A Library in the Palm of your Hand?

A Randomized Reading Intervention with Low-Income Children

Silke Anger[a], Bernhard Christoph[b], Agata Galkiewicz[f], Shushanik Margaryan*[c], Frauke Peter[d], Malte Sandner[e], and Thomas Siedler[c]

[a]Institute for Employment Research (IAB), University of Bamberg, and Institute of Labor Economics (IZA), [b]IAB, [c]University of Potsdam, IZA and Berlin School of Economics (BSoE), [d]German Centre for Higher Education Research and Science Studies (DZHW), [e]Technische Hochschule Nürnberg, IAB and IZA, [f]University of Potsdam and IAB

Abstract

Reading skills are crucial for academic success and long-term educational attainment. However, children from disadvantaged backgrounds read less than their more privileged peers. This study assesses the impact of a randomized reading intervention conducted in Germany targeting 11–12-year-olds from low-income households. The intervention involved distributing e-book readers, which provided free access to a large digital library of age-appropriate books, directly to the children's homes. Our results show that the intervention led to increased reading engagement among the children, which in turn improved their academic performance, particularly in reading comprehension and math. Additionally, we observe positive effects on their socio-emotional well-being.

Keywords: randomized controlled trial; low socioeconomic status; reading comprehension; early education

JEL Classification: C93; I20; I24

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1 Introduction

Multiple studies document early emergence and persistence of educational achievement gaps by socioeconomic background (Boggess, 1998; Coelli et al., 2007; Cunha et al., 2006; Dustmann, 2004; Ermisch and Francesconi, 2001; Heckman, 2008). A key area in which students from lower-income backgrounds perform worse than students from higher-income backgrounds is reading. Reading skills and text comprehension are crucial, as they predict overall academic achievement and further educational attainment (Alexander et al., 1997; Bigozzi et al., 2017; Herbers et al., 2012; Hernandez, 2011; Kern and Friedman, 2009; Slavin et al., 2009; Sonnenschein et al., 2010). Moreover, they are predictive of long-term labor market success and wages (Green and Riddell, 2003; Hanushek et al., 2015).

This paper evaluates the effects of a randomized reading intervention among disadvantaged children across Germany on reading behavior, academic achievement, socio-emotional well-being, and non-cognitive skills. The intervention consists of three key features. First, each child received an e-book reader with a pre-activated subscription to a digital library of about 1,000 books, allowing them to select books that align with their interests and reading abilities. Second, the devices were pre-activated with a password-protected child mode, restricting access to age-appropriate content and reducing barriers to use. Third, we provided book recommendations via postcards in collaboration with *Stiftung Lesen*, a charitable foundation that promotes reading, offering guidance similar to that which children from more educated backgrounds typically receive. Additionally, our geographically representative and spread-out sample of disadvantaged households mitigates concerns about spillover effects.

Our analysis, conducted one year after the intervention, shows that children who received the e-book readers are significantly more likely to engage in reading. Specifically, treated children are 17 percentage points more likely to have read an e-book in the last four weeks compared to those in the control group, representing an increase of approximately 140 percent, given the 12 percent baseline rate of e-book reading among control group

children. Importantly, this increase in e-book reading does not come at the expense of reading printed books; instead, we observe a rise in overall reading. Our findings also show that the treatment group engages in reading more frequently, with children in this group being more likely to read on more than one day a week compared to the control children.

The reading intervention positively affects children's academic achievement and socio-emotional well-being. To assess academic achievement, we created an index that includes reading comprehension, German and math grades, and academic aspirations. The estimated intention-to-treat effect on the index suggests a significant increase of 11 percent of a standard deviation. A closer examination of the individual components of this index reveals that the improvements are driven primarily by higher reading comprehension scores and math grades. Specifically, we find an 11 percent of a standard deviation increase in reading comprehension and an eight percentage point increase in the probability of receiving a good math grade.

Additionally, we assess the impact of the intervention on children's socio-emotional well-being using the Strengths and Difficulties Questionnaire (SDQ), a behavioral screening questionnaire. Socio-emotional skills are closely linked to student performance on standardized tests and are strong predictors of future educational attainment and labor market outcomes (Keilow et al., 2019; Heckman and Rubinstein, 2001; Cunha et al., 2010; Attanasio et al., 2020). Our analysis indicates that children who received the intervention scored ten percent of a standard deviation lower on the SDQ, indicating a positive shift in their socio-emotional well-being.

To establish whether the benefits of the intervention are stronger for some groups, we explore two dimensions of heterogeneity: the home environment and children's characteristics. To assess the home environment, we examine socioeconomic status, income levels, the presence of a conducive learning environment, and the frequency of parental involvement in educational matters. In terms of children's characteristics, we investigate po-

tential differences between girls and boys, age differences, migration background, baseline reading proficiency, grades in German and math, and reading habits. Our analysis reveals that, across these diverse predetermined (baseline) factors, the impact of the treatment on reading behavior, academic achievement, and SDQ score is not statistically different between the various groups. This indicates that the intervention is broadly effective.

To explore potential mechanisms behind our reading intervention's positive effects, we begin by assessing children's satisfaction with the e-book readers and find that more than 60 percent of the children who received the device report increased enjoyment in reading compared to before having the e-book reader. Our mediation analysis identifies significant pathways through which the intervention influences academic achievement and well-being (SDQ). Improvements in children's reading self-concept and behavior emerge as key mediators, suggesting that these factors are significant drivers of the educational and socio-emotional benefits observed from the intervention.

Our paper contributes to the literature in several ways. First, our article adds to the literature on early childhood educational interventions by examining how these interventions influence the human capital production function. According to this framework, skills develop through the investment of time, such as parental engagement and a child's own efforts and resources, such as access to educational materials and learning environments. Disparities in access to these resources are often cited as key drivers of the SES gap in reading skills, observable at as early as 18 months of age (Fernald et al., 2013). The home literacy environment, in particular, can be crucial, as children from low-SES households typically have reduced access to educational resources, early literacy experiences, and rich language exposure (Romeo et al., 2022). Our intervention addresses these constraints by providing e-book readers at no cost, along with subscriptions to a comprehensive library of age-appropriate books. This significantly reduces both the marginal costs and logistical barriers to accessing reading materials. Additionally, reading tips and the large age-appropriate digital library simplify the selection of suitable books and considerably reduce the effort required to switch between books.

Second, our intervention targets children directly. While parenting style and parental time investments are important factors in the production function, our strategy circumvents parental input, focusing instead on the child's direct interaction with educational content. Research suggests that after age ten, a child's own time investment becomes more critical than the time investment of others (Del Boca et al., 2014). By focusing on the child's direct interaction with these resources, we aim to mitigate socioeconomic disparities in skill development.

Third, in our study, children are given considerable freedom to select books that align with their individual interests and proficiency levels. We view this flexibility as crucial, as it increases the likelihood of a meaningful match between a child's reading ability and the book's readability.[1] The literature on direct reading interventions, such as book provision, suggests that their effectiveness hinges on how well the books provided meet students' specific needs (Holden, 2016; Kremer et al., 2013; Abeberese et al., 2014; Guryan et al., 2016; Glewwe et al., 2009).

Fourth, our study contributes to the literature on technology in education by providing new insights into how specific digital tools can support learning outcomes. Existing research on the use of computers in educational settings often shows that their impact on academic performance is limited or negative, primarily due to potential distractions (Beuermann et al., 2015; Cristia et al., 2017; Fairlie and Robinson, 2013; Fairlie and Kalil, 2017; Leuven et al., 2007; Malamud and Pop-Eleches, 2011).[2] In contrast, e-book readers present a unique advantage by minimizing distractions, as they have no browser access, games, or apps, but do offer immediate access to a broad range of books. This focus on a distraction-free digital tool provides a clearer picture of how technology can positively impact educational outcomes. Although a few studies have explored the use of e-book readers in classrooms with teacher guidance (Hashim and Vongkulluksn, 2018; Long and Szabo, 2016; Akbar et al., 2015), these studies are largely descriptive, with small sample

[1] For example, when a child starts reading a book and realizes that the text is too easy, too difficult, or uninteresting, they can switch to another book within seconds with just a few clicks.

[2] For an extensive overview, see Bulman and Fairlie (2016) and Escueta et al. (2020).

sizes, and lack the rigor of randomized controlled trials. To the best of our knowledge, this study is the first large-scale randomized controlled trial to assess the impact of e-book readers as a tool to enhance reading outcomes, offering new insights into the potential of digital resources in educational interventions.

Fifth, our study provides novel evidence of the spillover effects of reading interventions on outcomes beyond reading achievement. While most educational research focuses on direct improvements in reading and language skills, our findings demonstrate that enhancing reading skills has significant positive effects on other areas of academic performance, including math, as well as behavioral outcomes measured by the Strengths and Difficulties Questionnaire (SDQ). Our analysis also reveals cross-productivity between reading and other academic and behavioral skills, highlighting how investments in one area of education can lead to broader benefits.

Taken together, this study provides valuable insights that have the potential to inform education policy. There is widespread concern about poor school outcomes and growing achievement gaps early in life in many countries. Reading literacy, in particular, fell sharply between 2015 and 2022 in many EU countries (OECD, 2023).[3] We observe that the provision of e-book readers along with access to an age-appropriate digital library, results in a significant increase in reading engagement among children, positively influencing their literacy, numeracy, and socio-emotional well-being. These foundational skills are not only crucial in their own right, but are also essential for the development of higher-level cognitive abilities and have implications for further learning and academic success. Our study offers an easily scalable and inexpensive intervention strategy that can complement traditional educational approaches and foster children's learning across various settings.

The rest of the paper is organized as follows: Section 2 describes the experimental design and our intervention, while Section 3 outlines the empirical strategy. Section 4 presents the main results, as well as potential heterogeneity and robustness checks. Section 5

[3]From 2018 to 2022, the average reading performance across 35 OECD countries declined by ten score points. This is comparable to the learning equivalent of around three-quarters of a school year.

presents additional findings and evidence on mediators. Finally, Section 6 concludes.

