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Abstract

Effectively involving low-SES parents in human capital development
Evidence from a field experiment*

In this paper we analyze the effect of involving parents in human capital investment. We study the effect of a parental app on student effort in a digital homework practice tool, and its effect on subsequent human capital development. The randomized field experiment includes more than 2000 7-9 grade students of 2 schools and we specifically focus on different socio-economic status (SES) groups. The results indicate that parental involvement via an app positively affects effort and human capital development of 7th and 8th grade students, but not of 9th grade students. The positive effects are mainly driven by low-SES students and are larger for males.

JEL classification: I20, I21, I24, C93
Keywords: parental involvement, randomized field experiment, socio-economic status (SES), student effort, human capital development, secondary education

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1. Introduction

In traditional human capital models, ability and effort are seen as the basic determinants of the learning outcome and most studies analyse the investment decision regarding effort. In recent years, economists have increasingly paid attention to the role of incentives to foster student effort, mostly with the framework of behavioural economics in mind (for an overview, see Lavecchia et al., 2016). Most of ability and effort that contribute to human capital development take place in traditional education settings, but at home, parents also contribute to the human capital of their children (Cunha & Heckman, 2007; Heckman & Mosso, 2014). This happens through the relation between family background and educational outcomes (Sirin, 2005), but also via specific parental involvement, with the aim to increase (additional) effort towards human capital development. However, the effective time investment of parents regarding their children's human capital development varies strongly, not least with the socio-economic status (SES) of the parents and their educational level (Green et al., 2007), and it is unclear how to increase effective time investment.

This paper uses a randomized field experiment to study 1) whether a parental app can increase parental involvement in effort and human capital investment of students in lower secondary school, and 2) the extent to which the effect differs by SES and gender. We conducted an experiment in two schools in the Netherlands, involving *all* students in grades 7-9 of these schools. Parents were randomly selected to be invited to use a free app to be informed about their children's effort and cognitive development in mathematics and language in a digital homework tool. The app provided detailed information on whether their child put in effort (practiced with the tool), on math and language performance, and on effort and performance of classmates of their child. To gather information on student effort and performance in the digital tool, student background, earlier student performance and on

potential mechanisms, we use information from the digital practice tool, the school student administration system and from parent and student questionnaires.

From the literature it is unclear whether parental involvement can be manipulated to positively contribute to student effort and subsequent human capital development. Although there are many studies on effects of parental involvement, most studies use correlational analyses, fixed effects, or structural approaches (e.g. Todd and Wolpin, 2008; Cunha & Heckman, 2008; Aizer, 2004; Welsch & Zimmer, 2008), and there is a lack of experimental evidence on this (Avvisati et al., 2010). Only a few studies exist on the causal effect of parental involvement on effort and human capital development (Bergman, 2019; Mayer et al., 2018; Balli et al., 1998; Avvisati et al., 2014). Given the increasing use of technology, both at home and in schools, the question is whether technology can be used to effectively involve parents, including the low-parents. However, the existing studies mostly include non-digital interventions (Bergman (2019) and Mayer et al., (2018) being the exception) and are only able to show the effect on student behavior and effort but not on human capital development (again, Bergman (2019) being the exception).

This paper contributes to the literature in a number of ways: First of all, this individually randomized study with more than 2000 students has sufficient power to show an effect of the intervention if present. Although the previous experimental studies did find effects, they were a priori underpowered. Second, this study evaluates an intervention that does not cost a lot of effort or money from the school or the parents. The previous experimental studies mentioned above were cheap in financial costs yet were costly with respect to effort required from the school/teachers and/or the parents. Third, we do not only study the effect of parental involvement on student effort, but also on human capital development in mathematics and languages, whereas previous students did not study or were not able to show effects on student performance. Lastly, the study includes all students, not only socially deprived students, which

makes the external validity higher than some of the previously conducted studies that only focused on socially deprived neighborhoods and parents. However, similar to the previous studies, we *are* interested in the differences between different SES groups.

The analyses reveal a significant positive effect for 8th grade students from the provision of free access to a smartphone app, which allows parents to follow-up on their children's effort and mathematics and language performance. We find negative effects on effort of 9th grade students. Subgroup analyses show that the positive and significant effects that are found (both on effort and on human capital development) are more prevalent for male students and are mostly driven by the low-SES students, whereas the negative effect of the parental app on student effort in grade 9 is also due to the high-SES students. Further analyses of potential mechanisms reveal that there seems to be a better match in the needs and offers of parental involvement by children and parents in 7th and 8th grade, and not so much in 9th grade. Furthermore, it seems that the ranking of the child in the family can explain some of the findings, as it does seem that if low-SES parents can be persuaded to be more involved in their children school work, they will do so for all their children equally, whereas parents in the other two SES groups are significantly less likely to be involved through an app for their younger children than for the oldest child. We do not find any evidence for a substitution effect for high-SES parents and students.

In the following paragraphs, we continue with a section on background and experimental design, followed by descriptive statistics and the methodology used. The results section first focuses on the effect of the app on student effort, thereby analyzing all students as well as elaborating on the socio-economic heterogeneity of the effect. This is followed by the results on human capital development (math and language performance) and various robustness checks. Lastly, we discuss the descriptive outcomes of both a parent and a student

questionnaire, which we link to the causal effects that we find, and we analyze potential mechanisms of the effect we find for low-SES students. We finalize the paper with a discussion.

2. Background, Research Context and Experimental Design

a. The schools under study

The two schools under study are - to Dutch standards – both mid-sized schools for secondary education (junior high and high school), located in the Southern part of the Netherlands, in the province of Limburg. Both schools offer secondary education in all tracks[1] and are tracking students from 7th grade on in several prevocational, general and pre-university tracks. The two schools have 2169 and 2522 students respectively (national average M = 1514, SD = 1177), 182 and 212 FTE teachers employed (national average M= 124, SD = 104), a graduation percentage of 96 and 95 percent (national average M= 92, SD = 4), an average national exam grade of 6.8 and 6.6 (on a scale from 1 to 10) (national average M = 6.4, SD = 0.2) and a share of students that have to retain a grade of 3 and 6 percent (national average M =6 percent, SD = 7).[2] Hence, the students of both schools are doing relatively well in terms of performance.

b. The broader research context

The randomized field experiment with the parental app was part of a wider research project that studied the effect of parental involvement on whether students would do their homework in a digital practice tool[3] and the effect of (practicing with) this digital homework tool on math and language performance of secondary students (a so-called ITS, intelligent tutoring system, see Bartelet et al. (2016), Haelermans and Ghysels (2017) and Ghysels and Haelermans (2018)

[1] Dutch secondary education has a tracking system from 7th grade on, with 3 different tracks: prevocational education (which consists of 4 sub tracks where level 1 is the lowest (mainly practical) track and level 4 the highest (mainly theoretical) track), general higher education and pre-university education.

2 The data are from October 2014, and are obtained from the governmental website containing the Dutch open education data (https://www.duo.nl/open_onderwijsdata/databestanden/vo/).

[3] See Online Appendix 2 for more information on the digital homework tool Mousework

for literature overviews and effects from earlier studies on this ITS). This research project was set out in two secondary schools in the Netherlands, and included all students in grade 7, 8 and 9, with a total of 2450 students participating in the study[4]. All students were supposed to practice 30 minutes per week for math and 30 minutes per week for language with the digital homework tool, during one school year. For each class a specific teacher was assigned to keep an eye on this and motivate students to practice. The students' performance on math and language was measured using digital standardized validated tests (see Section 3d*ii*). They wrote a pretest in September 2014, a first posttest in January/February 2015 and a second posttest in June 2015.

The relevant policy context of the experiment are new learning goals introduced for the national graduation exam in order to tackle a lack of basic language and math skills in the Dutch population that was qualified as "problematic" (Commissie Meijerink, 2008). Van Groenestijn (2007) reported earlier on substantial deficiencies. Depending on the secondary education track, 10% to 50% of first-year secondary students (7th grade) have mathematics skills equivalent to or lower than the skills they are expected to possess at the end of Grade 4. Schools reacted to the new learning goals in a variety of ways, from highly targeted remedial teaching to extended teaching for all students. The schools under study decided to offer a digital homework tool for individual use at home, without specific action at school apart from communication about the new graduation exam and follow-up of the practicing behavior by (some) teachers. It was assumed that the didactical efficacy of the ITS, combined with the existing teaching of math and language, would suffice to reach the required skill levels. Moreover, the introduction of the new exam requirements was hotly debated in Dutch media,

4 Technically, this project was set out in three secondary schools. However, the third school was a lot smaller, only participated for Dutch language, and used a different student registration system, to which parents could *not* logon, contrary to the other two schools, implying a completely different control condition for the effect of parental involvement. Therefore, this third school was not comparable (although results were fairly similar when the school was included in the main analysis) and was therefore left out of the analysis for the paper at hand and is consequently not further mentioned in this paper.

which is likely to have motivated parents to take an interest in the topic and help motivate their children to use the tool effectively.

c. The randomized experiment with the parental app

Previous studies have shown that students are not necessarily intrinsically motivated to do their homework in the digital practice tool, but students tend to use it more frequently when they are motivated to do so by for example their teacher (Haelermans & Ghysels, 2017). Therefore, the above described research project also included a parental aspect, examining whether parental involvement via an app would increase the amount of homework time students spent in the digital practice tool, and whether that in turn would lead to higher performance. The app was free of charge and available for both IOS and Android. The app allowed parents to log on to the Mousework system with their child's login number (student number). Once logged in, they could see the number of minutes practiced per week, separately for math and language, in the current as well as in preceding weeks. They could also see a comparison between their child's practice behavior and the practice behavior of its classmates, and compare their child with him/herself over time. Furthermore, there were performance data available, again over time and compared with classmates, and a suggestion which aspects of math and language would still need to be improved. Parents could choose to look at the raw numbers, or read a short written story that was automatically generated based on these numbers. The app enabled parents to add multiple children to the app and follow all of them simultaneously.

