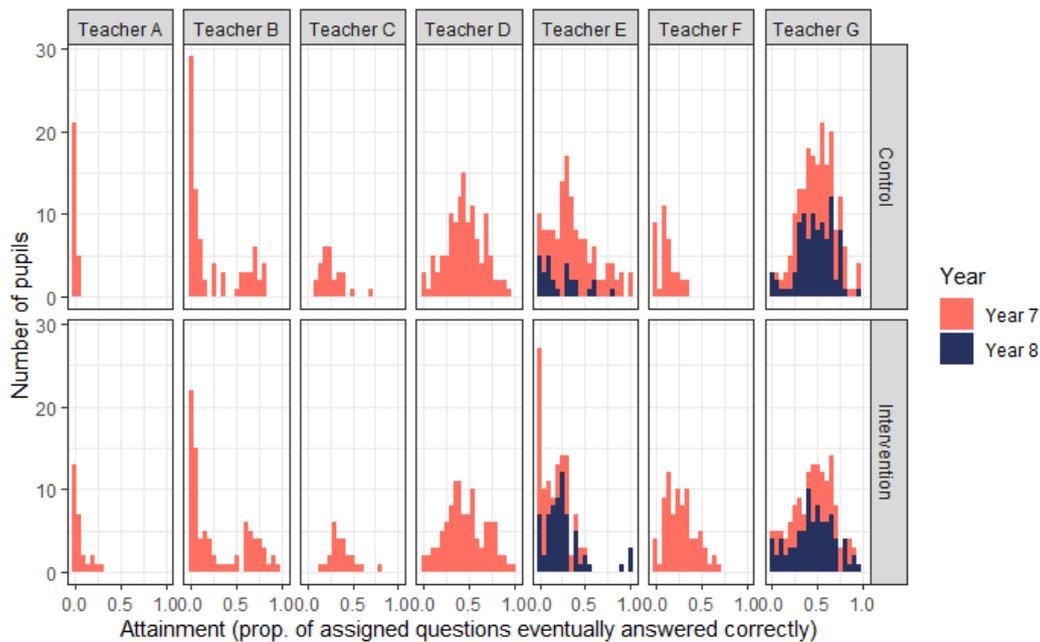


Figure 8: Attainment by teacher, condition, and year group



Implementation and process evaluation

Quantitative results: parent surveys

The parent survey included demographic information as well as measures of the quality of parents’ involvement in their child’s maths homework, adapted from Wonders’s (2017) quality of homework involvement measure (itself adapted from Dumont and colleagues (2014)) by slightly altering the wording and removing one item. The scale measured three constructs that were analysed separately: control, structure, and responsiveness (see the Theoretical Motivation for more details on these constructs).

All items of the survey as well as the introductory paragraphs are reproduced in Annex D. Parents in the intervention group were invited to complete the survey at two time points—the beginning and the end of the trial. The following sections describe the sample characteristics at both time points and the pre-post analysis conducted.

Sample characteristics

Parents who successfully signed up to the Eedi app were automatically invited to complete the first survey. As described above, a total of 192 parents signed up. We received 36 valid responses to the first survey, which corresponds to an 18% completion rate. Even with repeated reminders for survey completion, we were unable to increase completion rates. Mean age was 42.9 ($SD = 7.9$)⁵. 2 parents considered themselves single parents, 33 considered English their native language, and most ($N = 17$) parents spoke with their child about maths homework “about 2-3 times a week”. Table 11 displays their mean score and standard deviation on the three subscales at start-of-trial. Each scale consisted of several Likert-type items on a scale from 1, “never”, to 5, “always”, and scores for each subscale were created by averaging over the items.

Table 11: Start-of-trial parent survey results

Scale	Mean (SD)
Control (8 items)	2.98 (0.65)
Responsiveness (10 items)	4.25 (0.52)
Structure (9 items)	4.23 (0.57)

In the trial protocol we defined that parents who completed the first survey would be invited to complete the follow-up survey, since only these responses would allow us to calculate a difference score. Unfortunately, the initial survey completion rate was low ($N = 36$), and only these parents received an invitation for the second and final survey. We received 9 valid responses to the second survey (25% completion rate).

Mean age was 46.3 ($SD = 10.3$). 2 parents considered themselves single parents, 6 considered English their native language, and most (4) parents spoke with their

⁵ Three parents had reported an age below 20 years old. Assuming that the parents reported their child’s age instead, those responses were converted to NA.

child about maths homework “about 2-3 times a week”. Table 12 displays their mean score and standard deviation on the three subscales at both time points.

Table 12: End-of-trial parent survey results

Scale	Mean(SD) at start-of-trial	Mean (SD) at end-of-trial
Control (8 items)	2.81 (0.79)	2.73 (0.83)
Responsiveness (10 items)	3.91 (0.35)	3.98 (0.57)
Structure (9 items)	4.31 (0.52)	3.86 (0.78)

Pre-post analyses

Paired *t*-tests were conducted separately for each subscale, using only data from parents who answered at both time points. There was no significant difference in Control ($t(8) = 0.325, p = .753$) or Responsiveness ($t(8) = 0.339, p = .743$) but we did find a significant difference for Structure ($t(8) = 2.771, p = .024$): relative to the first survey, parents scored 0.44 (95% CI (0.07, 0.81)) points lower on the Structure subscale (a scale from 1 to 5) in the second survey.