2 Experimental Design

2.1 Sample

To draw our experimental intervention population, we rely on data from the Social Security Records of the German Federal Employment Agency. When selecting our experimental population, we focus on low-income and welfare-dependent households.[4] We conducted the first baseline survey in November 2020. The study collected an array of relevant socioeconomic and academic variables, including reading comprehension test, school grades, and educational aspirations. We also conducted surveys with the parents, allowing us to link children and their parents both at baseline and in the subsequent follow-up surveys. The survey data has the additional advantage that the participants (and their schools) are spread across different federal states in Germany, which reduces concerns about spillover effects between the treatment and the control group.[5]

Our experimental sample consists of 1,000 students aged 11–12. The selected sample of 1,000 children is assigned to the equal-sized treatment and control groups using a stratified randomization. We stratify our sample based on the following variables: (i) an indicator of receiving welfare, (ii) sex of the child, (iii) school grade (class) of the child, (iv) migration background, and (v) median split of baseline reading comprehension.

We deliberately focus on children aged 11–12 years. Following Cunha and Heckman (2007), the age range of 11–12 years old falls under what they define as a "sensitive period". According to the stage model of reading by Chall (1983), children at this age are more likely to have the necessary decoding skills to read books on their own, without needing help from teachers or parents.[6] In contrast, during the early stages of childhood, the

[4]For the purposes of this study, we define low-income households as those below the 60th percentile of the income equivalence distribution. In selecting the sample, we also excluded children with siblings in the same grade and those who did not complete our baseline reading comprehension test.

[5]Figure 1 shows the geographic spread of the treatment and control group, and online Appendix Table A1 presents the sample shares by federal state.

[6]She refers to this stage as when readers "start on the long course of reading to "learn the new"—new

formation of a child's human capital is significantly influenced by parental involvement. Research has consistently shown that parents with a lower socioeconomic background tend to allocate fewer resources to their children's education, contributing to the well-documented achievement gaps across various skills (Guryan et al., 2008). A recent reading intervention aimed at enhancing parental engagement in low socioeconomic households among children around age four has shown mixed effects on literacy skills (Kalil et al., 2023). Our study, however, intentionally targets children who reached the age at which they are capable of independently using e-book reader devices. Through this, we aim to mitigate the reliance on parental involvement in children's learning and human capital development.

Table 1 shows the summary statistics for relevant pre-treatment variables for the treatment and control groups. In both groups, roughly 50 percent of participants are girls. The average grades in German and math are 2.4 and 2.3, close to the average in Germany (Lettau, 2021).[7] A total of 78 percent of parents have at least a middle school leaving certificate and about 80 percent were born in Germany. The share of households with very low socioeconomic status, defined as receiving welfare, is just above 50 percent as a result of our oversampling. As the p-values in column (4) show, the randomization was successful and the baseline characteristics are balanced between the treatment and the control groups.

2.2 Intervention

One year after the baseline data collection, in November 2021, the households assigned to the treatment group received a letter announcing that they will receive an e-book reader with a free subscription to more than 1,000 age-appropriate books for an entire year.[8] Parents and children who did not wish to receive the device could opt out. Of the

knowledge, information, thoughts and experiments" (Chall, 1983: p. 20).

[7]The grading system in Germany assigns grades between 1 (very good) and 5 (poor) to schoolchildren of this age. Children can also receive the grade 6 (failing), however this rarely happens in this age group.

[8]After one year, the subscription expired. However, the household could keep the devices.

500 households assigned to the treatment group, 42 opted-out.[9] In mid-December 2021, households that did not opt-out received the pre-activated e-book readers.[10]

Our intervention incorporates several key features, which we outline below. First, each device comes with an activated subscription to a digital library containing approximately 1,000 books. Thus, children are granted considerable autonomy to select books that match their individual interests and proficiency levels. We view this freedom as critical, as it increases the likelihood of a meaningful match between children's reading abilities and book readability.

Second, the devices are pre-configured before dispatch. Our team created individual profiles for each child and enabled a password-protected child mode, ensuring that neither children nor their parents can deactivate the child protection settings. This configuration restricts the use of the e-book readers to age-appropriate books only.[11] This also significantly reduces the barriers to using the e-book readers, positioning the intervention as a means to lower the obstacles to initiating and sustaining regular reading habits.

Third, we sent postcards with book recommendations throughout the first five months of the intervention. The first one was mailed in the first week of January 2022 and the last one in the last week of April 2022. To ensure age-appropriate recommendations, we collaborated with *Stiftung Lesen*, the leading German charitable foundation that promotes reading. Participants received two types of postcards. These were either an illustrated postcard, including the name of the recommended book and a short description, or the name of the book and a link to a video produced by *Stiftung Lesen*. In these videos, members of the *Stiftung Lesen* team stage a conversation about the book content. We

[9]The original letter (translated from German) is displayed in the online Appendix. We did not replace households that opted out. Table 2 shows the characteristics of the households that opted out compared to those that did not. The table shows that the households that opted out do not significantly differ from those that did not.

[10]By early 2022, most pandemic-related school closures had been lifted, and the majority of schools had resumed in-person teaching, with students attending classes on-site.

[11]While parents could theoretically reset the devices to factory settings, this would result in the loss of the book subscription. Additionally, parents were informed that the e-book reader is intended exclusively for their child's use.

host the videos on a secure platform, where only the treated children could access them.[12] The basic idea here is to offer book recommendations to children in the treatment group, providing them with inputs akin to those routinely received by children from more educated backgrounds from their parents. For children from less educated families—such as the treatment group in our study—such parental advice is likely to be less common.[13] In addition, as the devices had access to 1,000 books, the reading tips could make it easier for the participants to choose their first book.

Our intervention thus leverages several features to address multiple barriers to reading engagement in a scalable manner. While future research could explore the individual contributions of these specific features, such as devices without subscription or reading recommendations, this study focuses on assessing the overall impact of our bundled treatment in facilitating reading habits.

We collected data in two follow-up online surveys. The first follow-up (wave 2) was conducted with children (and one parent) approximately six months after the experiment started, in summer 2022. The second follow-up (wave 3) took place in February–April 2023, shortly after the library subscription had expired. This survey is our primary data set for the analysis. Figure 2 provides an overview of the intervention and data collection timeline. The response rates for the follow-ups were 75 percent and 72 percent, respectively. Notably, our analysis, as detailed in Table 3, reveals that there are no statistically significant differences in the response rate between the treatment and control groups.[14] Moreover, in online Appendix Table A2, we address concerns of potential selective attrition showing that attrition is not selective based on reading behavior, reading

[12]Online Appendix Figure A1 shows the exact mailing days of the postcards and displays an example of both types of postcards. The videos can be accessed under `vimeo.com/user/156363831/folder/6212899`.

[13]To make sure that the number of contacts to the control group children was similar, we sent them an illustrated postcard to thank them for their participation in the study.

[14]Children were invited to the follow-up surveys by mail, which included a €10 voucher (pre-paid incentive) to be used in online shops or onsite retail stores. Another €10 voucher was announced to the children upon participation in the survey (post-paid incentive). After four weeks, non-participating children received a reminder letter. Children who had not participated after eight weeks, received another reminder letter which announced a voucher of even higher value (€30) upon participation. In parallel, parents of non-participating children were phoned to remind them of the survey.

comprehension, and school grades, all measured at baseline.

3 Empirical Strategy

We estimate and report both intention-to-treat (ITT) and treatment-on-the-treated (TOT) effects, with the ITT effects being our preferred specification. The equation for estimating the ITT is as follows:

$$Y_i = \alpha + \beta treat_i + \gamma strata_i + \epsilon_i \tag{1}$$

where Y_i is the outcome of interest for child i, $treat_i$ indicates the initial assignment to the treatment or control group, including those who opted out, $strata_i$ stands for fixed effects of randomization strata, and ϵ_i is the error term. Our main outcomes are in four areas: reading behavior, academic achievement, socio-emotional well-being (assessed through a Strength and Difficulties Questionnaire (SDQ)), and self-efficacy. For each outcome we construct an index, which summarizes several variables. We use indices for two primary reasons. First, aggregating variables into indices reduces noise, thereby enhancing signal detection and the precision of estimates. Second, indices decrease dimensionality, which alleviates complications associated with multiple hypothesis testing. We present two indices: a summary index following Kling et al. (2007), and an inverse-covariance weighted index (Anderson, 2008).

To estimate the TOT, we use the initial randomization assignment as an instrument for take-up (Angrist et al., 1996). We define treatment take-up as one if the child reports using the device alone or with their parents.[15] The first and second stage equations are as follows:

[15]We collected this information during the first follow-up in summer 2022. The children were asked who uses the e-book reader usually. The answer option are (i) I, (ii) I with my parents, (iii) my parents, (iv) my siblings, (v) my friends, (vi) others. The majority of children say that they use the device by themselves. Take-up receives the value one if children use the e-book reader alone or with their parents, and zero otherwise. The TOT estimations have slightly fewer observations, as we exclude optouts and those who did not respond to the question.

$$T_i = \tau + \delta treat_i + \lambda strata_i + \eta_i \tag{2}$$

$$Y_i = \nu + \theta \hat{T}_i + \gamma strata_i + v_i \tag{3}$$

where T_i is the take-up, and all other variables are defined as above. The identifying assumption is that treatment assignment does not affect those individuals who were assigned to treatment but did not participate. Given that our sample is drawn from across Germany, it is highly unlikely that this assumption would be violated. However, we should carefully point out that one possible issue with the TOT estimates is that the treatment assignment variable may be influenced by an experimenter demand effect. For example, some children might report that they use the e-book reader, even if they do not actually do so in reality. Therefore, we give more weight to the ITT estimates and report them as our preferred findings. In addition, the ITT effect is the more policy-relevant parameter.