The app registered the child's login number every time the parent logs in. Unfortunately, it was not possible to register what exactly the parent was looking at when logged in to the app. In case of multiple children, the app does register for which child the parent has logged in though.

As part of the experiment, only about half of the parents could actually log in to the app (as will be further explained in the identification strategy in Section 4a), whereas the other half did not have access (created as such that this was technically impossible). However, *all* parents where asked and motivated to download the app, for two reasons: 1) The app was not new and had already been promoted by the representative of the digital practice homework tool in the the year prior to the intervention. We wanted to prevent building on a previously existing potential information and selectivity problem (potentially leading to inequality in information, favouring student from better informed and more active parents, which are often the higher educated parents), and therefore chose to actively inform all parents about the app; 2) Given this first aspect, we wanted to get information on the willingness of parents of using the app at all, or rather, to get an idea about the selectivity of parental involvement using a digital tool such as this. Only after downloading and logging in (or trying to) parents would find out whether they were assigned to the treatment or control group. Parents who belonged to the control group would, upon trying to log on, get a message reminding them of the experiment and clarifying that they would be able to login to the app after January 2015 (i.e. for the second part of the schoolyear).

Parents were informed about the experiment in two ways. First of all, they received a letter via their child's school, explaining the study in plain, non-technical, language, and asking for their cooperation. Furthermore, the parents were informed at the yearly parental information meeting at the start of the school year. In the one of the two schools, the researchers presented the research and informed and motivated the parents to participate, whereas at the other school this was done by the personal mentor of each class (requested by the school, for organizational reasons). Although parents could use the app as often as they pleased, in both the letter and at this meeting, they were advised and asked to use it at least once a week.

Figure 1 shows the timeline of the parental app experiment. The experiment lasted for 14 to 18 weeks, depending on when exactly the students wrote the pre and posttest (as all students and classes in grades 7-9 were tested, and the number of computer rooms at the schools were limited, testing took a couple of weeks). In summer, students and teachers were assigned to classes. In week 32 randomization took place by the researchers, and in week 35 the school year started. Shortly thereafter, students wrote the pretest. At the same time, the schools organized parent information nights, in which the experiment was explained. Note that parents also received a letter which explained the experiment in the week before the information nights. At the end of the experiment, in week 48, we handed out parental questionnaires, to get additional background information from the parents, and the questionnaires were collected right after the Christmas break. A student questionnaire was filled out in the week after the posttest was written (it was logistically impossible to do this at the same time). With this, the experiment of the first semester, i.e. the parental app experiment, and the first part of the larger experiment came to an end.

[Figure 1 around here]

3. Data

a. Data sources

Data are collected, and merged at the student level, from multiple sources: 1) Statistics Netherlands, from which we collect family and parental background information, 2) the administrative system of the schools, from which we collect student background data and data on the parental use of the student administrative system and, 3) the Back office system of the digital homework tool Mousework, from which we collect practice data and student

performance on the tests, and 4) student and parental questionnaires, from which we collect additional information on both children's and parents' attitudes towards parental involvement.

b. Microdata from Statistics Netherlands

The microdata from Statistics Netherlands is register data, containing demographic, labor market (when available through tax administration data) and educational data, among others, on all residents of the Netherlands. From this source, we have access to job market information (whether someone has a job, income[5], fte and the financial situation of the household (from now on referred to as household funds), data on the educational level of parents and family information, such as the number of people in the household, the number of parents born abroad, the immigrant generation of the child, the birth year of both parents, and the Socio-Economic Status (SES) of the family. The Socio-Economic Status of the family is calculated based on the Dutch tax authorities' regular practice to define the total taxable household income, which sums the income of father and mother plus 4% of the household funds. By regular practice of the OECD equivalence scales (OECD), we divide this number by the square root of the number of people in the household to obtain an equivalized income (income adjusted to the composition of the household). This procedure eventually gives us an indication of SES. If parents are not registered to the same household number, we only include mothers' information, (because a large share of children lives with their mother when the parents are separated), unless it is explicitly registered that the child lives in the same household as the father.

c. The administrative system of the schools

i. Student background data

[5] This measure includes income from all sources, so not only from labor, but also from social security, among others.

From the school administrative system, we have information on the students' grade level, the average score on the primary school ability test, gender, age and situation at home (both parents living at home vs. parents having divorced or one parent being deceased). We merged these school data to a neighborhood SES indicator that is constructed by the Netherlands Institute for Social Research (SCP) at the 4-digit postal code level, roughly corresponding to a district. This variable is constructed by the Netherlands Institute for Social Research (SCP) and is constructed at the 4-digit postal code level, roughly corresponding to a district.

The experiment includes all students in grades 7-9 of the two participating schools, which amounts to 2450 students in total. First, the 2450 students are matched to the Microdata of Statistics Netherlands based on address, gender and date of birth. A total of 25 students cannot be matched because address, gender and date of birth do not uniquely identify them in the data (e.g. in the case of identical twins or immigrants). Of the 2425 remaining students that we can match to the microdata, 339 cannot be matched to the labor market data (i.e. household income and income from at least the parent that the student lives with in a household) that we need for our SES indicator, because we cannot identify their parents in the microdata or because the parents have missing information on the income data[6]. For five students we do not have all background information on previous performance, leaving us with a coverage of 85% (2081 students) of the students from the baseline sample.[7]

ii. Parental use of school administrative system

An important element of the context of our experiment regards the pre-existing means of digital follow-up offered to parents. Both schools have an electronic learning management system,

[6] The microdata shows that these parents do have a labour market status (e.g. employed, unemployed, on social benefits, etc.), and thereby an income, but that the income information is missing. Additional analyses show that this is not a selective sample with respect to student information, background data, or assignment to treatment.
[7] Note that this is higher than for example Golsteyn and Hirsch (2016), and Bee et al. (2016), who match between 76 and 81 percent of their original sample and who attribute the failure to link some individuals to the non-filing of taxes.

where among others students' background information, grades, schedule and homework are registered. Both schools have given parents access to the learning management system, such that parents can, for example, check on their child's homework and grades. Both schools have introduced the parental login in 2013/2014, and parents have received a once-only email at the start of that school year with some information and their login name. Parents of new students receive a similar email at the start of the school year when the child enters the school. The parents' email address(es) are also registered in this administrative system, and the schools use this to communicate with parents throughout the school year, additional to paper messages. On average, parents log in to this system about twice per week (an average of 48 times in the first semester, for the approximately 67% of parents that use their login at least once) , although there are differences between grade levels and SES-groups. Parents from lower grades log in more often whereas low SES-parents log in less often[8].

The number of logins provides interesting reference information for the parental involvement experiment, because it serves as a signal of involvement and more particularly of the willingness of parents to use an electronic instrument to get involved in the education process of their child. Therefore, we include this characteristic as a control in our analysis.

d. The Back office system of Mousework

i. Use of the homework tool

The main purpose of the parental app that is studied in this paper is to stimulate parental involvement and, by doing so, increase students' effort (use of the homework tool) and subsequent human capital development (math and language performance). The use of the homework tool was measured over the same period as the experiment with the parental app ran, namely between the pretest in September and the posttest in February. The first half of

[8] See Online Appendix 2 for more descriptive statistics on the use of the School Administrative System.

Table 1 shows the average amount of minutes students used the homework tool. Some students did not use it all, which influences the average amount of minutes. On average, students practiced 14 minutes per week during this period. However, the standard deviation is large, and therefore differences between students are very large. Note that students were asked to use the tool in total one hour (60 minutes) per week. Seventh grade students practiced the most and the difference between grade levels is significant. There are small, non-significant, differences between the SES groups, although there is more variation if we look at the differences between the separate grade levels both within and between SES groups (also significant). The second half of Table 1 shows the same statistics, but only for the students that practiced at least once. Now we see that the students who did use the tool have done so for an average of about 16 minutes. This statistic is higher for the 7th and 9th grade students (more than 16.5 minutes) than for 8th grade students. The distribution of the use of the homework tool in minutes is not normal, but skewed to the left, where there is a peak between 10 and 15 minutes and a declining number of students practicing more than 20 minutes.