These results were unexpected. Our expectation was that the intervention would increase parents’ responsiveness and provision of structure and decrease their use of controlling strategies in their involvement with their child’s homework. However, it would be premature to conclude that the Eedi parent app reduced parents’ provision of structure: the sample size for this comparison is very small, representing only 4.7% of eligible parents.⁶ Moreover, the design does not allow us to exclude the interpretation that confounding factors (such as the time of the school year) drove the observed differences. In a future trial, Eedi need to

⁶ 4.7% corresponds to the 192 parents who signed up to the app, out of the 929 parents assigned to intervention classrooms.

ensure an adequate sample size, for example by asking for more school support in distributing the surveys.

Qualitative results

Recruitment

We planned to conduct ten semi-structured interviews with randomly selected parents assigned to the intervention group across two to three school sites (of the total of 9 participating schools) at the end of the trial. The trial concluded on the 29th of February. Our team scheduled to conduct the interviews in the first two weeks of March. Unfortunately, the parent recruitment process was considerably more complicated than planned. Below we describe briefly the recruitment challenges we experienced.

First, the Eedi team sent phone interview invitation emails to all 'super-users': parents in the intervention group who (1) signed up, and (2) logged in at least 5 times. The Eedi team emailed these parents twice per week to get calls booked in. Contrary to the trial protocol, we did not first randomly pick a few super-users to reach out to. Eedi's experience with parent interview invitations is that, on average, only a few percent of the total pool (N = 60) respond. Therefore, we decided to extend the phone interview to all super-users. We focused on super-users because we are primarily interested in understanding the user experience. This project is focused on building insights for future practice. By interviewing parents who have interacted with the app at least a few times we would collect rich data on how to further improve the app. They were offered a £10 voucher for participation in a 20 to 30-minute interview.

When few super-users responded to our call for interviews, the Eedi team also sent out interview invitation emails to *all* intervention group parents who signed up to the Eedi app (N = 192). They would also receive a £10 voucher for their participation. This approach was chosen because interviews with non-users would help us understand how Eedi could better introduce the benefits of the parent app. Given the low sign-up rate to the app - considerably lower than our

original lower bound estimation of 400 sign-ups - Eedi was particularly interested in why parents failed to even complete the sign-up procedure. One of the parents in this non-user group took up the interview offer.

In summary, in total five parents responded positively to Eedi, 3 went on to schedule a phone interview timeslot with the Eedi research team. Out of these, two parents showed up at the scheduled time, and were successfully interviewed.

When the direct-outreach approaches did not result in the expected interview numbers, we asked the schools to nominate 3 to 4 parents from intervention classes. We would then reach out to these parents through the school contact. Unfortunately, this work was cut short by the COVID-19 pandemic. Schools had to close their doors and were no longer able to focus on this trial. They had not yet successfully contacted parents for interviews. We ceased further recruitment efforts.

Future lessons regarding recruitment:

- Work with schools to identify parents for interviews from the start. Instead of sending out invitations from Eedi, parents may have been more willing to complete a 30-minute interview if it was requested by the school.
- Collect more than just email addresses from parents. GDPR precludes Eedi from collecting more personal information than necessary, but in this project it would have been helpful to have access to parents' mobile phones. This would have allowed us to reach out in a more personalised manner.

In conclusion, we conducted two interviews only, with one 'super-user' (81 logins) and the second interviewee was an app user but not a super-user (3 logins). The phone interviews were recorded after receiving verbal informed consent.

Interview topic guide

The full topic guide can be found in Annex E. The semi-structured interview guide touches upon the following themes:

Table 13: Themes approaches through semi-structured interviews

<p>Context (business-as-usual without parent app)</p>	<ul style="list-style-type: none"> • How often do parents receive communications from the school? • Specifically within maths, how often do the school / teachers reach out? • Are parents proactive in reaching out to schools themselves?
<p>Recruitment</p>	<ul style="list-style-type: none"> • When did parents sign up? • How did schools introduce the project?
<p>Acceptability</p>	<ul style="list-style-type: none"> • How did parents and pupils react to the intervention? • If applicable, what were the reasons for withdrawal? • How open were parents to sign up to the app?
<p>Impact</p>	<ul style="list-style-type: none"> • What is the parent’s and pupil’s perspective on how the intervention affected them? • Did parents use the information provided to them through the Eedi app to inform their conversations with their child?
<p>Indirect effects</p>	<ul style="list-style-type: none"> • Did the parent app affect learners’ lives in areas that were not anticipated?
<p>Adverse effects</p>	<ul style="list-style-type: none"> • Do parents or pupils report any adverse effects of the parent app?

Unfortunately, due to the extremely limited sample size, we did not get detailed responses on each of the above themes. We will therefore not describe each theme in detail and instead provide a narrative summary of the key points shared by the interviewees.