To ensure our standard errors are accurate and not influenced by limited sampling, we also present p-values from randomization inference (Young, 2019). The randomization test works by permuting the treatment assignments to construct the permutation distribution of the test statistic under the null hypothesis of no treatment effect. The p-value is then calculated as the fraction of permuted statistics as or more extreme than the observed statistic.

4 Results

4.1 Main Results

This section outlines the main results of the study. Table 4 reports the estimated intention-to-treat and treatment-on-the treated effects on the four outcome indices, including standard p-values and randomization inference p-values. We do not report the first-stage results in the table for brevity. The first-stage coefficient suggests an 89 percent take-up

and is highly significant.

We begin by discussing the impact of the reading intervention on reading behavior. This index is determined by the following variables: the number of e-books and printed books read in the last four weeks, as well as how often the children read in a typical week.[16] We dichotomize these variables before building the index.[17] Both the summary index and the inverse-covariance weighted index reveal a positive and significant change in reading behavior among the treated children. For example, the ITT point estimate for the summary index in the first row of Table 4 suggests that the provision of e-book readers increased the frequency of children's reading by 26 percent of a standard deviation. The Anderson's index suggests a somewhat larger impact on reading behavior. The impact is very precisely estimated, as indicated by both the standard p-value and the p-value from randomization inference. We interpret this finding as a strong first-stage of the educational intervention on children's reading behavior.

Our next outcome is academic achievement. To construct this index, we rely on a reading comprehension test, the participants' school grades in math and German, and the educational aspirations of the children. To assess the reading comprehension of the participating children, we use a standard reading test developed by the Institute of Educational Quality Improvement (IQB).[18] This test involved reading an age-appropriate text and answering several single- and multiple-choice questions. To account for the age variation among the children, we administered a different test in each survey wave, adjusting the difficulty level accordingly. The answers were used to create standardized scores, facilitating comparison across different test versions. Our analysis indicates an increase in the academic

[16]We attempted to gather objective data on children's reading behavior by gathering device metadata from the "Parental Dashboard", after obtaining parental consent. However, we encountered several technical issues that hindered our data collection process. Among a small subset of the treated children, we found that the median daily reading time is 25 minutes and the mean is 47 minutes. Further, we noticed that the median reading time remains consistent over months, with a slight increase during school summer vacation.

[17]We generate a binary variable that equals one if the child reports to have read at least one (e-)book in the last four weeks, and zero otherwise. To categorize the variable 'frequency of reading' as a dichotomous variable, we set it to one if the child reads on two or more days in a typical week, and zero otherwise. Our results are not sensitive to the definition of the binary variables.

[18]The original tests (in German) can be found in the online Appendix.

achievement of the treated children. The ITT effect for the summary index indicates an increase in children's academic achievement of 11 percent of a standard deviation, and the corresponding estimate for the inverse-covariance-weighted index suggests a positive impact of 15 percent of a standard deviation.[19]

Next, we present the results regarding the socio-emotional well-being of the children. The SDQ is a screening questionnaire, covering the domains of emotional symptoms, conduct problems, hyperactivity and inattention, and peer relationship problems.[20] We expect reading to affect the SDQ score of children for multiple reasons. First, reading intervention can improve children's self-esteem and confidence. For example, struggling with reading can lead to feelings of inadequacy and frustration, which can contribute to emotional and behavioral difficulties (Mak and Fancourt, 2020). Second, reading intervention can improve cognitive and language skills, which can have a positive impact on emotional and behavioral outcomes (Roberts et al., 2015). For example, improved language skills may help children to express their emotions more effectively, which can reduce behavioral difficulties (Eisenberg et al., 2005). Third, reading intervention can also provide children with an opportunity to engage in a relaxing and enjoyable activity, which can provide a healthy outlet for children's emotions and reduce stress levels. Finally, reading complex stories and novels may enhance children's ability to take the perspective of others. In turn, this can positively influence how they interact with their peers and help reduce problems in peer relationships.

We find a statistically significant decrease in the SDQ score, implying an improvement in socio-emotional well-being. The ITT point estimate for the summary index suggests a reduction in the score of 10 percent of a standard deviation, while the inverse-covariance-weighted index indicates a reduction of approximately 15 percent. These findings suggest that the treated children experience an improvement in their socio-emotional well-being. It is important to note that these results rely on the children's self-assessments, as evidence

[19]The corresponding TOT point estimates are 19 percent and 25 percent of a standard deviation, respectively.

[20]Online Appendix Table A3 presents the various items of the SDQ.

shows that parental assessments of children's skills are directly influenced by the parents' own skills (Del Bono et al., 2020). Nevertheless, we also analyze the effect of the treatment on the SDQ as reported by parents. Our results indicate a statistically significant decrease in the difficulties score based on parental assessments as well.[21]

Finally, we analyze the impact on the self-efficacy index, which we measure through locus of control and grit. It is possible that the children who develop strong early literacy skills are more likely to have confidence in their abilities and persevere in the face of challenges. However, we do not find any evidence that the self-efficacy of the treated children responds to the reading intervention.

Overall, the results in Table 4 indicate that the e-book reading intervention increased children's reading engagement and improved their academic achievement. At the same time, the treated children experience fewer socio-emotional problems. The findings are very consistent across the two outcomes—the summary index and the inverse-covariance-weighted index—with the former providing lower bound ITT and TOT point estimates. Finally, p-values from randomized inference constitute a stricter or more conservative measure of inference for the majority of point estimates in Table 4. In the following, we therefore focus on the summary index (Kling et al., 2007) as our preferred outcome measure and report p-values from randomized inference.

4.2 Results for the Components of the Summary Indices

Presenting indices first increases the statistical power to detect effects and reduces the dimensionality of tested outcomes. After establishing significant effects on reading and academic achievement, and a negative impact on the SDQ composite index, we proceed to demonstrate the effect on the components of these three summary indices in Table 5. We start by focusing on the number of books read in the last four weeks. To simplify this analysis, we dichotomize the outcome by defining a variable that takes the value one if a child reports having read at least one (e-)book during this period, and zero otherwise.

[21] The estimated coefficient on the SDQ index is -0.170, with a p-value of 0.036.

The results indicate that children in the treatment group are 17 percentage points more likely to have read at least one e-book, representing an increase of about 140 percent. This finding is not surprising given that few children in the control group read e-books (12 percent).

To verify that the children in the treatment group are not merely substituting printed books with e-books, we then analyze the effect on the number of printed books and all books read. The second and third rows in Table 5 display the results of our analysis. Our findings indicate no evidence for substitution. On the contrary, we observe that children in the intervention group are 6.2 percentage points (approximately eight percent) more likely to report reading a book in the last four weeks compared to those in the control group. In total, the treated children have an 8.4 percentage point (approximately 10 percent) higher likelihood of having read at least one book in either format within the last four weeks. This suggests that the provision of e-book readers has a positive impact on reading habits, leading to a noticeable increase in overall book consumption among the treated children.

In addition, we explore how frequently the treated children engage in reading each week. The outcome for row four is equal to one if the child reads on more than two days in a typical week; otherwise, it is zero. Our coefficient implies an increased likelihood of this behavior by 7.9 percentage points (approximately 10 percent). In summary, the evidence presented here shows that providing e-book readers have the desired effect of increasing reading among the treated children. The TOT effects in column (3) of Table 5 confirm the main ITT results. As expected, the TOT effects are larger in magnitude, suggesting that the effect on children who did indeed use the devices is stronger.[22]

In the following part, we examine the effects on academic achievement. We present the effects on reading comprehension, grades in German and math, and educational aspirations one year after the intervention had started. Based on our ITT estimates, the treated

[22]The TOT estimates suggest an increase in reading of 34–50 percent of a standard deviation, an improvement in academic achievement of 19–25 percent of a standard deviation, and a decrease in the SDQ score of 6–13 percent of a standard deviation.

children experienced an improvement in reading comprehension of around 11 percent of a standard deviation. Although the effect is positive, the p-value is above 10 percent. On the other hand, the TOT effect indicates a statistically significant increase of 15.6 percent of a standard deviation in the reading comprehension of the treated children at the 10 percent significance level. The magnitude of this estimate is comparable to the results reported by Abeberese et al. (2014), who estimate a 13 percent of a standard deviation improvement in reading comprehension over a 31-day read-a-thon study, although their sample did not specifically target disadvantaged children. In a meta study of summer reading interventions, Kim and Quinn (2013) report an 11–22 percent of a standard deviation effect, with larger benefits for children from low-SES backgrounds.[23]

We proceed with analyzing the impact of the intervention on grades in German and math. The final grades are based on school report cards one year after the intervention and are self-reported. The grading system in Germany assigns grades between one (very good) and six (failing) to schoolchildren, although children in this age group rarely receive a six. We recode the grading variables to indicate the child has a very good or good grade score as one, and zero otherwise. The estimates suggest that there is no statistically significant effect on German grades, while math grades among the treated children show improvement. Results infer that the probability of receiving a good or very good grade in math increased by 8.4 percentage points after one year. The TOT effects suggest a slightly larger increase of 11 percentage points. This kind of disparity between math and native language grades is not uncommon. For example, Bettinger (2012) finds that financial incentives increase math scores, but not English scores. Similarly, Bergman (2021) reports that test scores for math increased while English scores remain unchanged as a result of providing parents with information about missed assignments.

Next, we examine the effect on aspirations, as part of academic achievement. The variable

[23]Several interventions find no impact on academic outcomes. For example, Rouse and Krueger (2004) find that a computerized program for reading skills has no effect; Bettinger (2012) finds that financial incentives fail to improve reading scores; and Goux et al. (2017) find that an after-school reading program has no impact on reading enjoyment and skills.

takes the value one if the child has aspirations to attend the highest (academic) school track (Gymnasium) and zero otherwise. However, the results show no impact on the probability of aspiring to the higher track.