[Table 1 around here]

ii. Math and language test data

The math and language skills are measured using digital standardized math and language tests, which are written by all students in September 2014 and February 2015. These are standardized validated tests developed by the company of the tool, and these tests are based on other nationally validated tests. The reliability (Cronbach's alpha scores of between .79 and .92) and validity of these tests is analyzed yearly by the tool developer, based on norm data of several participating schools (Schijf & Schijf, 2014). Although the pre and posttest are digital tests that are developed by the same company as the tool and are administered in the same digital

environment as the tool, the tests themselves are external to the practice exercise tool and do not contain any of the exercise questions. The tests measure whether students have mastered the required national numeracy and language level they are supposed to have, given their age and given the fact that they finished primary school (called 'reference level') and range between 0 and 200[9].

e. Questionnaires

During our study, both students and parents were asked to fill out a questionnaire. We wanted to get more insight in students' motivation for school in general, and asked questions on the courses mathematics and Dutch, on the program Mousework, on the time spent on homework, on their opinion on parental involvement and on their work attitude. The parental questionnaire contained background questions, a few questions on Mousework and the app, and eight statements on parental involvement in general. As not all students, nor all parents, filled out the questionnaires, the answers to the questionnaires are only used for explaining potential mechanisms[10].

4. Methodology

a. Identification strategy

To study the effect of the use of an app for parents on whether students do their digital homework and how much time they spent in the digital environment, a randomized field experiment was set up. As explained above, all students had a login account and were supposed to practice in the digital tool. First, students (and, hence, parents) were individually randomized into a treatment and control group, where treatment status implied that they could login to the

[9] More information the mathematics and language tests, as well as the descriptive statistics, can be found in the Online Appendix 2.
[10] More information the questionnaires, as well as on the response rates, can be found in Online Appendix 2.

app, and control status implied that it was technically impossible for them to log in the app with their child's login number. The randomization was done using a random number generator and classified students and their parents based on odd and even numbers. For practical (technical) reasons, and to avoid spill-over effects, siblings were supposed to have the same treatment status, so all children that had a sibling that belonged to the treatment group whereas they themselves did not were also added to the treatment group. This practical arrangement causes the selection likelihoods of students with siblings at school to be slightly higher than other students, but the actual impact of the latter is limited[11]. In effect, 55 percent of all children had parents that were able to actually login to the app (i.e. the treatment group). Because more than 2000 students are individually randomized (though clustered at the family level if discrepancies arose) we have a high enough number of observations to have confidence that we have randomly divided observed and unobserved characteristics of both students and parents. This is confirmed by a joint F-test on the available student parental and family characteristics, which shows no significant differences between students in treatment and control group. However, separate T-tests on all 28 characteristics, with a Bonferroni correction applied (accepted significance level of 0.002), show significant differences on four characteristics: school, immigrant generation of child and the birth year of both parents (see Table A4 in Online Appendix 1). Parents of students in the control group are slightly older than of students in the treatment group, students in the control group are slightly more often born abroad and we have slightly more students from school two in the control group. It is a priori unclear how these differences might influence the results.

[11] As a first check, we tested specifications including an indicator regarding the number of children at school. This does not change the effect estimates neither regarding practice behaviour, nor regarding math outcomes.

b. Compliance with Assignment

Evidently, providing parents with access to a tool does not guarantee its effective use. Moreover, parents had to download the app before they could even start using it to get involved. Table 2 describes the first step: the downloading. As explained earlier, the allocation of parents to the control or experimental group was only revealed after downloading[12]. Therefore, Table 2 refers to the full population of students (and their parents). Of 2086 students in the dataset, 20% of the parents downloaded the app. Similar to the use of the parents' portal of the learning management system and the response rates of the parent questionnaires, downloading happened more often among parents of 7th grade students (22%), decreasing gradually over parents of 8th grade students (19%) to 17% of the parents of 9th grade students. The separate statistics per SES group show that the download rate is the highest for the lowest SES group. The differences between grade levels and between SES groups are significant at the 5% level, but there are no significant interactions[13].

[Table 2 around here]

Table 3 reveal some information about the second step: the use of the app. The number of observations in Table 3 is far less than in Table 2, because of a double selection process: only one out of five parents effectively downloaded the app (see Table 2) and only roughly half of them had access to the tool, because of the randomization of the experiment (55%, see previous section).

[12] Note that the vast majority of parents downloaded immediately after the parental information nights, when the research was introduced. Almost all parents that did download did so long before autumn break, when students receive their first grade overview.

[13] Additional analyses show (see Table A5 of Online Appendix 1) that children from parents who downloaded the app have a higher score on the primary school ability test, are a bit younger (most likely because 7th grade students are overly represented in the group that did fill out the parental questionnaire) and have more often a stable home situation and a higher SES (and underlying variables).

Table 3 shows that complying parents (that both downloaded and used the app at least once) used the app on average 19 times during the period of the experiment, which is slightly more than once a week. When compared with the data of number of logins to the education management system, this may seem little, but the app is obviously much narrower in scope, as it refers to voluntary homework assignments in the ITS on math and language, instead of the full schooling process that is being registered in the education management system. We will return below to the association between both.

[Table 3 around here]

c. Instrumental Variable analysis

To identify the Average Treatment Effect (ATE) of access to the digital practice tool on minutes of digital homework and on test scores we use the notation first used by Rosenbaum and Rubin (1983). We observe a student *i's* total amount of minutes of digital homework or test score y_i and the treatment, a parents' access to the parental app, d_i, which results in the following equation:

$$y_i = d_i y_i(1) + (1 - d_i) y_i(0), \qquad (1)$$

Where $y_i(1)$ is the number of minutes spent on digital homework for students or the test score from treated parents and $y_i(0)$ is the amount of minutes spent on digital homework or the test score for students from untreated parents. Since the randomization ensures the independence between the treatment and potential outcomes, we identify the ATE as follows:

$$\tau_1 = E[y_i(1) - y_i(0)]. \qquad (2)$$

We can estimate the ATE using either simple *t*-statistics or using a linear regression. The linear regression is estimated as follows:

$$y_i = \alpha_0 + \alpha_1 d_i + \alpha_2 X_i + \varepsilon_i, \qquad (3)$$

Where d_i is the assignment to treatment of the parent(s) of student i, X_i are the students', parents' and family observable characteristics, such as ability variables, gender, age, income of parents, SES, et cetera, which are independent of the treatment, ε_i are the residuals at the student level which are assumed to be normally distributed with a mean of zero and a variance of σ^2.

However, the experiment provides parents with access to the app, but can of course not ensure that parents actually download and use the app. As we have seen in the section on compliance with the assignment, not all parents have downloaded the app and not all parents who have downloaded the app have actually used the app, making it technically an intent-to-treat effect (ITT) instead of an average treatment effect.

In order to control for the actual use of the app, we use a two-stage-least-squares (2SLS) instrumental variable approach to estimate the Local Average Treatment Effect (LATE) or, in other words, the treatment effect on the treated. Here we use the dummy that indicates the random assignment for access to the app as an instrument for the actual use of the app. The assignment to the treatment or control group is (highly) correlated with the use of the app, but uncorrelated with the error term, since the assignment was done randomly. The first stage is then estimated as follows:

$$p_i = \beta_0 + \beta_1 d_i + \beta_2 X_i + \varepsilon_i, \quad (4)$$

where p_i is the participation status. In the second stage, we use the predicted participation probability in the regression as follows:

$$y_i = \gamma_0 + \gamma_1 \hat{p}_i + \gamma_2 X_i + \varepsilon_i, \quad (5)$$

5. Results

a. The effect of the parental app on the use of the homework tool

Our main interest lies in the differential effect of the parental app by SES. However, before we look into that, we first present the results for the full sample of students, as well as the separate grade levels[14], to see if there is an effect for the overall population. Note that we only present multivariate regressions with a lot of covariates in the paper. However, we ran all analysis also without covariates, and the coefficients are very stable[15].

Full sample

Table 4 compiles the estimates for the immediate goal of the intervention, the practicing behavior of the students. In upper right corner, the effect of the provision of access to the smartphone app is shown under the heading ITT. We see that children react differently to the (potential) involvement of their parents depending on their age, which leads to an apparently insignificant overall effect, as well as for grade 7, but significant effects when looking at grades 8 and 9. In effect, the parental involvement enabled by the app leads 8th grade students to increase their practicing time with 2.6 minutes per week (over an average of 13, which is an effect with a magnitude of 0.2 of a standard deviation), while 9th grade students reduce their practicing time by 2.5 minutes (over an average of 12). This is an interesting finding that we will further look into when studying potential mechanisms in Section 7. Note that the size of the coefficient, as well as the average number of minutes practiced is quite small given that students were asked to practice 60 minutes per week and given that parents were actively informed about these 60 minutes. From a policy point of view, the ITT results are the most

[14] We have compared treatment and control group also per subsample that we analyze in this paper, and there are no significant differences on observables for the subsamples by grade level, SES or gender.
15 The regressions without covariates of Tables 5 can be found in Online Appendix 1 in Tables A6.

interesting results, as you can offer an app, as a policy, but you cannot force people to actually download and/or use the app.