Sample

Table 14: Interview sample

Interview code	N app logins ⁷	Parent gender	Pupil year	Pupil gender	Pupil age	Timing of interview
PA01	81	Female	7	Male	12	March 2020
PA02	3	Female	7	Male	11	Feb 2020

Results

Business-as-usual: parent-school communication in the absence of the app

Visibility of the child’s maths learning was limited to what the child told their parents. PA01 mentioned that their child had access to various platforms to keep track of their homework, but they themselves did not. Both interviewees did not feel up to date with homework progress in maths class before the trial. They would only get contacted by the teacher if anything went awry - missing homework or poor marks. Both parents appear pro-active, however, as they mentioned reaching out to the teacher at times if they had any concerns.

Additionally, they would receive limited information from their child about progress in class: *"The only time I know if he is late on homework is one the occasion that he ends up with a red mark on the [school's homework] software."* (PA01). One of the interviewees also mentioned that her son was **dismissive** when she asked what he was learning about, or if he had any homework. [A shrug] is *"about as much feedback as I get"* (PA01). The other interviewee spent most afternoons with her child, looking over his homework

⁷ The number of logins listed here is based on app logins – parents may have also logged in via the web platform. These logins are more difficult to track as the website is often ‘cached’ – which means that the parent stays logged in over time, and individual logins cannot be tracked. The second interviewee mentioned that she checked the Eedi webpage more frequently than the Eedi app.

completion. She felt up to date with the child's progress, primarily because she was present in the room whenever he was doing his homework. The negotiation of roles in the shift from primary to secondary school was salient to both interviewees. From knowing both the parents of all classmates - "*You see them in the playground every day*" (PA01) - to not having any interaction resulted in feelings of **disconnection**. At the same time, the parents acknowledge their child's need for greater **independence**: "*He's feeling like he needs that independence*" (PA01). Respecting the child's independence, both parents resisted reaching out to the teacher often.

This negotiation between parents and their children - of connection versus independence - is a pertinent theme found across many studies on parent engagement and school transitions. For example, Davies and colleagues (2011) find that especially parents from deprived neighbourhoods disengage with their child's school at transition points. Adolescence is often seen as a transition period where "the network of significant others is restructured" (Helsen et al., 2000, p. 320) as peer support becomes crucial while parental support diminishes in importance for the child's construction of image and status. Nevertheless, a number of studies find that parental social support is closely related to adolescent well-being, and more so than peer support (Helsen et al., 2000; Malecki & Demaray, 2003; Stice et al., 2004). Perceived parental support is associated with lower incidence of internalising problems in adolescence, such as anxious and depressive symptoms (Stice et al., 2004). Autonomy-supportive parenting, which is characterised by consistent and sensitive parenting behaviour, is associated with higher autonomous motivation for school, greater perceived well-being and competence, and increased engagement and effort (Vasquez et al., 2016). Finally, supportive parenting practices such as providing emotional warmth, clear expectations, and autonomy support are predictive of high academic engagement (Bempechat & Shernoff, 2012).

The challenge remains that, even when parents are interested in supporting their child's learning, an **information gap** occurs. The pupil has information about their learning, such as upcoming homework, grades, missed assignments, which they can decide to share or not. Parents normally only have infrequent

opportunities to close this gap, for example through parent evenings or letters from school. These communications are rarely forward-looking: they normally focus on missed assignments or low grades. Both interviewed parents expressed interest in knowing more about their child's learning, especially what is coming up. Eedi's parent app closes this parent-school information gap.

"In the background I'd quite like for my own piece of mind to know what is happening". [...] "I was quite excited about it at first, because it gives me the visibility I am lacking" (PA01)

Recruitment

Both parents were informed by the school about the trial. Throughout both interviews, it became clear that parents were not fully informed about the nature of the intervention. Both interviewees mentioned that the school decided to trial a new way of completing maths homework, rather than trialling a parent notification element to the already-existing procedure of Eedi quiz completion. To illustrate, PA02 explained that the school informed her that the trial would be *"a way that homework would now be set on a weekly basis"*.

All schools participating in this trial were existing users of the Eedi platform in Years 7 and 8. Therefore, parents' assumption that the present project was trialling the platform for pupils rather than the parent element was incorrect. It should be noted that Eedi provided all participating schools with informational letters about the trial, clearly noting that we are testing the parent element. It appears that schools were not fully successful in conveying this message. We cannot conclude much from two interviews only, but it may be important for Eedi to build in structured parent onboarding communication. Schools may not be able to fully convey the purpose of Eedi's pupil platform and accompanying parent app.

An employee of Eedi offered to deliver parent evenings about the app. Five schools delivered a parent evening in collaboration with Eedi, one school received a visit to help teachers prepare for launching to parents, and three received an online support session. Delivering parent evenings throughout the country would

not be a scalable offer - therefore, creating a set of engaging onboarding videos for parents may be a suitable alternative.

Acceptability

Both interviewees started off with enthusiasm for the app, but lost engagement over time. Their disengagement stemmed from distinct sources:

Challenge: teacher mis-assignment of Scheme of Work

PA01 enjoyed the functionalities of the app, and indeed used them regularly, until the child started receiving almost daily notifications for homework completion and started losing track. Additionally, the child complained that the quizzes were not in sync with what was being taught in class and disengaged further. The list of late quizzes grew longer, and the parent was unable to motivate the child to close the gap: *"It becomes a demotivating thing that there is so much to be done"* (PA01).