Finally, we show the effect on each attribute of the SDQ score. These are: peer relationship problems, hyperactivity or inattention, conduct problems, and emotional symptoms. The results suggest that the largest improvement was in peer relationships.

4.3 Heterogeneity

In this section, we examine potential differential impacts of the e-book reader intervention across various baseline characteristics for our summary outcome indices. We estimate a modified version of the intention-to-treat model (equation 1), as follows:

$$Y_i = \alpha + \beta_1 treat_i + \beta_2 group_i + \beta_3 treat_i \times group_i + \gamma strata_i + \epsilon_i \tag{4}$$

where $group_i$ is an indicator equal to one if a child is in the given group, and zero otherwise. $strata_i$ is defined as in equation (1). In cases where we examine heterogeneity in the baseline characteristics used for stratification, we do not include an additional fixed effect for that group.

We categorize our sample, based on predetermined (baseline) characteristics into two distinct areas: (i) home environment, and (ii) child characteristics.[24] We make this distinction because each of these areas can significantly influence reading behavior and subsequently impact both cognitive and non-cognitive skills.

A substantial body of literature suggests that the family and home environment play a crucial role in children's development (Angrist and Lavy, 2009; Bettinger, 2012; Guryan et al., 2014; Bergman et al., 2018). To investigate whether the impact of the current reading intervention varies across different home environments, we use data on household

[24]Online Table A4 presents summary statistics of the baseline variables used for the heterogeneity analysis.

socioeconomic status (welfare receipt), income, learning environment, level of parental support with homework before and during school closures, and communication with parents regarding school material. Panel A of Figure 3 plots the estimated coefficient $\hat{\beta}_3$ from equation (4) and the corresponding 90 percent and 95 percent confidence intervals for the outcome reading index. There is a slight indication that the reading behavior might be more strongly affected for children coming from somewhat less disadvantaged environments, but the point estimates are not precisely estimated.

Next, we explore the heterogeneity of the e-book reader provision across the child's baseline (predetermined) characteristics. We examine factors such as the child's sex, age, migration background, self-assessed reading skills, grades in German (math), and frequency of reading. For example, the effect might differ by sex, as girls tend to perform better in reading (Logan and Johnston, 2010). It is also possible that children who are a little older or who already have better academic skills may benefit from the intervention differently. However, we again find no statistical evidence that the effects of the treatment vary by these characteristics.[25]

In summary, our exploration of the heterogeneity of the e-book reader provision across various baseline characteristics reveals no statistically significant differences in the treatment's impact. Despite examining multiple factors such as child demographics, academic performance, and frequency of reading, our findings suggest a consistent effect of the intervention across diverse child profiles.

4.4 Robustness

We assess the robustness of our main findings to introducing additional control variables into our main regression specification. In Table 6, we successively add control variables, which we refer to as Set 1, Set 2, and Set 3. Set 1 comprises controls for the baseline reading competence score, grades in math and German, and grit. Moving to Set 2, we

[25]Online Figures A2 and A3 display the corresponding point estimates for the outcomes academic achievement and SDQ, respectively.

extend the control variables to include indicators for whether the children have their own desk, their own room, their own e-book reader, access to the internet, and whether the primary language spoken is German (all of which are measured at baseline, prior to the intervention). Set 3 goes further by incorporating fixed effects for year of birth, month of birth, federal state of residence, parent's employment status, and parent's educational qualifications. To handle missing values for control variables, we impute them with sample averages and account for them using dummy variables in our analysis. Table 6 presents the ITT estimates and the permuted p-values. Treatment-on-the-treated (TOT) effects are shown in online Appendix Table A5. The table shows that our estimates are not sensitive to the inclusion of additional control variables.

Another typical concern in these interventions is the potential violation of the stable unit treatment value assumption (SUTVA). This assumption would be violated if the control students also benefited from the reading intervention. Since randomization of the treatment occurred at the household level, it is highly unlikely that treatment and control students shared the same class or school. Furthermore, as shown in Figure 1, the experimental participants are geographically dispersed across different regions of Germany and it is therefore very unlikely that treatment and control children know each other or interact with one another. The average geographical distance between children in the treatment group and children in the control group is slightly more than 300 km (186 miles).

5 Additional Evidence

5.1 Concordance in Parents' and Children's Responses

In this section, we provide additional empirical evidence on children's reading behavior, as reported by both children and parents. We begin by examining the treatment effects on outcomes measured during the first follow-up, conducted approximately six months after the start of the experiment. In this survey, we asked both children and their par-

ents an identical set of questions, aimed at assessing the reliability of children's responses and addressing concerns about potential experimental demand effects. Table 7 displays the results pertaining to reading behavior for children and parents separately. The variables are binary and are defined as outlined above. The estimates show that in the first follow-up too there was a significant positive effect on the reading behavior of the treated children as measured in the parents' survey. Reassuringly, the point estimates based on children's and parental responses are highly comparable. For example, both children and parents report an increase in the likelihood of having read a book in the last four weeks of around six percentage points, with p-values from randomized inference of 0.018 and 0.006, respectively. We interpret the close alignment of the estimates between parents and children as supporting evidence of the reliability of children's survey responses.

In the first follow-up, we also asked parents to evaluate their child using the SDQ items. Our results show that the parents in the treatment group assess their children as having fewer behavioral problems. We do not have the children's assessment of their own SDQ in the first follow-up, however the results in Table 7 are in line with our findings from the second follow-up.

5.2 Mechanisms and Mediation Analysis

In this section, we study the possible mechanisms for the positive effects of our reading intervention. First, we present exploratory evidence on children's satisfaction with the devices. Second, we analyze the potential mediators of the effects that we find in the spirit of Heckman and Pinto (2015).

Satisfaction with the devices: One potential mechanism for increasing reading through our intervention is the inherent appeal and advantages of the e-book readers compared to traditional printed books. To explore this, we surveyed children in the treatment group about their satisfaction with the e-book readers and their enjoyment of using the device. The distribution of their responses is illustrated in Figure 4. The descriptive analysis indicates a high overall level of satisfaction with the e-book readers, an increase in reading

frequency since receiving the device, and a notable 60 percent of children reporting greater enjoyment in reading than before. These findings provide suggestive evidence that e-book readers can enhance the enjoyment of reading.[26]

Mediating variables: We perform the mediation analysis for our three main outcomes: reading behavior, academic achievement, and SDQ. The potential mediators we investigate are a) the child's reading self-concept, b) positive leisure activities, and c) study hours. To shed light on the mediators of academic achievement and SDQ, we additionally consider the index of reading behavior as a mediator. All mediator variables are measured in the first follow-up (six months after the start of the intervention), before the outcome assessments a year later. The mediators we consider are those that are positively and significantly impacted by the treatment.

To assess children's reading self-concept, we utilize three variables: (i) "I sometimes have difficulties understanding a text very well," (ii) "I can understand stories very well and quickly," and (iii) "I have to read many things several times before I really understand them." Responses are rated on a four-point scale from "I completely disagree" to "I completely agree." Figure 5 illustrates the proportion of children who agree (somewhat or completely) with each statement. At baseline, there is no significant difference in reading self-concept between the treatment and control groups. However, six months into the reading intervention, notable differences emerge. For instance, fewer than 20 percent of the treated children report difficulties in understanding a text, compared to 26 percent in the control group.

In examining the impact of leisure activities, we categorize them into positive and less constructive types. Positive leisure activities include computer and usage, music-related activities, and sports. Conversely, less constructive activities include social media en-

[26]In Figure A4 in the appendix we show coefficients from ten separate regressions, each testing whether a child reported reading a specific book title. In the first follow-up survey, both control and treatment group participants were asked whether they had read any of a list of ten books. Six of these books were actively recommended to the treatment group via postcards and videos, while the control group received no such recommendations. The remaining four books were not mentioned to either group. We find a statistically significant increase in the likelihood that the treated children read the recommended books.

gagement and watching television. Since the treatment does not significantly affect the latter, they are excluded from our mediation analysis. We asked respondents to report the frequency of their engagement in these activities during a typical week.

Following the approach of Heckman and Pinto (2015), we assume that the treatment influences the outcomes through both direct and indirect channels. The indirect effects operate via the observed mediators discussed above, while the direct effects include all unmeasured factors. Our mediation analysis, therefore, aims to quantify the relative contribution of these indirect effects. To implement this, we augment equation (1) by incorporating the vector of mediators, denoted as M. The coefficients associated with these mediators, γ^j, where j indexes the individual mediators, are then estimated. Subsequently, we estimate the treatment effect of the intervention on each mediator separately, capturing these effects with the coefficients λ^j. The contribution of each mediator to the overall treatment effect is calculated as the ratio: $\frac{\hat{\gamma}^j \times \hat{\lambda}^j}{\hat{\beta}}$, where $\hat{\beta}$ represents the estimated treatment effect on the outcomes derived from the unconditional regression in equation (1).

The results are illustrated in Figure 6. Panel (a) examines potential mediators of reading behavior, panel (b) academic achievement, and panel (c) SDQ index. Each mediator's contribution is represented by different shades of the horizontal bar, with the gray area indicating the unexplained portion of the treatment effect.

The figures reveal that, among the measured mediators, the explanatory power for the treatment effect on the reading index is relatively modest. Specifically, 94 percent of the observed positive effect on reading behavior remains unexplained by the factors we consider, with reading self-concept accounting for approximately 5 percent of the effect. Panel (b) and (c) demonstrate that reading self-concept and reading behavior are significant mediators for academic achievement and children's socio-emotional well-being. All factors considered collectively account for 43 percent of the treatment effect we find on academic achievement and 34 percent of the effect on SDQ.