However, given the rather meagre compliance rate we documented above, it is also of interest to look into the working mechanism more directly. To that end, we investigate whether the effective use of the app can be linked with the practicing intensity of the students. As a (descriptive) reference estimate, we report in the lower left corner of Table 4 a simple OLS result relating the dummy whether a parent used the app to the child's practicing. As could be expected, we obtain highly significant estimates. However, the direction of the relation is surprisingly homogeneous, we find positive relationships for all grade levels, where we would expect a negative sign for 9th grade students, based on the ITT. Actually, the difference between the ITT and OLS call for caution regarding selection effects. Therefore, we apply an instrumental variable approach with "access to the app" (randomized experimental condition) as the first stage instrument. Results regarding the first stage are shown in the upper left corner of Table 4. The instrument is significant for parents of students of all ages, because cross-over was literally technically impossible. However, due to non-compliance the coefficients are not that large. The actual effect of usage estimates (second stage estimates, LATE) are reflected in the lower right corner of Table 4. Parents of 8th grade students who are involved in their children's homework by getting access to the app make their children engage more in the homework tool. For 9th grade students, the generally negative effect revealed by the ITT-estimate, does not change. App-using by the parents is in this case related to students who practice less with the homework tool.

[Table 4 around here]

Differential effects by Socio Economic Status (SES)

Similar to previous studies, who have mainly focused on socially deprived students, we also look into different groups of students with respect to socio economics status. However, instead of only focusing on socially deprived, or low-SES students, we focus on all student by interacting the treatment dummy with the three groups of SES. We have split the sample in three groups, where we create a low-SES group (SES-group 1, lowest tertile), a medium-SES group (group 2, middle tertile) and a high-SES group (group 3, highest tertile)[16], based on the previously discussed SES-variable that we have created based on the data from Statistics Netherlands. The results of the 1st stage, ITT, OLS and second stage analyses for all three SES-groups are presented in Table 5. All first stages are highly significant. The ITT in the upper right corner shows that the positive effect in grade 8 seems to be driven by low-SES students, whereas the negative effects in grade 9 are present for both low and high-SES students (but not for middle-SES students). The effect of parents having access to the app for low SES-students in grade 8 is around 6.5 minutes per week of increased practice time (equivalent to an effect of 0.4 of a standard deviation). The second stages show similar significant results but have very high coefficients, most likely due to the low first stage coefficients and the large differences within the low-SES groups (as there are many students in this group that have not practiced at all). We checked whether the large coefficients of the second stage were due to outliers on the number of times parents checked the app and/or on the number of minutes the child practiced in the tool. However, the large coefficients and significant results remained even after deleting all 30 parents that checked the app more than 40 times (more than twice as much as we asked), after deleting all 36 students that practiced more than 60 minutes per week (which was what the school asked for) and after deleting both (where only 2 students belonged to both groups). We have also performance additional checks with the logarithm of minutes practiced, to trim potential outliers in the dependent variable, but the coefficients in the second stage remain very

[16] Other ways of defining the SES-groups, as well as other proxies for SES, will be tested and discussed in the robustness analyses.

large[17]. We also inspected the data for the complying parents and students in the low-SES group, but there are no extreme or strange outliers in his group. Furthermore, the results are not based on only a few (active) parents and students, as the share of parents within this SES-group that uses the app is only slightly lower than for the other SES-groups.

However, since the ITT is much more interesting from a policy point of view, we have decided to focus on the ITT results in the remainder of this paper[18].

[Table 5 around here]

Next, we look at subsamples for gender. Table 6 presents the ITT-results[19] of the analyses separately for male and female students. Table 6 shows that the positive effect of parental app use on students' use of the homework tool in grade 8 is larger for male than for female students, but is significant at the 5 percent level for both males and females. The negative significant effect for grade 9 students seems to be driven by girls, for both the low and high SES-group, and especially the low-SES group. Potential mechanisms for this finding are explored in Section 7.

[Table 6 around here]

[17] Results of these additional checks can be found in Online Appendix 1 Table A7.
[18] Note that we checked whether the unrealistically large coefficients were due to outliers on the number of times parents checked the app and/or on the number of minutes the child practiced in the tool. However, the large coefficients and significant results remained even after deleting all 30 parents that checked the app more than 40 times (more than twice as much as we asked), after deleting all 36 students that practiced more than 60 minutes per week (which was what the school asked for) and after deleting both (where only 2 students belonged to both groups). We have also added robustness checks with the logarithm of minutes practices, to trim potential outliers in the dependent variable, which shows a similar picture. Nonetheless, we find our ITT results more interesting.
[19] The full tables with first stages, OLS and 2SLS-results can be found in Online Appendix 1 (Tables A8 and A9).

b. The effect of the parental app on math and language performance

The outcome we discussed so far is the immediate goal of the intervention, but also an instrumental one. Ultimately, the goal of the innovation of the teaching process by using the homework tool and getting parents to help motivate students to use it, is the improvement of skills. It is important to mention that we only register whether parents log in to the app, but that we cannot see whether they look at the math or language performance and use of the homework tool of their child. Therefore, so far, we have focused on use of the homework tool in general, without making the distinction between math and language, as we cannot say anything about that. However, performance of students is measured for math and language separately and as these are two very different domains of performance, we will analyze them separately here.

Tables 7 summarizes the main results[20], first for math and language in general, and in the second half of the table split by gender. In the first part of table 7, for math, we see that the ITT estimates suggest that the stimulus to parental involvement given by the app is effective in raising the math performance of 8th grade students (of both the lower and the middle SES groups) with about 0.2 of a standard deviation and the language performance of 7th grade students in the lower SES group with about 0.1 of a standard deviation. The negative effect on usage for 9th grade students that we discussed in the previous tables seems to mostly harm the language performance of low-SES students.

[Table 7 around here]

The second part of Table 7 shows that all the previously mentioned results for math and language seem to be driven by boys. We do not see any significant effect for girls. The lack of a significant effect for female students could of course be a power problem, given the low

[20] The full tables with first stages, OLS and 2SLS-results can be found in Online Appendix 1 (Tables A10 – A15).

number of observations. However, there are fewer males than females in the sample, and the coefficients are much larger for males than for females. Therefore, even if we *do* have a power problem and there potentially is an effect for females as well, we can conclude that the effect is much larger for male students. Potential mechanisms for the findings on performance, SES and gender are explored in Section 7.

6. Robustness analyses

As robustness analyses, of which all the results can be found in Table 8, we first of all have defined the SES-groups differently (results in Table 8[21]). We now do not create equally sized SES-groups but use the mean and standard deviation to create groups. We separate the SES-groups by defining the group borders by half a standard deviation around the mean on both sides and a full standard deviation around the mean. These analyses confirm the finding of the positive effect in grade 8 and the negative effect in grade 9 for low-SES students. In a next robustness check, we add controls on parental involvement taken from the student questionnaire. This substantially reduces the sample in size, but adds information on how much involvement students *want* from their parents. Again, the results are not very different. Next, we do not create tertiles by SES, but quartiles. In these results, we find that the previously found effects in grades 8 and 9 are still driven by the lowest SES-group. We do not find significant results for the other three groups, except for the second lowest SES group for the total sample of students. Next, we do not use SES but the four categories of educational level of the mother. Given that the fourth category defines individuals for whom we have missing parental education information, the first three categories confirm our findings, namely that the positive effect is only found for children of lower educated mothers. Note that there are very few mothers in the lowest level of education category, especially for 8 and 9th grade. Lastly,

[21] All results presented in Table 8 are ITT results.

we have clustered standard errors at the class level in one analysis, and at the school level in another analysis, and these analyses also show almost identical significance results as before. All in all, our robustness checks give confidence that our results and conclusions with respect to SES are robust and not dependent on specifications chosen or variables used.

[Table 8 around here]

7. Mechanisms

a. Differential results by grade level and gender

In order to get an idea about the mechanisms behind the effects that we found above in Section 5, we ran correlations between the answers of students in the student questionnaire, about the (desired level of) parental involvement, and the answers of parents in the parental questionnaire, about their involvement.

The positive effects for 8th grade students can be explained by the findings from the correlations analyses[22], which show that these age groups of students are still more inclined to listen to their parents and accept parental involvement. We find that 8th grade students who would like more help also get more help with homework from their parents. On the other hand, if we look at 9th grade students, where we find a negative effect of parental involvement on using the homework tool, these students are already adolescents who accept less from their parents and are often obstreperous. Ninth grade students practice less if parents help more with homework, if parents feel they need more help and if parents try to help them if their motivation is gone. Furthermore, if 9th grade students feel that parents should interfere less they also practice less. These findings indicate the obstreperous behavior of the 9th grade students that in turn may explain the earlier findings on the effect of the use of the app by parents. It is also in

[22] See Online Appendix 3 for descriptive statistics and a discussion on these correlations

line with previous findings regarding the link between parental involvement and student behavior reported on in the literature (Hoover-Dempsey et al., 2001; Patall et al., 2008).