The parent also mentioned that the progress app stopped functioning in January 2020. This may occur when (i) two teachers assign a Scheme of Work (SOW) to one single class, which can happen when a teacher ticks the wrong class code when assigning a SOW, or (ii) a class stops using Eedi. The end of January was originally communicated as the end of the trial, so the teacher may have erroneously stopped using the platform. A recommendation to Eedi therefore is to send automatic pop-up notification to teachers when the system detects that a class is assigned more than one scheme of work, as well as warnings when usage drops significantly. Second, teachers may require more on-boarding training to avoid mis-assigning SOWs. Both pupil and parent disengaged from the Eedi platform once lessons and quizzes started to mismatch. PA02 also encountered this problem:

"Sometimes he says, 'we haven't done this', and then he really struggles and doesn't get a very good score in the end. Then I think it is a little pointless".

(PA02)

Challenge: parent self-efficacy in supporting their child's maths learning

PA02 felt that the parent app did not offer many functionalities. The interviewee spent time with her child, every week, completing the Eedi quizzes. As a result, she saw her child's progress via the child's Eedi access. The parent app indeed gives this same information, albeit in a more resuméd format. It could reasonably be expected that the parent notifications are useful to parents who do not closely accompany their child's homework progress. Further, the parent did not explore all possible functionalities of the parent app. She had not explored the functionality of offering encouragement (through emoticons and photos) to the child, nor the tips for planning. When asked if she would be interested in receiving these communications, she answered that:

"I'm not confident I would be the right person to be having a discussion about what he is doing" [...] "I am not the right person to sit with the math and try to teach him" (PA02).

The above quote illustrates the parent's resistance to speaking to her child about **math concepts**, while she was strongly engaged with whether or not her child completed homework. When the interviewer explained that parents are not expected to discuss math concepts (Pythagoras, right-angled triangles) but general planning and understanding of the child's misconceptions, she felt that she would not be able to take the required follow-up action:

"Personally, I would prefer that the onus was put on the school" [...] "I would prefer that the teacher would receive these messages" (PA02)

Both due to the low sample size and lack of convergence between interviewees, the current process and implementation evaluation cannot draw strong conclusions about the acceptability of the Eedi app. On the one hand, the possibility to gain understanding of the child's progress over time was welcomed, and on the other hand the parents might not know what to then do with this information. We encourage Eedi to conduct further follow-up interviews with parents and teachers to gain greater insight into these emerging themes.

Impact

We hypothesised that the parent notifications would encourage parents to speak to their children about maths more often. Again, due to the low sample size we cannot draw conclusions. Nevertheless, the feedback shared by parents may help Eedi think through further iterations of the parent app.

PA01 noted that parent-child communication about maths occurred **more often** during the trial period than before: [We] "*certainly spoke much more about maths*" [...] "*It's good to get a reminder*" (PA01). She felt more **empowered**, due to advance notice of upcoming homework and missed deadlines, to ask her child when he was planning to complete the quizzes. Additionally, she felt more **informed** about the child's achievement thanks to the Progress Graphs ("Analytics") made available through the app.

The second interviewee, as set out in the previous theme, was less positive about the added functionality of the parent app. She agreed that it was useful to have access to the data without having to ask the child but did not feel she had the required knowledge or skills to support her child to overcome misconceptions. A second theme also emerged from this interview: the parent was **resistant** to online homework completion:

"I do prefer paper-based things rather than 'apps for this' and 'websites for that', which I think is the way schools are going these days" (PA02)

Further questioning made clear that the resistance was primarily caused by the mismatch between the classroom teaching and quiz topics. The parent felt that this issue did not occur when teachers delivered paper-based homework assignments on a weekly basis.

We therefore recommend Eedi to consider how to encourage the teacher to continuously re-adjust the Eedi SOW throughout the term. Currently, teachers can set a SOW at the start of the year, which automatically sends out homework quizzes to pupils. As such, teachers may forget to re-adjust the Eedi SOW when topics take longer to teach than expected, resulting in the observed mismatches.

Indirect or adverse effects

We found little evidence on these themes, either in a positive or negative direction. PA01 mentioned that the app resulted in a greater number of conversations about maths, but that this did not spill over to other subjects. Neither parent reported adverse effects.

App functionality

Finally, we summarize positive and negative feedback about the app functionality, as well as areas for improvement.

Positive feedback

- Having access to visual summaries of child performance through regularly updated graphs (PA01, PA02);
- Having an overview of the child's maths learning without needing to ask the child for information (PA01, PA02);
- Ease of seeing upcoming deadlines and missed homework. Enables child and parent to plan ahead. (PA01, PA02).

Negative feedback

- Frequency of quiz deliveries. Both parents felt that the frequency was too high. They suggested quizzes should be limited to a maximum of 2 per week to ensure the child does not fall behind (PA01, PA02);
- Quizzes started getting out of sync with lessons over time - as discussed in the main text, teachers may not have updated the Eedi SOW regularly enough as their teaching schedule changed (PA01, PA02).

Ideas for further improvement

- Insert clearer view of when quizzes were completed - so the parent can see how many their child completed per week (PA01);
- Explore additional graph options, such as a bar graph per week, colour coding, plotting activity over time (PA01);

- Consider only showing an X number of missed quizzes, when the list is long: “He is willing to put in a bit of work in, but if he sees hours and hours of work, it puts him off” (PA01);
- Keeping the number of quizzes per week consistent so that parent and child can plan the homework schedule ahead (PA02);
- Parent encouragement did not show up on the child’s web app; either it should be clearer that encouragement will only be delivered via the app, or the modes should be integrated more successfully (PA01).