Note, however, that drawing causal inferences from these results requires making assumptions about the sources of variation in the mediators, as discussed by Imai et al. (2010). Since we do not have exogenous variation across specific channels and are limited to a single instance of randomization, this analysis can only provide suggestive evidence regarding the role of different mediators in explaining the observed treatment effects.

5.3 Comparisons to Other RCT Reading Interventions and Cost-Benefit Analysis

In this section, we compare our results with other RCT reading interventions, and also benchmark our findings to experimental studies on computer-assisted reading programs. We mainly focus on RCTs with children of similar age. Finally, we provide cost-benefit analyses and briefly discuss them in light of other educational studies.

Randomized controlled reading interventions. Abeberese et al. (2014) examine a 31-day reading intervention in schools in the Philippines. The key components of the program were the provision of age-appropriate books to schools, teachers' being trained to incorporate reading, and teachers being supported in initiating reading in the classroom. The authors find an immediate increase in reading skills by 0.13 standard deviations among 4th graders. The effect decreases to 0.06 standard deviations three months after the program.

Kim and Guryan (2010) study a summer reading intervention for low-income Latino children in California. At the end of 4th grade, children were randomly assigned to three different groups. In the first treatment group, children received ten books of their choice during the summer vacation. In the second treatment group, children also received ten books of their choice and they and their parents were invited to attend three literacy events. Children in the third group constitute the comparison group. The authors find significant positive effects on self-reported reading behavior, but no significant positive effect on reading achievement.

Another related body of literature comprises randomized experiments on computer-assisted

reading programs. We compare our findings to those of the well-powered studies on a reading comprehension program called Intelligent Tutoring for the Structure Strategy (ITSS) among 4th and 5th graders in the United States (Wijekumar et al., 2012, 2014). The program teaches a particular technique for breaking down expository texts. Wijekumar et al. (2012) find that treated students who used the ITSS for 30–45 minutes per week for approximately half a year improved their standardized reading comprehension test by 0.1 standard deviations. The follow-up RCT study by Wijekumar et al. (2014) also examines whether the structure strategy, implemented through a web-based intelligent tutoring system, improved 5th graders' reading comprehension. Treated students were found to improve their reading comprehension by, on average, 0.2 standard deviations.

Overall, in comparison to previous studies, our reading intervention significantly enhances both reading behavior and academic achievement, while being less resource-intensive and independent of external support from teachers, parents, or tutors.

Cost-Benefit Analysis: At the time of our reading intervention, the cost of an e-book reader, including the one-year book subscription, was around 100 euros. The cost of the production of video recommendations amounts to approximately 16,000 euros, and there were additional costs for the design of the postcards, postage, and student assistants' working hours for pre-configuration. We calculate the total cost of the e-book reader provision at about 130.000 euros, or 260 euros per e-book reader.

For the benefit analysis, we build on Hanushek and Woessmann (2008) who summarize that several studies consistently find that a one standard deviation increase in test scores is linked to a roughly 12 percent increase in earnings. Based on our point estimate of an increase of 0.11 standard deviations in reading comprehension, this corresponds to an increase in earnings of around 1.3 percent.[27] We then calculated a present discounted value of the life long earnings gains of our reading intervention of around 5,150 euros (based on the minimum wage in Germany in 2024) and 10,135 euros (based on the average

[27]This is very likely a lower bound, as we are not accounting for the positive effects on math, socio-emotional well-being, and positive potential social benefits for society.

monthly gross earnings of 4,323 euros as of April 2023).[28] Overall, this implies benefit-cost ratios of about 20 and 39, respectively. These compare favorably to other early childhood educational intervention programs. Obviously, the high ratio in our setting results from the very low costs of e-book reader provision compared to other educational interventions (i.e., face-to-face tutoring programs, reducing class sizes, longer school days).

6 Conclusion

This paper provides insights into the impact of a large-scale randomized reading intervention, that provides e-book readers with an access to a comprehensive digital library to 11–12-year-old children from disadvantaged backgrounds. Drawing on a robust experimental design, we find that children in the treatment group show a higher likelihood of engaging with both e-books and printed books, along with an overall increase in reading frequency. These positive effects on reading translate into improved reading comprehension, higher math grades, and greater socio-emotional well-being one year after the start of the intervention. Our study underscores the importance of targeted interventions during key transitional years in schooling, when children are gaining greater autonomy in their learning pursuits. By focusing on this critical period, we aim to mitigate the influence of parental involvement and empower children to independently harness the benefits of the e-book reader technology.

Our study addresses a gap in the literature by exploring the impact of e-book readers on educational success and socio-emotional outcomes, which are crucial for later life. Our findings suggest that e-book readers, with their minimal distraction potential and the flexibility to cater to individual interests, can be a promising tool for enhancing reading habits and academic performance. Teachers, educational experts, and politicians face many challenges, such as teacher shortages, differences in school performance based on social background, and a high number of school dropouts among children from

[28] We calculated the present discounted value of an increase in annual earnings of 1.3 percent with a discount rate of 5 percent over a time window of 30 years.

low-income families. Resolving these problems is often expensive, time-consuming, and cannot be achieved overnight. Our study provides indications on how the reading habits and academic performance of children from disadvantaged backgrounds can be positively influenced, complementing the investments made within the school. Equipping children with e-book readers at home and providing access to age-appropriate books is feasible at a reasonable cost, easy to implement, and highly scalable. A limitation of our study is our difficulty to separate the independent effect of providing children with e-book readers from the impact of reading recommendations and the advantage of access to an extensive library. These distinctions present interesting avenues for future research.

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Figures and Tables

Figure 1: Geographic spread of the sample



Notes: The figure shows the map of Germany and its sixteen federal states, as well as the geographic spread of treatment and control children.

Figure 2: Intervention and data collection timeline

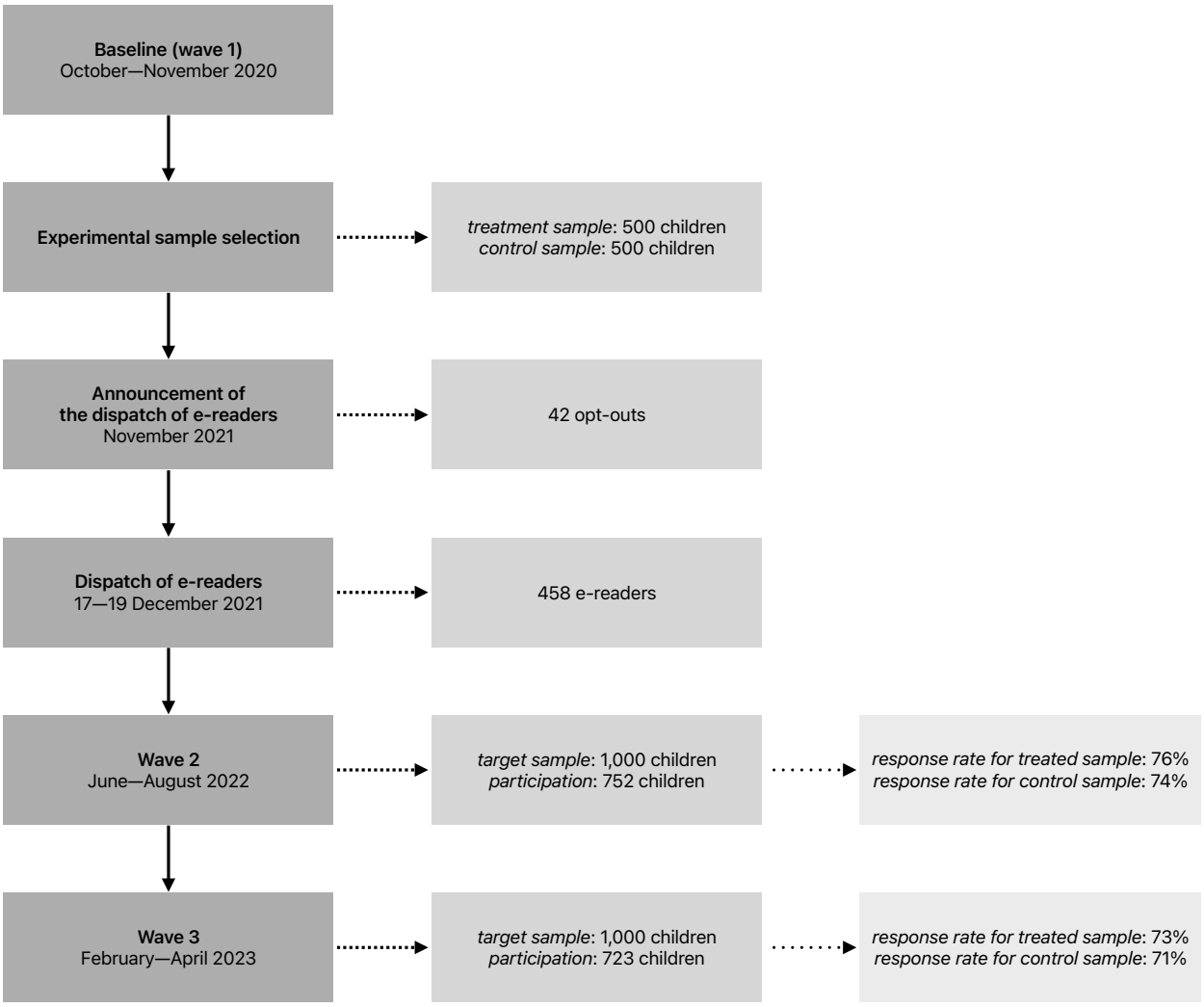
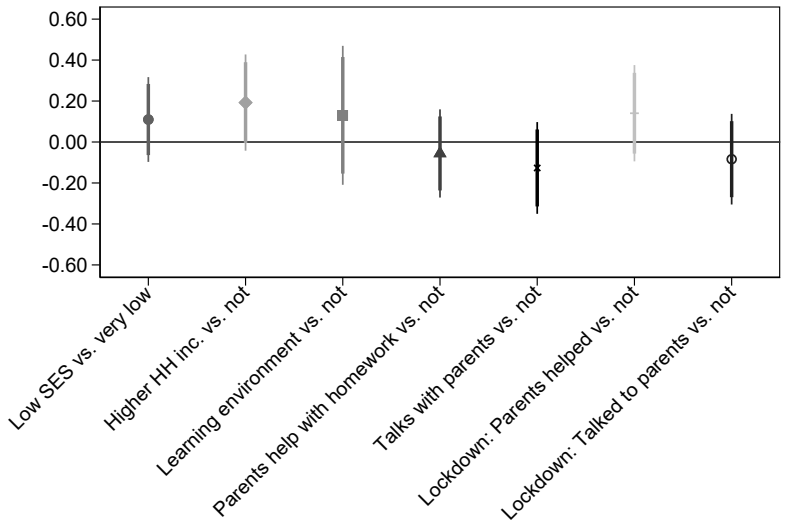
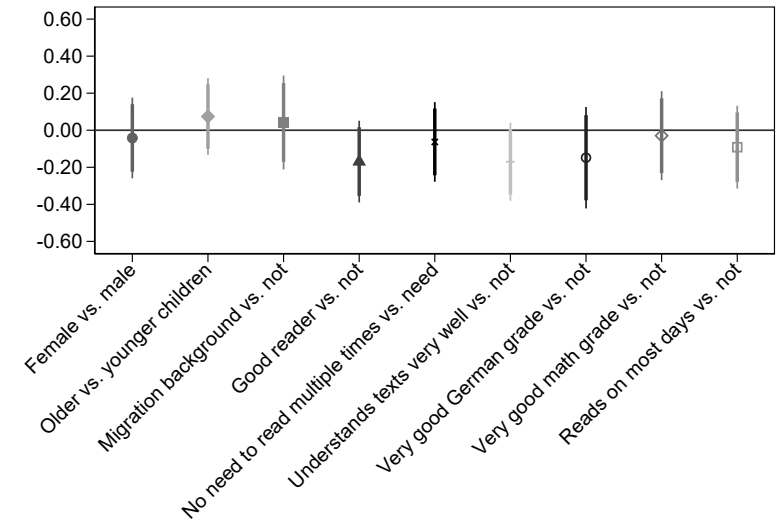