Therefore, a second potential mechanism that relates to the one discussed above seems to be difference in biological development. Grade 9 students have already entered puberty whereas grades 7 and 8 students in general have not. As the biological development is age related, we have also split the sample by age group instead of by grade, which is shown in Table 9. Here we see similar results as to when we split the sample by grade level, supporting the hypothesis that grade 9 students respond in a complete adverse way to parental involvement.

Next, we look into potential reasons why the effects are more prevalent for male students. In these analyses (not visible in table 9) we see a similar pattern in the answers to the questionnaires of students and their parents. We see a larger discrepancy in the answers between parents and students for girls than for boys. This could be explained because girls enter puberty earlier than boys and might therefore be less inclined to listen to their parents to practice in the online tool.

[Table 9 around here]

b. Differential results by SES

Lastly, we want to dig deeper into why the effect is mainly present for low-SES students. Therefore, we run additional regressions, correlations and descriptive statistics to explore potential reasons why the effect is mainly present for low-SES students[23].

[23] The results of these additional analyses are presented in Tables C2-C7 in Online Appendix 3.

These analyses show that for grades 7 and 8, in the low-SES group, there is a much larger difference between the minutes practiced by children whose parents used the app and children whose parents did not use the app, than for the other two SES groups. For grade 9, the difference is smaller for the low-SES group, than for the other two groups. Although in the low-SES group the number of parents that have used the app is smaller than in the other groups, these parents and/or children seem to have listened better to the instructions of children having to practice 60 minutes per week in total. As discussed before, this might also mean that the 2SLS effects we find are driven by a small number of individuals.

Furthermore, we find that in the low-SES group, in the parental questionnaire, parents indicate significantly less frequently that their children need little help. On the other hand, children in the low-SES group report less often that they want less interferences by their parents on school related issues. This might point at a better match between needs of children and their parents view on their needs.

We also find that that parents who downloaded the app in the low SES-group are more likely to talk to their children at school (in comparison with a negative, and not significant, correlation for the other two SES-groups), and more often help their child with their homework (although not significant). So these seem to be the more involved parents. Next, we hypothesized that high-SES parents might use the school administrative system more often and therefore feel that they do not need the app. Here, we find that, although the low-SES group shows a higher correlation between using the school admin system and the app (in both cases, using it at all) than the other groups, this is still a small correlation, and there is no correlation between the number of times both systems are used. So the latter does not seem to be a potential explanation for the differences in found effects.

The additional analyses also show that in the low-SES group, there is a smaller share of parents in the treatment group, compared with the other two groups. Furthermore, low-SES

parents less often filled out the questionnaire, downloaded the parental app, and used the parental app. This might point at a selective group of parents that downloaded and used the app, even more so in the low-SES group. However, there does not seem to be a substitution effect in digital involvement, as these analyses also show that there is no significant difference in the number of times parents logged into the school admin system and the number of minutes the students practiced per week, between the three SES groups.

Correlations between SES and app use and download behavior show that *within* the low-SES group, there is no difference in the educational level of the mother with respect to who used and downloaded the app. We do see that SES within the low-SES group is a little higher for app users and downloaders, but the correlation is less than 0.1 and only significant for app downloads.

Furthermore, we also find that in the low-SES group there is a low and insignificant correlation for whether the parents used the app, and whether the child is the younger (either youngest, or middle child) or the oldest child, whereas for the other two SES groups younger children are less likely to have parents that used the app. We also see that for the low-SES group there hardly is a difference for children who are the younger or oldest child in whether they would like less interference by their parents, whereas for the other two SES-groups there is a larger difference between the younger and oldest children.

In line with this, we find that the positive effects are larger and more significant for younger children than for older children. This can be related to the literature that says that older children get more attention by their parents (by default, because they were born earlier) (Cabus & Ariës, 2017), meaning that younger children have much more to gain from increased parental involvement. Since in the low-SES group we find that younger children are much more likely to have a parent that uses the app, in comparison with the other two SES-groups, this could be one of the explanations for the effect we find.

8. Conclusion and Discussion

In this paper we analyzed the effect of parental involvement on the use of a digital homework practice tool and on math performance of all students in grade 7 to 9 of two secondary schools in the Netherlands, with a specific focus on differences between Socio Economic Status groups. The experiment consisted of an app in which parents can follow their child's practice behavior in the digital homework tool, using a randomized field experiment at the individual level. For additional information on parental involvement both students and parents were asked to fill out a questionnaire.

We focus the analysis of the results from the viewpoint of the provision of access to the tool ("Intent to Treat", ITT), the most policy relevant part, and show that parental involvement via app-use positively affects practice behavior of 8th grade students, but negatively affects practice behavior of 9th grade students. Furthermore, we find positive effects of app use on students' language and mathematics score at the end of the experiment, which is driven by the 7th and 8th grade students, respectively.

Subgroup analyses show that the positive and significant effects that are found (both on the use of the homework tool for grade 8 and on math and language performance) are more prevalent for male students and are mostly driven by the low-SES students, whereas the negative effect of the parental app on the use of the homework tool in grade 9 is also due to the high-SES students.

As such, our results add to the rather limited existing experimental literature on interventions to raise parental involvement. In contrast with intensive interventions like those reported about by Bergman (2019) and Mayer et al. (2018), giving access to a parent app linked to an existing digital homework tool, requires little effort for the school and the teachers. Nevertheless, it proved effective in raising involvement and beneficial to the learning progress of the students.

A potential explanation for our findings with respect to SES could be that an app might be less socially selective (in terms of parental SES and parental education) than for example an intervention that fosters the use of specific books or other educational techniques that require a high education of parents. Apps are used by everybody and might be a lot more appealing to low-SES parents than more traditional interventions.

Both the parental and the student questionnaire shed additional light on how students and parents experience parental involvement and how students feel about that. For 7th and 8th grade students, parents and students are very much aligned with respect to their needs and offers of parental involvement, whereas there is a clear discrepancy in this for 9th grade students and their parents, which might have to do with the puberty age of 9th grade children. This is confirmed by the analysis that we provided by age, instead of by grade level: for younger children we find the positive effect and for older children we find the negative effect.

The difference in findings between the different grade levels and the different-SES groups is intriguing and one could wonder whether there would be a substitution effect where high-SES parents use different ways of parental involvement than our app. We looked into many potential mechanisms in the final part of this paper and although we do see some differences between the SES groups, the results do not point towards a substitution effect.

For example, we hypothesized that high-SES parents might use the school administrative system more often and therefore feel that they do not need the app. However, if we check the data, we do not see any correlation between SES-status (neither high nor low SES-status) and use of the school administrative system. Furthermore, one could argue that high-SES parents that use the app are more effective for the use of the homework tool by their children, because high-SES children might already perform quite well, and therefore do not need to practice that often. However, here again the data shows that this is not the case, there

does not seem to be a relationship between SES-status and performance levels for math and language.

Also, one could argue that more involved, high-SES parents might be less inclined to download the app in the first place, because they realize they only have a 50% chance of belonging to the treatment group, and they rather invest their energy in other involvement with their child's school career. And although we see that high-SES parents are slightly more likely to download and use the app, we do not see differences in background characteristics of these parents that are likely candidates to explain these differences (such as parental education, or the use of the school admin system, as discussed above).

All in all, there does not seem to be a substitution effect that can explain our finding that the effect of parental involvement on student homework behavior are mainly found for low-SES students. It is possible that the specific question of the school to be involved as a parent by using the app on the smartphone has specifically triggered low-SES parents who are not so much involved just by intrinsic motivation, whereas medium and high-SES parents are more intrinsically motivated to be involved anyway. The differences between the low-SES group and the other groups with respect to filling out the questionnaire, downloading the app and using the app also potentially point towards a selective group of parents in the low-SES group, but this is once more not confirmed by the data, showing that there is no difference in educational level between the groups, nor within the low-SES group.

However, we do see some patterns in the mechanisms analyses that might explain our findings. First of all, there seems to be a better match in the needs and offers of parental involvement by children and parents for 7^{th} and 8^{th} grade students. Furthermore, it seems that the ranking of the child in the family also plays a role in this. Literature has shown that younger children have much more to gain from increased parental involvement. Since younger children in the low-SES group are much more likely to have a parent that uses the app, in comparison

with the other two SES-groups, this could be one of the explanations for the effect we find. We also see that the effect for younger children is larger and more significant in the low-SES group. It is likely that the younger children in the low-SES groups have even more to gain than the average younger child, as parental involvement is generally lower in the low-SES group. Future research should look further into this, but it does seem that if low-SES parents can be persuaded to be more involved in their children school work, they will do so for all their children equally, whereas parents in the other two SES groups are significantly less likely to be involved through an app for their younger children than for the oldest child.