Recommendations

Recommendation 1: Design easy-to-access parent-onboarding materials

Include information on (1) who sets the homework, because parents may erroneously assume the system itself assigns topics, when the teacher actually has direct control, and (2) web and app functionality for parents.

Recommendation 2: Remind teachers to update SOW on Eedi platform

The bottleneck of successful implementation appears to lie with teachers forgetting to re-organise the Eedi quiz dates when their teaching schedule changes. For example, Eedi may experiment from reminders every few weeks, directing teachers directly to the Eedi SOW planning.

Recommendation 3: Explore making the app available for other subjects too

Both parents mentioned that the child has to access various platforms to get information about their upcoming homework, from class WhatsApp groups, to dedicated homework platforms (ePraise, Show My Homework). This can be confusing. If a school uses Eedi across subjects, the platform can also be used to aggregate all information about upcoming and overdue homework.

Conclusion

This project aimed to test the impact of the parent app on the child's learning in maths, across Years 7 and 8. We hypothesised that providing parents with simple actions to help their child plan their learning and overcome misconceptions would improve pupil effort and achievement through improved parent-child communication.

Pupils in classes that received access to the parent app did not achieve higher attainment in maths than pupils in control classes, as measured by quiz scores on the Eedi platform. Additionally, they did not attempt significantly more questions than their peers in control classes. Pupils eligible for Free School Meals showed lower levels of effort and attainment, while those categorised as English as Additional Language showed higher levels of effort and attainment.

These findings do not provide conclusive evidence on the effectiveness of the parent app: only one fifth (20.6%) of parents assigned to the intervention group proceeded to sign up with their parent code. As such, a small number of parents (N = 192) received access to real-time information about their child's learning and simple actions to complete. Because the vast majority of intervention parents never took part in the intervention, it is likely that the impact estimate is brought down by the observed non-participation. Further, the platform data shows that quiz completion varies strongly by teacher. How the teacher implemented the Scheme of Work appears to have had a strong effect both on student motivation and effort, and the usefulness of the parent notifications. Some teachers clearly enforce Eedi quiz completion, as evidenced by high average completion rates for the whole class. As randomisation was performed at the classroom level, the teacher appears to have had a stronger effect on treatment estimates than parent app access.

Exploratory analyses did not provide evidence that students systematically varied by condition on our secondary outcomes (providing explanations, reviewing incorrect questions, and engaging with the improve section). A complier average causal effect analysis suggested that, among parents who complied with the intervention (or those in the control group predicted to have complied with it,

had they been offered the option), children in the intervention group were slightly less likely to answer assigned question and slightly more likely to answer questions correctly (or correct questions after answering them incorrectly). However, particularly due to the very low number of compilers (N = 60, or about 6% of all intervention parents), it would be premature to assume that these effects generalise beyond the current trial.

The process and implementation evaluation similarly suffered from sample size restrictions. Parent survey completions were low, as well as sign-ups to the semi-structured phone interview. Nevertheless, the clearest emerging theme suggests that the implementation challenges seem to stem primarily from an imperfect implementation of the Eedi platform by participating teachers. Parent notifications delivered through the parent app or web functionality will be unlikely to benefit parents and pupils as long as the frequency and timing of the maths quizzes is irregular and suboptimal. A number of suggestions for app functionality improvements are offered in the final section of this report.

In conclusion, the trial recruitment and implementation challenges preclude us from being able to provide clear evidence on the effectiveness of the parent notifications. Future trials may benefit from randomisation at an individual level, as classroom-level implementation makes it difficult to disentangle the effect of the teacher on quiz completion rates from the effect of the parent app. This trial was randomised at the classroom level for pragmatic reasons: sign-up was encouraged at parent evenings, which were organised by class.

The intervention - parent notifications - was delivered over a relatively short period of time of 5 to 11 weeks, depending on the school onboarding date. Additionally, pupil attainment was not measured through formal in-class assessments due to timing of the implementation - final exams were due later in the term. Both effort and attainment were measured only via the Eedi platform. Future trials may explore collecting national attainment data, which would likely be considerably less affected by teacher implementation of the platform. Additionally, this trial's low parent participation rates lead to a lack of clarity on the confidence we can have in our treatment estimates. Before the parent app is

further rolled out, it would be advisable to conduct a more detailed qualitative study with teachers to understand how to better integrate Eedi with teachers' (constantly changing) Schemes of Work.