Figure 3: Heterogeneous effects of the e-book reading intervention on reading behavior

(a) by home environment

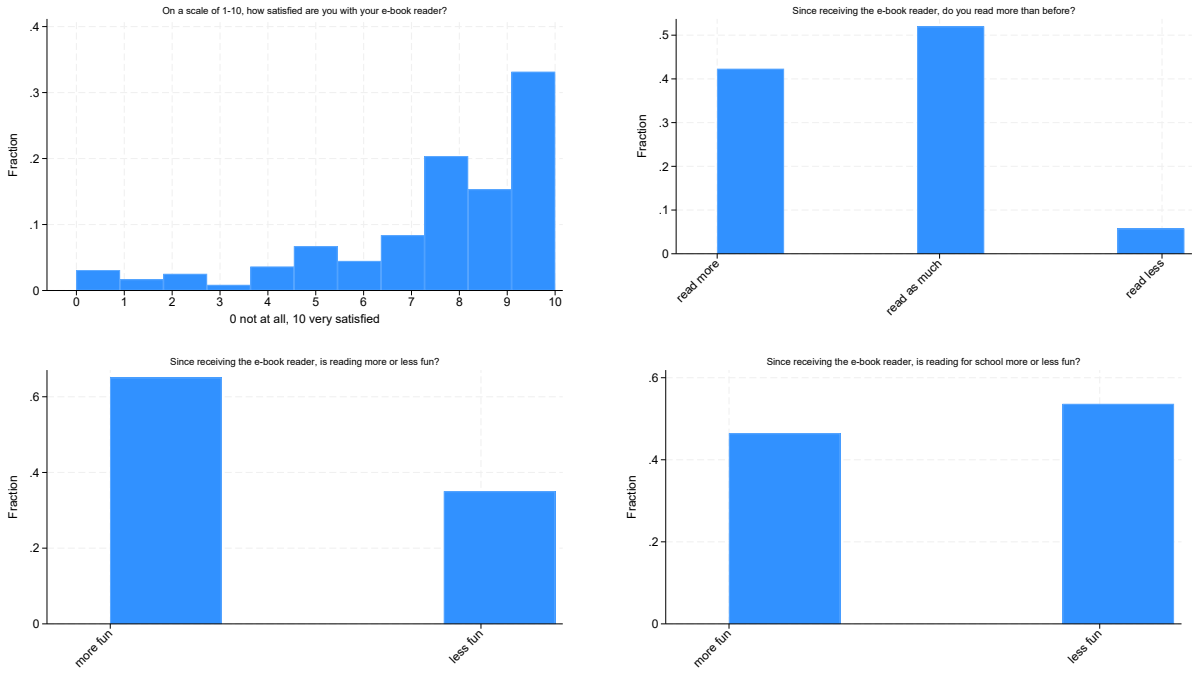


(b) by child characteristics



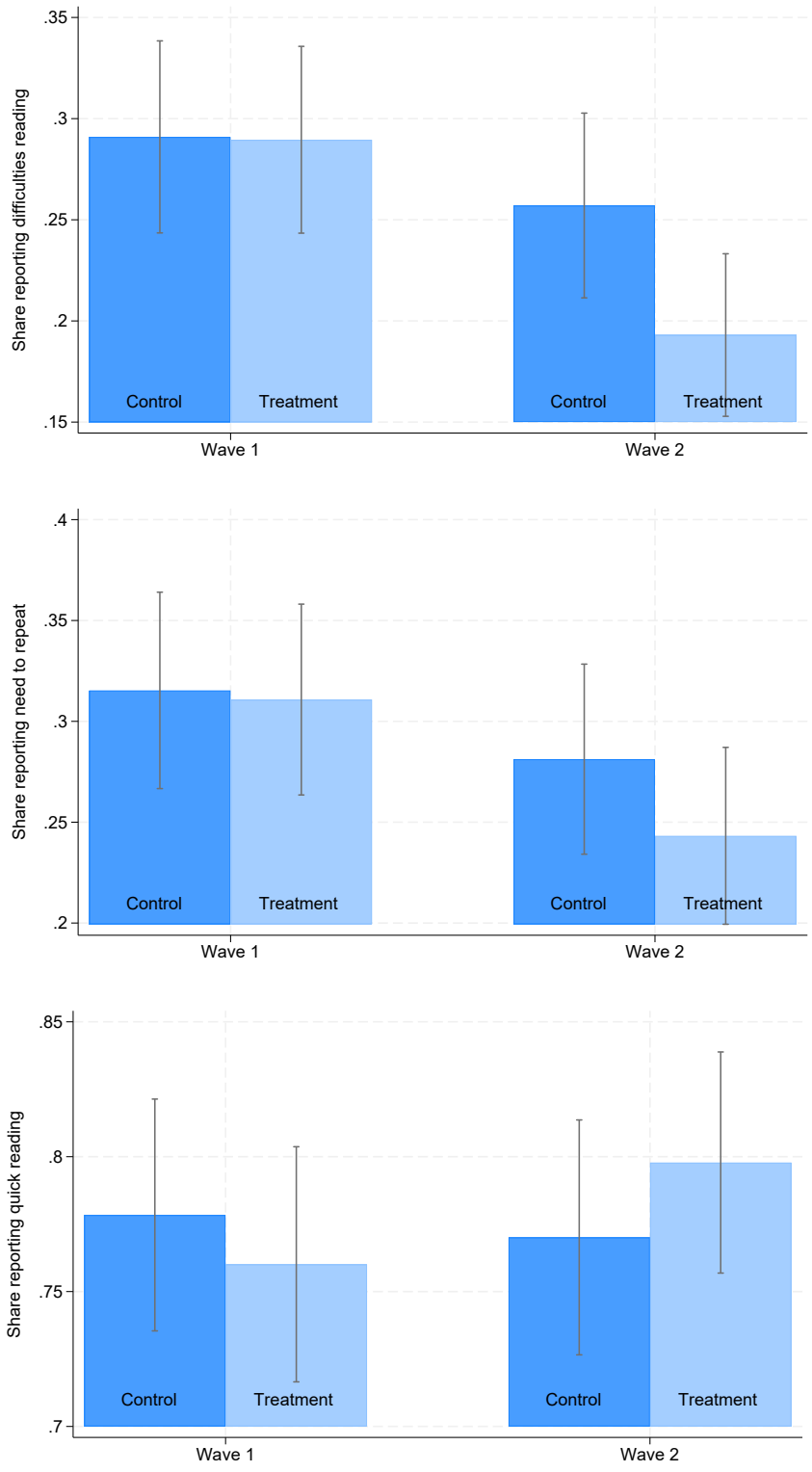
Notes: The figures plot the $\hat{\beta}_3$ coefficients from equation (4) with corresponding 90% and 95% confidence intervals, respectively. Each point estimate comes from a separate regression. All stratifying variables are measured at baseline.

Figure 4: Self-reported satisfaction with e-book readers, reading frequency, and enjoyment of reading



Notes: Figure (a) at the top left depicts treated children's satisfaction with their e-book readers on a scale from 0 to 10. Figure (b) at the top right plots the share of treated children based on whether they read more, the same, or less since receiving the e-book reader. Figures (c) and (d) at the bottom show the share of treated children who report that reading, for leisure or school, respectively, has been more or less enjoyable since receiving the e-book reader.