In sum, the provision of a smartphone-based follow-up app for parents proves to foster homework activities as well as performance of students, especially in low-SES families and in the early years of secondary education. This implies that parental involvement can easily be increased for low-SES families as well, using technology and specifically asking for it, resulting in positive effects for those students that could often use an additional help to focus on their school.

9. References

Aizer, A. (2004), "Home Alone: Supervision after School and Child Behavior", Journal of Public Economics, 88(1), 1835–1848.

Avvisati, F., Besbas, B., & Guyon, N. (2010). Parental involvement in school: a literature review. Revue d'économie politique, 120(5), 759-778.

Avvisati, F., Gurgand, M., Guyon, N., & Maurin, E. (2014). Getting parents involved: a field experiment in deprived schools. *Review of Economic Studies, 81*(3), 57-83.

Balli, S. J., Demo, D. H., & Wedman, J. F. (1998). Family involvement in children's homework: an intervention in the middle grades. *Family Relations, 47*(2), 149-157.

Bartelet, D., Ghysels, J., Groot, W., Haelermans, C., & Maassen van den Brink, H. (2016). The differential effect of basic mathematics skills homework via a web-based intelligent tutoring system across achievement subgroups and nathematics domains: A randomized field experiment. *Journal of Educational Psychology, 108*(1), 1-20.

Bergman, P. (2019). Parent-child information frictions and human capital investment: evidence from a field experiment. Conditionally accepted for publication in *Journal of Political Economy.*

Cabus, S. J., & Ariës, R. J. (2017). What do parents teach their children? - The effects of parental involvement on student performance in Dutch compulsory education. *Educational Review, 69*(3), 285-302.

Commissie Meijerink. (2008). *Over de drempels met taal en rekenen - Hoofdrapport van de expertgroep doorlopende leerlijnen taal en rekenen.* Enschede.

Cunha, F. & J.J. Heckman (2007), \The Technology of Skill Formation," *The American Economic Review*, 97(1), 31-47.

Cunha, F. & Heckman, J. J. (2008), “Formulating, Identifying and Estimating the Technology of Cognitive and Noncognitive Skill Formation”, Journal of Human Resources, XLIII, 739–782.

Duncan, G. J., & Murnane, R. (2016). Rising Inequality in Family Incomes and Children's Educational Outcomes. *RSF: The Russell Sage Foundation Journal of the Social Sciences, 2*(2), 142-158.

Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: a meta-analysis. *Educational psychology review, 13*(1), 1-22.

Ghysels, J., & Haelermans, C. (2018). New evidence on the effect of computerized individualized practice and instruction on language skills. *Journal of Computer Assisted Learning, 34*(1), 440-449.

Green, C. L., Walker, J. M. T., Hoover-Dempsey, K. V., & Sandler, H. M. (2007). Parents' motivations for involvement in children's education: an empirical test of a theoretical model of parental involvement. *Journal of Educational Psychology, 99*(3), 532-544.

Groenestijn van, M. (2007). Rekenvaardigheid in de brugklas. *Remediaal, 7*, 5-9.

Haelermans, C., & Ghysels, J. (2017). The Effect of Individualized Digital Practice on Math Skills at Home – Evidence from a Randomized Experiment on Whether and Why it Works. *Computers and Education, 113*(1), 119-134.

Heckman, J. J. & S. Mosso (2014). \The Economics of Human Development and Social Mobility," *Annual Review of Economics*, 6(1), 689-733.

Hoover-Dempsey, K. V., Battiato, A. C., Walker, J. M. T., Reed, R. P., DeJong, J. M., & Jones, K. P. (2001). Parental Involvement in Homework. *Educational Psychologist, 36*(3), 195-209.

Lavecchia, A., H. Liu, & P. Oreopoulos (2016). *Behavioral Economics of Education: Progress and Possibilities,* in Handbook of Economics of Education Volume 5, edited by E.A. Hanushek, S. Machin and L. Woessmann, Elsevier, 1-74, 2016

Mayer, S. E., Kalil, A., Oreopoulos, P., & Gallegos, S. (2018). Using behavioral insights to increase parental engagement: the parents and children together intervention. Forthcoming in *Journal of Human Resources*, doi 10.3368/jhr.54.4.0617.8835R.

OECD. *Note on Equivalence Scales*. Retrieved from http://www.oecd.org/eco/growth/OECD-Note-EquivalenceScales.pdf

Patall, E. A., Cooper, H., & Robinson, J. C. (2008). Parental involvement in homework: a research synthesis. *Review of Educational Research, 78*(4), 1039-1101.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika, 70*(1), 41-55. doi:10.1093/biomet/70.1.41

Schijf, G. M., & Schijf, T. (2014). *Handleiding Online Testprogramma's*. Muiswerk Educatief, Hoorn

Sirin, S. (2005), "Socioeconomic Status andAcademicAchievement:AMeta-Analytic Review of the Research", Review of Educational Research, 75(1), 417–453.

Todd, P. E. & Wolpin, K. E. (2007), "The Production of Cognitive Achievement in Children: Home, School, and Racial Test Score Gaps", Journal of Human Capital, 1, 91–136.

Welsch, D. M. & Zimmer, D. M. (2008), "After-School Supervision and Children's Cognitive Achievement", *The B.E. Journal of Economic Analysis & Policy*, 8(1), art. 49.

Tables and Figures

Figure 1 – Timeline of the Experiment

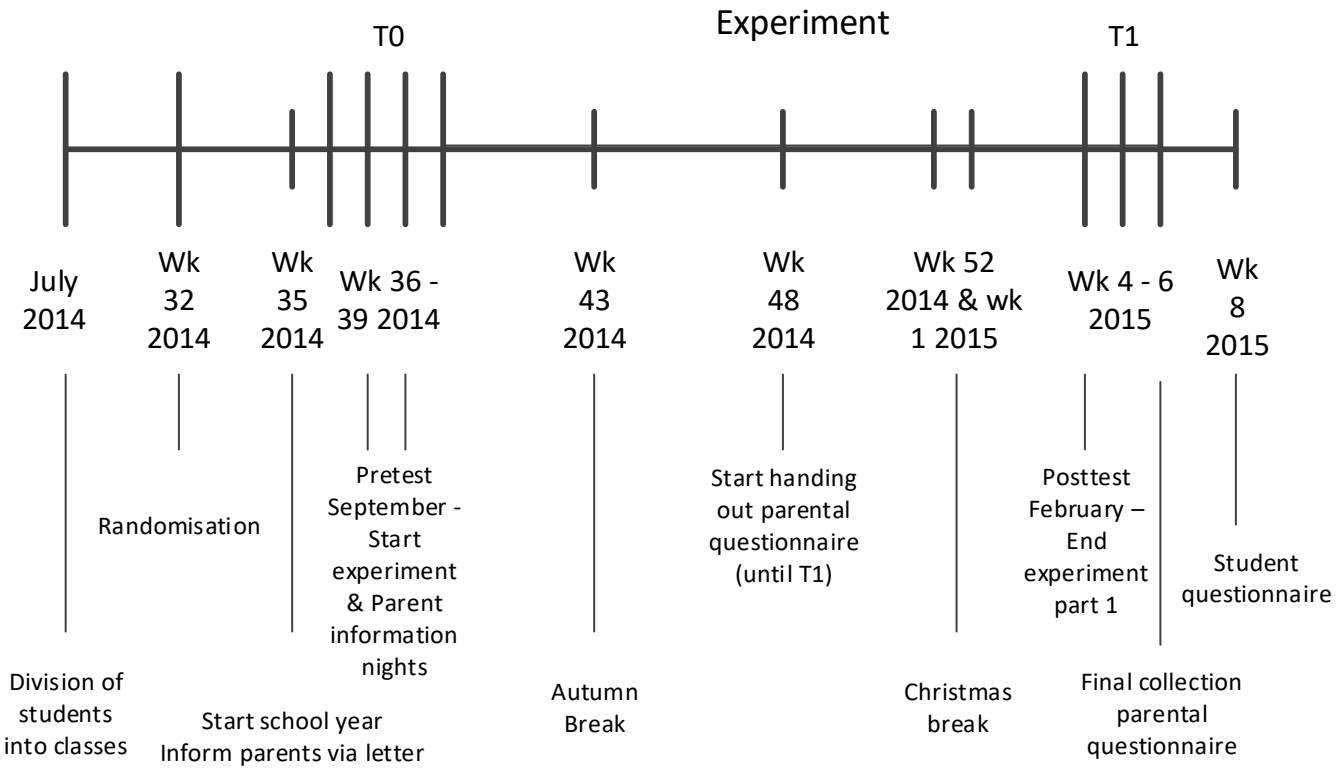

Table 1 – Practice time in online homework tool (complete experimental period)