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Annexes

Annex A: Code for randomization

```
## Make reproducible. Set seed according to day of randomization
(DDMMYYYY) + sequential number for analyses on the same day. Randomize
classes in ascending order based on their EEDI class ID.
## First analysis on August 28, 2019 would be 290820191, second analysis
290820192.
## On a new day start sequence anew
RNGversion("3.5.2")
set.seed(290820191)

## Create a vector with each class code
class <- c("a", "b", "c", "d", "e")

# Randomize the order of the vector
class_r <- sample(class)

## Create a vector with the conditions, with as many conditions as there are
classes, half being "Exp" and half being "Con". If the number of classes is
uneven, create one extra condition to balance them (half should still be "Exp"
and half "Con").
condition <- c("Exp", "Con", "Exp", "Con", "Exp", "Con")

# Randomize the conditions
condition_r <- sample(condition)

# Join into a common table, make dataframe.
class_by_condition <- as.data.frame(cbind(class_r, condition_r))

## Print the results. If uneven number of classes, IGNORE LAST ROW. Then
document the results. Don't forget to replace "N" with the same number as
above
```

class_by_condition

Annex B: Covariate-adjusted results for effort and attainment

Effort

Table B1: Covariate-adjusted primary results, effort

	Estimate	Standard Error	z-value	p-value
Intercept	-1.513	0.402	-3.760	<.001
Condition (Exp)	-0.391	0.291	-1.345	.179
FSM6 (Yes)	-0.524	0.013	-41.796	<.001*
EAL (Yes)	0.319	0.013	24.654	<.001*
Gender (Male)	-0.420	0.008	-55.426	<.001*
KS2 (Normalised)	0.371	0.010	36.864	<.001*
Year (Year 8)	0.014	0.395	0.036	0.971
Age	0.191	0.012	16.369	<.001*
Condition * FSM6	-0.037	0.017	-2.170	0.03

*all < 2×10^{-16} , model based on 1720 observations.

The ICC for students within classrooms was estimated at 0.429, and the ICC for classrooms within schools was estimated at 0.334.

Table B2: Odd-ratios and 95%CI for covariate-adjusted primary results, effort

	Odds-ratio	95% CI
Intercept	0.220	0.095, 0.505
Condition (Exp)	0.677	0.379, 1.204
FSM6 (Yes)	0.592	0.578, 0.607
EAL (Yes)	1.375	1.341, 1.410
Gender (Male)	0.657	0.647, 0.667
KS2 (Normalised)	1.449	1.421, 1.478
Year (Year 8)	1.014	0.464, 2.228
Age	1.21	1.183, 1.238
Condition * FSM6	0.964	0.932, 0.996

Attainment

Table B3: Covariate-adjusted primary results, attainment

	Estimate	Standard Error	z-value	p-value
Intercept	-1.662	0.304	-5.475	<.001
Condition (Exp)	-0.119	0.213	-0.557	.578
FSM6 (Yes)	-0.450	0.0122	-36.743	<.001*
EAL (Yes)	0.201	0.013	16.074	<.001*

Gender (Male)	-0.242	0.007	-34.856	<.001*
KS2 (Normalised)	0.652	0.010	63.351	<.001*
Year (Year 8)	0.04	0.288	0.139	.89
Age	0.06	0.011	5.557	<.001
Condition * FSM6	0.037	0.017	2.124	0.03

*all < 2×10^{-16} , model based on 1720 observations.

The ICC for students within classrooms was estimated at 0.286, and the ICC for classrooms within schools was estimated at 0.327.

Table B4: Odd-ratios and 95%CI for covariate-adjusted primary results, attainment

	Odds-ratio	95% CI
Intercept	0.19	0.101, 0.354
Condition (Exp)	0.888	0.581, 1.356
FSM6 (Yes)	0.638	0.622, 0.653
EAL (Yes)	1.223	1.193, 1.253
Gender (Male)	0.785	0.775, 0.796
KS2 (Normalised)	1.920	1.882, 1.959
Year (Year 8)	1.041	0.588, 1.842
Age	1.062	1.039, 1.084
Condition * FSM6	1.0378	1.003, 1.074

Annex C: sample of Eedi app messages for parents

Type	Template	Action	Outcome (if completed)
Late Homework	Each Eedi homework takes about 10 minutes to complete	Ask {{studentFirstName}} to complete their overdue homework on {{quizName}} 📅	Yay! {{studentFirstName}} has now completed this homework
Zero Attempts	{{studentFirstName}} hasn't completed any maths homework on Eedi yet 😞	Ask if {{studentFirstName}} can log in to eedi.co.uk 📧. If they can't, let us know - parents@eedi.co.uk	Yay! {{studentFirstName}} has now completed their first quiz!
ZeroAttempts	Having lots of overdue homework can make it hard to get back up to date 😞	Tell {{studentFirstName}} that Eedi recommends that they spend 30 minutes a week on their overdue section 📅	Yay! {{studentFirstName}} has now completed their first quiz!
QuizResults	In {{quizName}}, Eedi helped {{studentFirstName}} to identify {{incorrectAnswersCount}} misconceptions	Understand {{studentFirstName}}'s misconceptions by reviewing their report at https://app.eedi.co.uk	(No follow-up action)
QuizResults	{{studentFirstName}} got full marks in {{quizName}} 🎉	Give {{studentFirstName}} a high-five from Eedi! 🙌	(No follow-up action)
QuizResults	We think {{studentFirstName}} needs some support based on their recent quiz results	Ask {{studentFirstName}} to show you their {{quizName}} results by logging in to Eedi and going to the "done" section. Tip: suggest they spend 20 minutes practicing in the 'improve' section.	(No follow-up action)
QuizResults	{{studentFirstName}} did not review any results to questions they got wrong last week. This means they do not know where they went wrong 😞	Suggest that next week {{studentFirstName}} spends 5 minutes reviewing the results at the end of a quiz	Yay! {{studentFirstName}} has reviewed some of their questions
QuizResults	{{studentFirstName}} reviewed some of the results to questions they got wrong last week! 🙌	Discuss with {{studentFirstName}} what they learnt by looking at these results 📅	Yay! {{studentFirstName}} has reviewed all of their questions
ParentReport	After {{studentFirstName}} completes a quiz you can view the results and effort in our reports 📄	Check this out on your Eedi profile here: https://app.eedi.co.uk	(No follow-up action)
SchemeProgress	{{studentFirstName}} has completed {{completedAssignmentsCount}}	Give {{studentFirstName}} a high-five from Eedi! 🙌	Ask {{studentFirstName}} to show you their new results