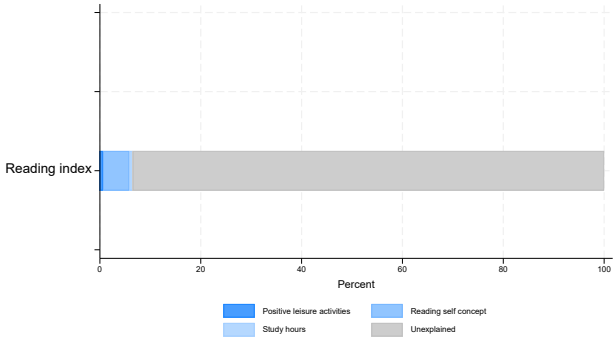
Figure 5: Self-assessed reading skills at baseline and six months after start of the reading intervention



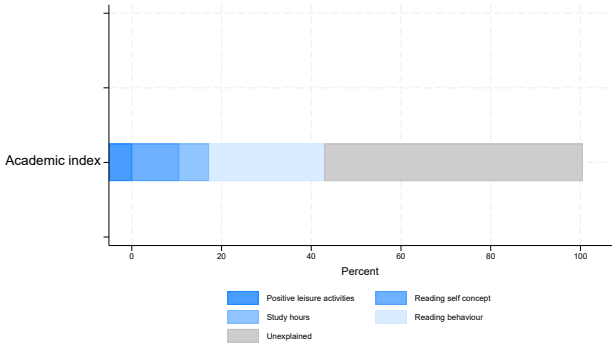
Notes: The figure presents the share of children reporting reading difficulties (top panel), the need to reread material (middle panel), and the share considering themselves fast readers (bottom panel). The results are shown for the baseline and the first follow-up survey.

Figure 6: Mediation analysis

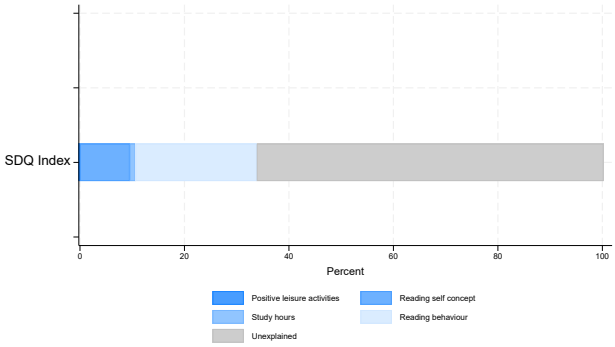
(a) Reading index



(b) Academic achievement index



(c) SDQ index



Notes: This figure shows the results of our mediation analysis. Panel (a) shows the decomposition of the treatment effect on the outcome reading index, panel (b) displays the decomposition for the academic achievement index, and panel (c) shows the decomposition of the treatment effect on the outcome SDQ index.

Table 1: Balance of covariates at baseline (November 2020)

	Control	Treatment	Difference	p-value
	(1)	(2)	(3)	(4)
Female	0.52	0.51	0.01	(0.85)
Grade	4.43	4.43	-0.00	(0.98)
Year of birth	2010.07	2010.13	-0.05	(0.24)
Month of birth	6.53	6.38	0.15	(0.50)
Reading score	-0.00	0.00	-0.01	(0.92)
German	2.39	2.34	0.05	(0.33)
Mathematics	2.33	2.28	0.05	(0.38)
Parents' school leaving qualification	0.78	0.79	-0.01	(0.69)
Parents born in Germany	0.79	0.79	0.00	(0.88)
Very low socioeconomic status	0.53	0.54	-0.00	(0.95)
Number of observations	500	500		

Notes: German and mathematics are the respective school grades, measured on a scale of 1–5, where 1 is the best possible grade. Parental school leaving qualification is a binary variable taking on the value 1 if the parent has at least a middle school (Realschule) qualification, and zero otherwise. Very low socioeconomic status refers to students who come from households receiving welfare.

Table 2: Balance of the covariates at baseline between opt-outs and those who received e-book readers

	Received e-book reader	Opted out	Difference	p-value
	(1)	(2)	(3)	(4)
Female	0.52	0.43	0.09	(0.25)
Grade	4.43	4.43	0.00	(1.00)
Year of birth	2010.13	2010.07	0.06	(0.61)
Month of birth	6.37	6.48	-0.11	(0.85)
Reading score	0.02	-0.21	0.24	(0.15)
German	2.33	2.40	-0.07	(0.61)
Mathematics	2.28	2.33	-0.05	(0.75)
Parents' school leaving qualification	0.79	0.81	-0.02	(0.75)
Parents born in Germany	0.80	0.71	0.08	(0.21)
Very low socioeconomic status	0.54	0.50	0.04	(0.63)
Number of observations	458	42		

Notes: German and math are the respective school grades, measured on a scale of 1–5, where one is the best possible grade. Parental school leaving qualification is a binary variable taking on the value one if the parent has at least a middle school (Realschule) qualification, and zero otherwise. Very low socioeconomic status refers to children who come from households receiving welfare benefit.

Table 3: Response rates in follow-up surveys

	Control (1)	Treatment (2)	Difference (3)	p-value (4)
Response rate in:				
Wave 2	0.74	0.76	-0.02	(0.42)
Wave 3	0.71	0.73	-0.02	(0.44)
Both surveys	0.63	0.64	-0.01	(0.69)

Notes: Response rates are calculated based on the original sample of 1,000 participants. The third row of the table presents the share of children who participated in both follow-up surveys.

Table 4: Effect of e-book reading intervention on main outcomes

	Intention-to-treat (ITT)	p-value	p-value from randomized inference	Number of obs.	Treatment-on-the-treated (TOT)	p-value	p-value from randomized inference	Number of obs.
Reading behavior								
Summary index	0.262	0.000	0.000	712	0.344	0.000	0.000	635
Inverse-covariance weighted index	0.385	0.000	0.000	712	0.502	0.000	0.000	635
Academic achievement								
Summary index	0.114	0.016	0.018	687	0.194	0.004	0.004	614
Inverse-covariance weighted index	0.145	0.033	0.056	687	0.246	0.008	0.006	614
Strength and Difficulty Questionnaire (SDQ)								
Summary index	-0.101	0.049	0.054	667	-0.101	0.103	0.104	596
Inverse-covariance weighted index	-0.153	0.041	0.036	667	-0.148	0.101	0.112	596
Self-efficacy								
Summary index	0.042	0.366	0.382	669	0.028	0.614	0.626	598
Inverse-covariance weighted index	-0.046	0.551	0.546	669	-0.055	0.544	0.576	598

Notes: This table shows the impact of the e-book treatment on four indices: reading behavior, academic achievement, behavior (SDQ), and personality (self-efficacy). All indices are standardized with the mean and standard deviation of the control group. The summary index is a simple summary measure of the respective individual components in the spirit of Kling et al. (2007). Inverse-covariance weighted index implements the generalized least-squares method of index construction proposed by Anderson (2008). All regressions control for strata (randomization block) fixed effects. Only observations with observed outcomes are included. The outcomes are measured in the second follow-up, around 13 months after the start of the reading intervention.

Table 5: Effect of e-book reading intervention on components of summary indices

	Intention-to-treat (ITT)	p-value of randomized inference	Treatment-on-the-treated (TOT)	p-value of randomized inference	Mean
Reading behavior					
At least one e-book	0.165	0.000	0.244	0.000	0.125
At least one printed book	0.062	0.040	0.071	0.062	0.764
At least one book[a]	0.084	0.004	0.102	0.004	0.795
At least two days/week[b]	0.079	0.012	0.091	0.012	0.741
Academic achievement					
Reading comprehension	0.114	0.162	0.156	0.086	-0.050
German	0.013	0.752	0.050	0.294	0.494
Mathematics	0.084	0.038	0.109	0.018	0.467
Aspirations	0.002	0.984	0.016	0.734	0.620
SDQ					
Peers	-0.146	0.028	-0.125	0.200	0.000
Hyperactivity	-0.098	0.230	-0.107	0.244	-0.000
Conduct	-0.066	0.366	-0.035	0.688	0.000
Emotional	-0.107	0.138	-0.150	0.112	0.000

Notes: This table shows the impact of the e-book treatment on components of the four indices. The variables in the index *Reading behavior* are binary, taking the value one if the child has read at least one book in the last four weeks or reported reading on at least two days a week. Reading comprehension is a standardized score of the reading test a year after the intervention. Math and German grades are dichotomized to take on the value one if the student has a good grade (1 or 2 on the German grading scale), and zero otherwise. Components of SDQ are standardized with a mean of zero and a standard deviation of one. All regressions control for strata (randomization block) fixed effects. Only observations with observed outcomes are included.

Table 6: ITT: Robustness check

	Set 1		Set 2		Set 3	
	ITT	p-value of randomized inference	ITT	p-value of randomized inference	ITT	p-value of randomized inference
Reading behavior						
Summary index	0.262	0.000	0.280	0.000	0.278	0.000
Inverse-covariance-weighted index	0.388	0.000	0.411	0.000	0.406	0.000
Academic achievement						
Summary index	0.114	0.018	0.114	0.022	0.112	0.028
Inverse-covariance-weighted index	0.145	0.032	0.148	0.044	0.145	0.052
SDQ						
Summary index	-0.110	0.034	-0.098	0.056	-0.097	0.062
Inverse-covariance-weighted index	-0.166	0.034	-0.147	0.062	-0.145	0.070
Self-efficacy						
Summary index	0.044	0.364	0.057	0.226	0.054	0.246
Inverse-covariance-weighted index	-0.048	0.508	-0.025	0.772	-0.024	0.748

Notes: This table shows the impact of the treatment on four indices: reading behavior, academic achievement, personality, and behavior. All indices are standardized with the mean and standard deviation of the control group. Inverse-covariance-weighted index implements the generalized least-squares method of index construction proposed by Anderson (2008). All regressions control for strata (randomization block) fixed effects. Only observations with observed outcomes are included.