	Obs	Average	St. Dev
Total minutes practiced	2,086	13.88	15.18
Total minutes practiced (grade 7)	740	16.34	16.30
Total minutes practiced (grade 8)	736	12.83	14.19
Total minutes practiced (grade 9)	610	12.16	14.56
SES 1	Obs	Average	St. Dev
Total minutes practiced	676	13.51	15.68
Total minutes practiced (grade 7)	243	13.15	14.99
Total minutes practiced (grade 8)	253	18.72	17.94
Total minutes practiced (grade 9)	244	17.05	15.31
SES 2	Obs	Average	St. Dev
Total minutes practiced	686	13.99	15.42
Total minutes practiced (grade 7)	234	14.74	16.11
Total minutes practiced (grade 8)	241	11.29	12.80
Total minutes practiced (grade 9)	261	12.53	13.41
SES 3	Obs	Average	St. Dev
Total minutes practiced	724	14.11	14.48
Total minutes practiced (grade 7)	199	12.49	15.97
Total minutes practiced (grade 8)	192	11.15	13.25
Total minutes practiced (grade 9)	219	12.73	14.33

WHEN PRACTICED AT ALL

	Obs	Average	St. Dev
Total minutes practiced	1,810	15.99	15.23
Total minutes practiced (grade 7)	693	17.45	16.26
Total minutes practiced (grade 8)	671	14.07	14.26
Total minutes practiced (grade 9)	446	16.62	14.68
SES 1	Obs	Average	St. Dev
Total minutes practiced	567	16.10	15.85
Total minutes practiced (grade 7)	212	15.07	15.11
Total minutes practiced (grade 8)	246	19.26	17.91
Total minutes practiced (grade 9)	235	17.70	15.23
SES 2	Obs	Average	St. Dev
Total minutes practiced	602	15.95	15.49
Total minutes practiced (grade 7)	213	16.19	16.17
Total minutes practiced (grade 8)	216	12.60	12.90
Total minutes practiced (grade 9)	242	13.52	13.44
SES 3	Obs	Average	St. Dev
Total minutes practiced	641	15.94	14.41
Total minutes practiced (grade 7)	142	17.50	16.43
Total minutes practiced (grade 8)	140	15.30	13.31
Total minutes practiced (grade 9)	164	17.00	14.19

Table 2 – Download statistics app

	Obs	Average	St. Dev
Downloaded parental app	2,086	0.20	0.40
Downloaded parental app (grade 7)	740	0.22	0.42
Downloaded parental app (grade 8)	736	0.19	0.39
Downloaded parental app (grade 9)	610	0.17	0.37
SES 1	Obs	Average	St. Dev
Downloaded parental app	676	0.16	0.37
Downloaded parental app (grade 7)	243	0.19	0.40
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SES 2	Obs	Average	St. Dev
Downloaded parental app	686	0.21	0.41
Downloaded parental app (grade 7)	234	0.16	0.37
Downloaded parental app (grade 8)	241	0.19	0.39
Downloaded parental app (grade 9)	261	0.21	0.41
SES 3	Obs	Average	St. Dev
Downloaded parental app	724	0.21	0.41
Downloaded parental app (grade 7)	199	0.13	0.34
Downloaded parental app (grade 8)	192	0.20	0.40
Downloaded parental app (grade 9)	219	0.18	0.38

Table 3 – Usage statistics app

	Obs	Average	St. Dev
Number of times used parental app	228	18.82	30.60
Number of times used parental app (grade 7)	92	17.30	19.92
Number of times used parental app (grade 8)	75	18.59	26.55
Number of times used parental app (grade 9)	61	21.39	45.40
SES 1	Obs	Average	St. Dev
Number of times used parental app	49	17.33	23.26
Number of times used parental app (grade 7)	19	16.74	17.02
Number of times used parental app (grade 8)	36	19.44	22.32
Number of times used parental app (grade 9)	37	15.51	19.12
SES 2	Obs	Average	St. Dev
Number of times used parental app	87	22.14	40.64
Number of times used parental app (grade 7)	18	22.28	31.60
Number of times used parental app (grade 8)	28	15.54	21.77
Number of times used parental app (grade 9)	29	19.24	27.95
SES 3	Obs	Average	St. Dev
Number of times used parental app	92	16.48	21.73
Number of times used parental app (grade 7)	12	10.83	16.00
Number of times used parental app (grade 8)	23	34.39	69.70
Number of times used parental app (grade 9)	26	14.77	17.46

Table 4 – The effect of parental use of the app on students' use of the homework tool

	First stage				ITT			
	dependent: dummy whether the parents used the app				dependent: Number of times the child used the homework tool			
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Assignment experiment	0.200***	0.225***	0.189***	0.192***	0.562	1.347	2.607*	-2.554*
	(0.0130)	(0.0231)	(0.0215)	(0.0235)	(0.665)	(1.207)	(1.033)	(1.203)
N	2081	740	733	608	2081	740	733	608
R-squared					0.037	0.052	0.093	0.043
F-statistic	237.52	94.31	71.62	62.16	3.756	2.091	3.862	1.402
	OLS				IV/2SLS			
	dependent: Number of times the child used the homework tool				dependent: Number of times the child used the homework tool			
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Dummy app used	9.227***	11.11***	9.320***	6.524**	2.809	5.997	13.82**	-13.27*
	(1.050)	(1.783)	(1.685)	(1.988)	(3.277)	(5.197)	(5.342)	(6.610)
N	2081	740	733	608	2081	740	733	608
R-squared	0.071	0.099	0.123	0.053	0.055	0.089	0.114	-0.106
F-statistic	7.538	4.175	5.255	1.744	3.826	2.175	3.952	1.213

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, year

standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 5 – The effect of parental use of the app on students' use of the homework tool – By SES

	First stage				ITT			
	dependent: dummy whether the parents used the app				dependent: Number of times the child used the homework tool			
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Assignment experiment SES 1	0.140***	0.164***	0.144***	0.108***	1.018	0.989	6.469***	-6.261***
	(0.011)	(0.019)	(0.019)	(0.019)	(1.162)	(2.090)	(1.818)	(2.091)
Assignment experiment SES 2	0.211***	0.250***	0.178***	0.202***	1.576	1.971	0.472	3.054
	(0.014)	(0.025)	(0.024)	(0.026)	(1.167)	(2.061)	(1.818)	(2.126)
Assignment experiment SES 3	0.227***	0.251***	0.212***	0.230***	-0.847	0.825	1.035	-4.118**
	(0.014)	(0.025)	(0.023)	(0.025)	(1.131)	(2.121)	(1.721)	(1.991)
N	2081	740	733	608	2081	740	733	608
R-squared					0.071	0.108	0.107	0.062
F-statistic	54.35	25.20	18.61	10.44	6.271	3.771	3.689	1.670
	OLS				IV/2SLS			
	dependent: Number of times the child used the homework tool				dependent: Number of times the child used the homework tool			
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Dummy app used SES 1	11.808***	17.063***	18.116***	-3.197	7.311	5.995	44.751***	-57.697**
	(2.216)	(3.833)	(3.366)	(4.378)	(8.219)	(12.295)	(12.702)	(22.464)
Dummy app used SES 2	8.880***	10.180***	6.041**	9.251***	7.512	7.955	3.359	15.484
	(1.687)	(2.845)	(2.683)	(3.183)	(5.479)	(7.977)	(10.292)	(12.175)
Dummy app used SES 3	7.488***	8.281***	6.084**	8.277***	-3.836	3.268	4.155	-17.697*
	(1.648)	(2.845)	(2.647)	(3.035)	(4.926)	(8.159)	(8.193)	(10.037)
N	2081	740	733	608	2081	740	733	608
R-squared	0.047	0.093	0.138	0.063	0.038	0.059	0.059	-0.310
F-statistic	3.289	2.025	4.920	1.719	3.257	1.952	3.502	1.197

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, grade level

standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 6 – The effect of parental use of the app on students' use of the homework tool – By gender

	Boys				Girls			
	ITT ; dependent: Number of times the child used the homework tool							
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Assignment experiment SES 1	2.228	2.426	7.547**	-3.280	0.217	-1.100	5.328**	-7.831***
	(1.810)	(3.205)	(3.007)	(3.123)	(1.528)	(2.809)	(2.334)	(2.896)
Assignment experiment SES 2	1.748	4.586	-1.709	1.784	1.443	-0.368	2.541	3.224
	(1.780)	(3.152)	(2.688)	(3.355)	(1.557)	(2.749)	(2.505)	(2.840)
Assignment experiment SES 3	0.242	3.237	1.158	-2.088	-1.923	-1.218	1.271	-6.145**
	(1.672)	(3.201)	(2.594)	(2.840)	(1.544)	(2.859)	(2.355)	(2.838)
N	914	344	314	256	1167	396	419	352
R-squared	0.083	0.167	0.113	0.130	0.072	0.116	0.128	0.068
F-statistic	3.355	2.916	1.685	1.589	3.685	2.217	2.644	1.089

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, grade level

standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 7 – The effect of parental use of the app on student math and language performance (in total and by gender)