	nt}} assignments and doesn't have any misconceptions 📖		
SchemeProgress	{{studentFirstName}} has {{unresolvedMistakesCount}} misconceptions to resolve	Ask {{studentFirstName}} to show you what they need to work on in their Eedi Improve section	{{studentFirstName}}'s number of misconceptions has changed. Check their recent results for more information.
SchemeProgress	{{studentFirstName}} has completed all of their quizzes! 📖👏	Tell {{studentFirstName}} to keep up the good work from Eedi! 😊	Updated information: {{studentFirstName}} has completed {{completedAssignmentsCount}}/{{assignmentsCount}} quizzes
LastLogin	{{studentFirstName}} has never logged in to Eedi	Check to see if {{studentFirstName}} can login to Eedi. If not, talk to their teacher for the login details	Yay! {{studentFirstName}} has now logged in to Eedi
LastLogin	{{studentFirstName}} last logged into Eedi {{daysSinceLastLogin}} days ago	Please remind {{studentFirstName}} to log in to check for any homework on the dashboard	Yay! {{studentFirstName}} has logged in to Eedi recently

Annex D: Parent questionnaire

Note: the same survey was sent out to parents pre-trial and post-trial.

This parent survey is designed to find out how your child is developing, over the course of the trial, in relation to their homework. There are no right or wrong answers, please just answer as honestly as possible! Your responses will be fully anonymised and will not be shared with the school.

You will see several statements about how you relate to your child's homework. Please indicate, for you and your child, how often you engage in each of the behaviours. Please read each item carefully and be as honest as possible; there are no right or wrong answers. Your responses will be fully anonymised and won't be shared with the school.

Measure/construct/item	Response options, processing
Demographic questions	
What is your age?	Free text field
What is your Eedi parent code?	Free text field
What is your email address?	Email
How many children live in your household (in total)?	Drop-down box: 0, 1, 2, 3, 4+
Do you consider yourself a single parent?	Three options: Yes, no, other (please specify ___)
What is your level of education?	Options: Degree or equivalent, Higher education, A Level or equivalent, GCSEs grades A*-C or equivalent, Other qualifications, No qualification, Don't know
Is English your native language?	Options: Yes, No
Is a language other than English used every day in your household?	Options: Yes (which language? ___), No
In general, how often do you speak to your child about their maths homework?	Never Less than once a week About once a week About twice, three times

a week
 About four, five times a week
 Always

Quality of homework involvement.

Control (higher scores undesirable)	<ol style="list-style-type: none"> 1. I help my child with homework even when they do not need help 2. I interrupt my child while he/she is doing homework 3. I sit next to my child while he/she is doing homework and immediately correct any mistakes he/she makes 4. I tell my child there will be consequences (e.g, restricted TV) if they do not put enough effort into his/her homework 5. I express frustration or disappointment with my child over their performance during homework completion 6. I have to instruct my child to do his/her homework for them to start doing homework 7. I remind my child that the child must complete his/her homework 8. I check or ask if the child has completed his/her homework 	<p>5-point scale:</p> <p>1 - never 2 - once in a while 3 - half the time 4 - very often 5 - always</p> <p>Averaged within the subscale</p>
--	--	--

Responsiveness (higher scores desirable)	<ol style="list-style-type: none"> 1. I help my child with his/her homework if they ask for help 2. I am attentive to my child's emotional needs while he/she completes homework 3. I help manage my child's emotions so he/she can complete their homework 4. I comment on my child's mistakes in 	<p>5-point scale:</p> <p>1 - never 2 - once in a while 3 - half the time 4 - very often 5 - always</p>
--	--	--

	homework privately and not in front of other people	Averaged within the subscale
	5. I view mistakes my child makes in homework in a positive light	
	6. I am glad if my child provides answers in homework that are different from what is expected but interesting	
	7. I tell my child that he/she has the ability to overcome difficulties in homework	
	8. I make sure my child does not feel incompetent when they find homework to be difficult	
	9. I make my child feel that he/she is important and special while they work on homework	
	10. I give our child the feeling that he/she is valued even if he/she does not understand the homework	
Structure (higher scores desirable)	1. I have a consistent reaction to when the child asks for help with homework	5-point scale: 1 - never
	2. I make sure my child has a quiet environment, free from distractions (e.g., TV, music) to complete his/her homework	2 - once in a while 3 - half the time 4 - very often
	3. I avoid interrupting my child with questions and other tasks (e.g., chores) while the child is doing homework	5 - always
	4. I make sure my child has the necessary tools (e.g., pens, ruler) when completing homework	Averaged within the subscale
	5. I make sure my child has enough desk space and proper lighting while completing homework	
	6. I clearly communicate with my child when	

- homework is to be completed
7. I have a set time period in the day when homework is to be completed
 8. I make sure there are predictable consequences for not doing homework, or exerting enough effort
 9. I make sure my child dedicates an appropriate amount of time doing homework each day

Annex E: Interview guide

Super Users: parents who downloaded the app and used it at least 5x

Introduction

I'll tell you a little bit about the project first. Then, I'll ask you to confirm verbally if you are happy to take part in this short interview.