	Math				Language			
	ITT ; dependent: Number of times the child used the homework tool							
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Assignment experiment SES 1	1.472	0.560	4.788**	0.621	-2.473	3.627*	-2.070	-6.147**
	(1.030)	(1.373)	(1.981)	(1.604)	(1.910)	(2.122)	(3.685)	(2.482)
Assignment experiment SES 2	1.855*	0.385	5.498***	-1.311	-0.139	-0.339	1.619	1.761
	(1.000)	(1.300)	(1.927)	(1.581)	(1.859)	(1.944)	(3.667)	(2.481)
Assignment experiment SES 3	0.150	0.148	0.139	1.793	-0.783	-2.355	0.517	3.003
	(0.962)	(1.332)	(1.816)	(1.468)	(1.756)	(1.958)	(3.407)	(2.232)
N	1920	678	677	565	1709	599	596	514
R-squared	0.906	0.425	0.531	0.574	0.676	0.575	0.561	0.856
F-statistic	701.936	20.106	30.772	30.305	134.674	32.394	30.438	121.186

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, grade level

standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 7 – The effect of parental use of the app on student math and language performance (in total and by gender) - continued

	Boys							
	Math				Language			
	ITT ; dependent: Number of times the child used the homework tool							
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Assignment experiment SES 1	3.606**	0.903	8.203**	1.503	-1.292	7.060**	-1.759	-6.864*
	(1.658)	(2.028)	(3.321)	(2.699)	(2.989)	(3.273)	(6.046)	(3.770)
Assignment experiment SES 2	1.922	-0.010	8.477***	-4.419	1.000	2.819	-1.052	-0.691
	(1.586)	(1.899)	(2.989)	(2.841)	(2.884)	(3.031)	(5.507)	(3.993)
Assignment experiment SES 3	0.196	0.617	2.812	1.574	-1.787	-2.335	1.935	1.509
	(1.467)	(1.919)	(2.820)	(2.358)	(2.639)	(3.019)	(5.180)	(3.252)
N	842	316	290	236	753	275	254	224
R-squared	0.906	0.458	0.571	0.626	0.681	0.589	0.618	0.877
F-statistic	313.830	10.734	15.410	15.437	62.154	15.609	16.151	61.803
	Girls							
	Math				Language			
	ITT ; dependent: Number of times the child used the homework tool							
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Assignment experiment SES 1	-0.241	0.573	2.177	-1.073	-3.500	0.588	-1.205	-4.626
	(1.325)	(1.927)	(2.507)	(2.042)	(2.500)	(2.912)	(4.814)	(3.375)
Assignment experiment SES 2	1.500	1.098	3.259	0.311	-0.649	-1.031	4.649	2.279
	(1.299)	(1.826)	(2.566)	(1.916)	(2.460)	(2.641)	(5.072)	(3.207)
Assignment experiment SES 3	0.133	0.722	-1.463	1.813	0.485	-2.840	-0.557	5.177*
	(1.290)	(1.897)	(2.428)	(1.934)	(2.369)	(2.660)	(4.665)	(3.105)
N	1078	362	387	329	956	324	342	290
R-squared	0.908	0.431	0.525	0.555	0.679	0.587	0.540	0.854
F-statistic	413.866	11.118	17.409	16.549	78.672	18.515	16.224	67.668

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, grade level

standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 8 – Robustness analyses

ITT	SES groups defined based on + and - 0.5 SD				SES groups defined based on + and - 1 SD				Including controls on parental involvement from student questionnaire			
	dependent: Number of times the child used the homework tool											
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Assignment experiment SES 1	1.052	1.908	6.192***	-6.934***	0.977	0.675	5.448**	-4.682*	1.414	1.988	8.281***	-8.960***
	(1.230)	(2.237)	(1.885)	(2.246)	(1.564)	(2.897)	(2.434)	(2.795)	(1.565)	(3.066)	(2.067)	(2.794)
Assignment experiment SES 2	0.726	1.455	2.096*	-1.089	0.637	1.572	2.484**	-2.199*	1.420	1.940	-1.090	3.747
	(0.800)	(1.453)	(1.265)	(1.412)	(0.728)	(1.320)	(1.139)	(1.315)	(1.421)	(2.629)	(1.999)	(2.511)
Assignment experiment SES 3	-0.576	-0.074	-0.502	-2.071	-0.324	0.099	0.435	-2.489	-0.619	3.349	1.846	-7.750***
	(1.289)	(2.293)	(2.058)	(2.339)	(1.481)	(2.666)	(2.436)	(2.622)	(1.378)	(2.681)	(1.839)	(2.479)
N	2081	740	733	608	2081	740	733	608	1350	473	504	373
R-squared	0.037	0.059	0.106	0.054	0.037	0.059	0.101	0.046	0.053	0.118	0.161	0.195
F-statistic	3.199	1.966	3.658	1.444	3.174	1.961	3.467	1.217	2.640	2.298	3.518	3.221

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, grade level

standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 8 – Robustness analyses – continued

ITT	4 SES groups dependent: Number of times the child used the homework tool					4 groups education level mother dependent: Number of times the child used the homework tool			
	Total	Grade 7	Grade 8	Grade 9		Total	Grade 7	Grade 8	Grade 9
Assignment experiment SES 1	0.992	2.342	6.355***	-7.728***	Assignment experiment educ level mother 1 (primary or secondary educ)	15.309***	24.357***	-10.872	6.646
	(1.219)	(2.226)	(1.886)	(2.187)		(4.577)	(6.205)	(13.766)	(8.696)
Assignment experiment SES 2	2.140**	2.110	2.059	2.199	Assignment experimentused educ level mother 2 (upper sec or vocational educ)	7.589***	10.531***	6.061*	5.140
	(1.065)	(1.905)	(1.668)	(1.940)		(2.127)	(3.948)	(3.136)	(3.952)
Assignment experiment SES 3	0.095	0.088	1.848	-0.866	Assignment experiment used educ level mother 3 (higher educ)	2.916	5.141	3.783	-2.032
	(1.093)	(2.036)	(1.664)	(1.932)		(2.096)	(3.413)	(3.294)	(4.340)
Assignment experiment SES 4	-0.987	0.350	0.137	-3.611*	Assignment experiment used educ level mother 4 (missing)	12.141***	12.133***	14.000***	10.428***
	(1.171)	(2.138)	(1.859)	(2.050)		(1.518)	(2.635)	(2.428)	(2.788)
N	2081	740	733	608	N	2081	740	733	608
R-squared	0.039	0.060	0.106	0.069	R-squared	0.077	0.113	0.137	0.063
F-statistic	3.214	1.905	3.502	1.787	F-statistic	6.549	3.809	4.700	1.641

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, grade level

standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 8 – Robustness analyses – continued

	standard errors clustered at class level				standard errors clustered at school level			
ITT	dependent: Number of times the child used the homework tool							
	Total	Grade 7	Grade 8	Grade 9	Total	Grade 7	Grade 8	Grade 9
Assignment experiment SES 1	1.018	0.989	6.469***	-6.261***	1.018	0.989	6.469**	-6.261**
	(1.103)	(1.491)	(1.867)	(1.764)	(0.390)	(1.585)	(0.460)	(0.293)
Assignment experiment SES 2	1.576	1.971	0.472	3.054	1.576	1.971	0.472	3.054*
	(1.134)	(2.255)	(1.666)	(1.886)	(1.434)	(1.416)	(1.860)	(0.271)
Assignment experiment SES 3	-0.847	0.825	1.035	-4.118**	-0.847	0.825	1.035	-4.118
	(1.141)	(2.180)	(1.499)	(1.952)	(0.680)	(4.996)	(0.746)	(0.806)
N	2081	740	733	608	2081	740	733	608
R-squared	0.071	0.108	0.107	0.062	0.071	0.108	0.107	0.062
F-statistic	4.096	12.936	4.802	2.749	4.096	12.936	4.802	2.749

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, grade level

clustered standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 9 – Regression analyses split by age group instead of grade level

	ITT			
	dependent: Number of times the child used the homework tool			
	Total	Age 12	Age 13	Age 14
Dummy app used SES 1	1.018	1.815	3.794*	-5.391**
	(1.162)	(2.308)	(1.972)	(2.219)
Dummy app used SES 2	1.576	1.809	0.486	0.959
	(1.167)	(2.206)	(1.904)	(2.416)
Dummy app used SES 3	-0.847	0.719	1.753	-4.621**
	(1.131)	(2.098)	(1.897)	(2.293)
N	2081	626	746	511
R-squared	0.038	0.055	0.098	-0.231
F-statistic	3.257	1.584	2.025	0.984

Controls = primary school ability score, gender, age, country of birth, situation at home, ses (neighborhood), mother part time, mother has a job, number of people in the household, educational level mother, individual SES, number of parents born abroad, child born abroad, school, type of education, grade level

standard errors in parentheses

* $p<0.1$; ** $p<0.05$; *** $p<0.01$