My name is {Sam/Bibi/Diogo} and I work at {Eedi / CLOO}. We are testing if the Eedi parent app can help improve maths learning in your child's school. Your child completes {his/her} maths homework on the Eedi platform, and parents can receive customized info about their child's progress.

This interview will take around 20 to 30 minutes. There are no right or wrong answers. If you don't understand a question, just let me know. You can also stop the interview at any time without giving me a reason. Your answers will not be linked back to you by anyone, so feel free to speak openly.

We'll record this call, so we can share it with our researchers. It will be shared with our research partner CLOO. Please confirm if you are happy to take part?
{yes i do / no I do not}

You will receive a £10 voucher for your participation. Which will be sent to your

email, and could take up to 30 days to process.

Part 1: context

First, I would like to know a bit more about the communication between you and your child's school, specifically in maths.

Last year, how did you learn about your child's maths learning?

Did the school reach out to let you know of your child's learning in maths?

- who usually reaches out?
- how often? too much, too little?
- did you understand what topics your child was struggling with, and how you could help?
- Did you understand their strengths?

Did you ever contact the school to discuss maths?

- What were you most interested in discussing with them?

Part 2: acceptability + fidelity

What did you think about Eedi and the parent app when you first learnt about it?

How often did you use the app?

- How were you reminded to log in? Did it become a routine?

What did you like about the app?

Is there anything you wish the app could do?

Did you discuss your child's maths with {him/her}?

- did you discuss anything specific you learnt from the parent app? what did you talk about?
- was your child aware you knew about their maths progress through the Eedi app? What did they think about this?

How did you talk about maths before having access to the app, and how do you talk now? What changed?

How were you introduced to the Eedi parent app?

- Who introduced it to you?
- What did they say the purpose of the app was?
- Was it clear to you how you were supposed to use it?
- Was it clear to you who to ask if you ever had questions about the platform?
- How could that process be improved?

Why did you sign up?

- What did you expect to be able to do on the app?
- What info did you expect to see there?

Did you have any difficulty signing-up?

Do you have any suggestions for how you would improve the app?

Part 3: indirect and adverse effects

Would you say you spoke more or less about your child's learning because of this project?

Did you speak about other subjects (i.e. beyond maths) because of the app?

How did you feel when receiving the Eedi app messages?

- Any positive feelings?
- Any negative feelings?

Part 4: end

Thank you for taking the time to speak to us. Is there anything else you would like to tell us about?

[end the interview]

Low Users: parents in intervention group who never used the app (but might have downloaded it)

Introduction

I'll tell you a little bit about the project first. Then, I'll ask you to confirm verbally if you are happy to take part in this short interview.

My name is {Sam/Bibi/Diogo} and I work at {Eedi / CLOO}. We are testing if the Eedi parent app can help improve maths learning in your child's school. Your child completes {his/her} maths homework on the Eedi platform, and parents can receive customized info about their child's progress.

This interview will take around 20 to 30 minutes. There are no right or wrong answers. If you don't understand a question, just let me know. You can also stop the interview at any time without giving me a reason. Your answers will not be linked back to you by anyone, so feel free to speak openly.

We'll record this call, so we can share it with our researchers. It will be shared with our research partner CLOO.

Please confirm if you are happy to take part? {yes i do / no I do not}

You will receive a £10 voucher for your participation. This may take up to 30 days to process.

Part 1: context

First, I would like to know a bit more about the communication between [school name] and parents, focusing specifically on maths.

Last year, how did you learn about your child's maths learning?

Did the school reach out to let you know of your child's learning in maths?

- who usually reaches out?
- how often? too much, too little?
- did you understand what topics your child was struggling with, and how you could help?
- Did you understand their strengths?

Did you ever contact the school to discuss maths?

- What were you most interested in discussing with them?

Part 2: acceptability + fidelity

How were you introduced to the Eedi parent app?

- Who introduced it to you?
- What did they say the purpose of the app was?
- Was it clear to you how you were supposed to use it?
- Was it clear to you who to ask if you ever had questions about the platform?
- How could that process be improved?

From our data we understand that you never actively used the app.

Can you tell us why?

- Did you complete any steps of the sign-up process? (if broken off, ask why)
- Can you tell us what kept you from opening it more regularly?
- Was the idea of having more information about your child's math

learning relevant to you?

- What about your child or partner? How did they feel about the Eedi platform and app?

Would you recommend any changes to the app to make it more appealing?

Could we change anything about the introduction process to make the app more appealing?

Do you know any parents who used the app? What did they tell you about using it?

- Would you be interested in giving it another try?

Part 3: end

Thank you for taking the time to speak to us. Is there anything else you would like to tell us about?

[end the interview]