Table 7: Reading behavior six months after experimental start (survey wave 2)

	ITT	p-value of randomized inference	Number of obs.
	Reported by children		
At least one e-book	0.433	0.000	734
At least one printed book	0.002	0.990	742
At least one book	0.061	0.018	733
At least two days/week	0.056	0.014	741
	Reported by parents		
At least one e-book	0.412	0.000	705
At least one printed book	-0.029	0.310	719
At least one book	0.065	0.006	703
At least two days/week	0.064	0.002	723

Notes: This table shows the impact of e-book readers on reading behavior in survey wave 2, as reported by the children and parents. All variables are binary. The variable *(At least one e-book)* takes the value one if the child has read at least one (e)-book in the last four weeks. The variable *At least one book* takes on the value one if the child has read at least one book in the last four weeks, regardless of the format. The variable *At least two days/week* takes on the value one if the child reads on at least two days a week. Randomization inference p-values are reported next to the coefficients. All regressions control for strata (randomization block) fixed effects. Only observations with observed outcomes are included.

Appendix A

Cover letter and information sheet about the Kindle Kids e-reader

Own translation from German

Mr./Mrs. [Last Name]

Recipient's Address

City, Zip Code

Dear Mr./Mrs. [Last Name],

We would like to thank you and your child once again for your participation in the first CoDu survey in fall 2020. The next survey has been delayed due to current developments and is expected to take place in mid-2022. We would be very pleased if you would also take part in further surveys.

In the meantime, we would like to provide a Kindle Kids e-reader to [your daughter/son who was] born in [month of birth] [year of birth] and attended 4th or 5th grade in the last school year and participated in our first survey. As part of our study, children will receive an e-reader so they can read over 1,000 popular and age-appropriate books for free for a year. You can find more information about the Kindle Kids e-reader on the next page.

If you agree, you don't need to do anything else. The Kindle Kids e-reader will be sent to you automatically within the next three weeks. This will not incur any costs for you.

If you do not wish to receive the Kindle Kids e-reader, please return the detachable, anonymized reply form on the last page in the enclosed, stamped envelope by 26.11.2021. This will not incur any costs or disadvantages for you.

However, we hope that you and your child will enjoy this opportunity to read fun and adventurous stories together.

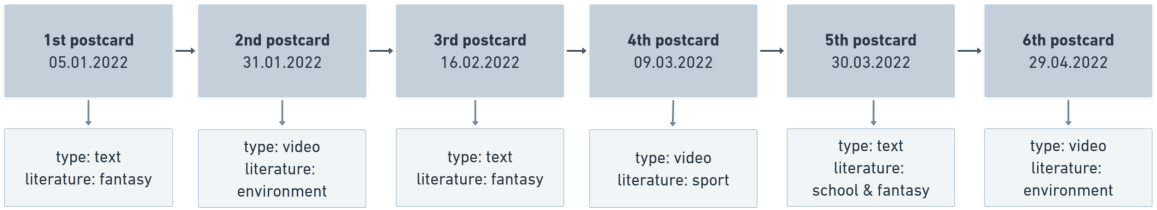
Sincerely,

P.S. Below you will find additional information on the Kindle Kids e-reader:

Information sheet on the Kindle Kids e-reader:

- As part of our study, we are providing you and your child with a Kindle Kids e-reader free of charge.
- Parental controls are already activated on the Kindle Kids e-reader, so you do not need to set up anything.
- With the e-reader, your child can read over 1,000 popular and age-appropriate books for a year free of charge.
- The e-reader makes reading easy on the eyes.
- There is no access to games, the internet, or videos. No messages can be sent, and there is no advertising.
- If you have any questions or problems, please call our hotline at (0911) 179 7771, and we will be happy to help you.

Figure A1: Postcard mailing timeline and sample postcards with and without a video link



A postcard with a link to a video



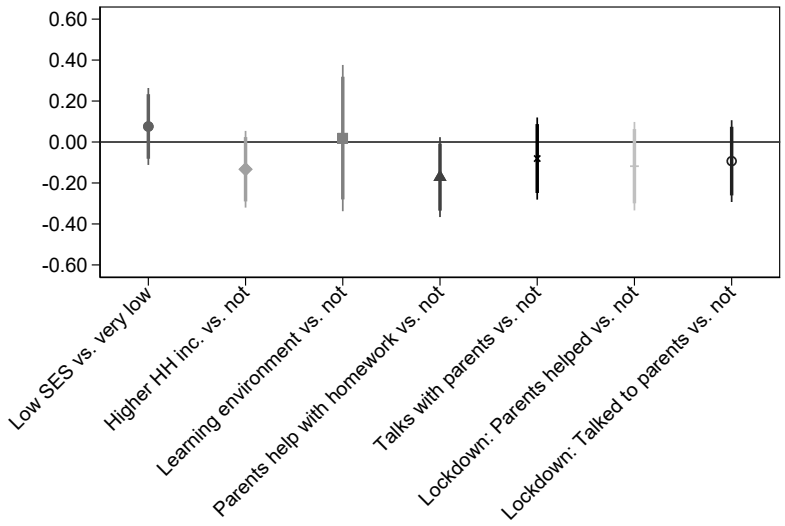
A postcard without a link to a video



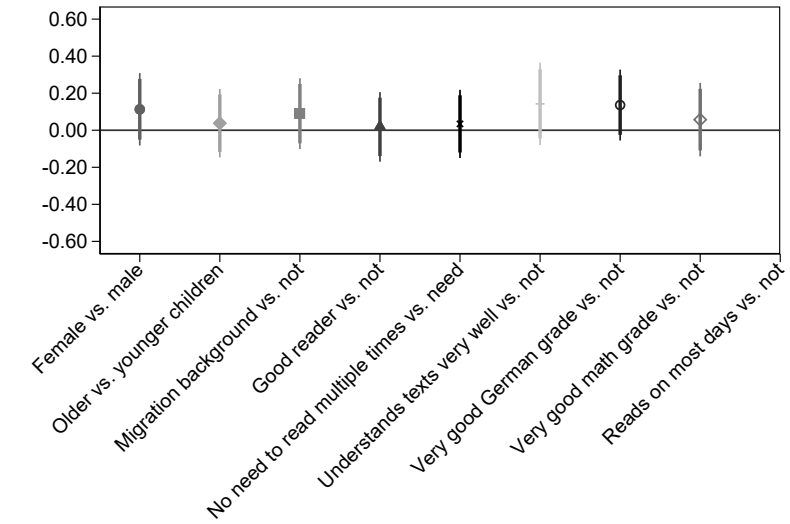
Notes: The letter announces that the households will receive an e-book reader, unless they opt out. The verbatim translation of the framing is: "As part of our study, children will receive an e-book reader so they can read over 1,000 popular and age-appropriate books for free for a year."

Figure A2: Heterogeneous effects of e-book reading intervention on academic achievement

(a) by home environment



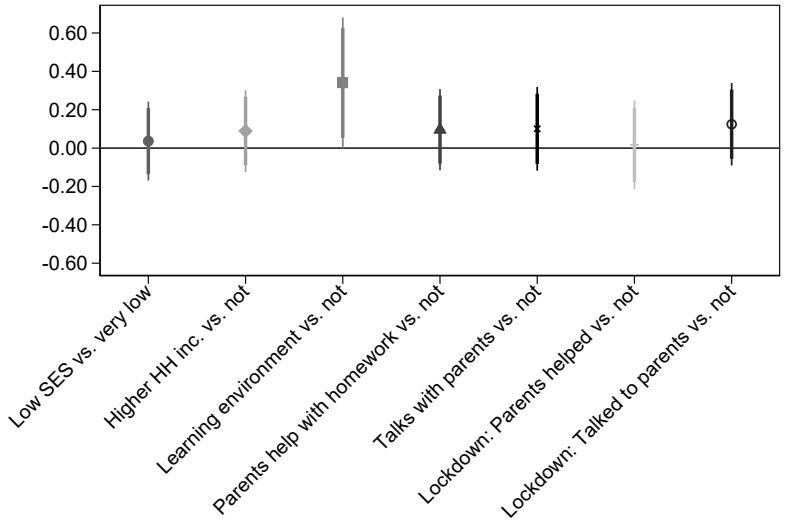
(b) by child characteristics



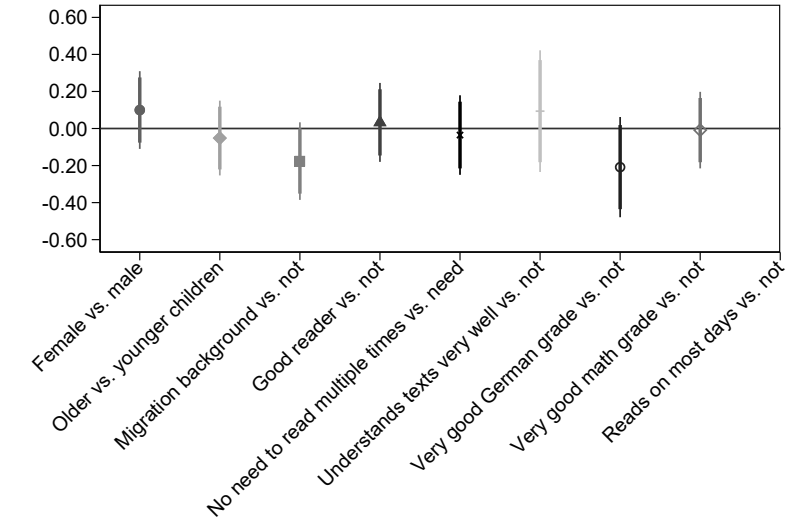
Notes: The figures plot the $\hat{\beta}_3$ coefficients from equation (4) with corresponding 90% and 95% confidence intervals, respectively. Each point estimate comes from a separate regression. All stratifying variables are measured at baseline.

Figure A3: Heterogeneous effects of e-book reading intervention on Strength and Difficulty Questionnaire (SDQ)

(a) by home environment

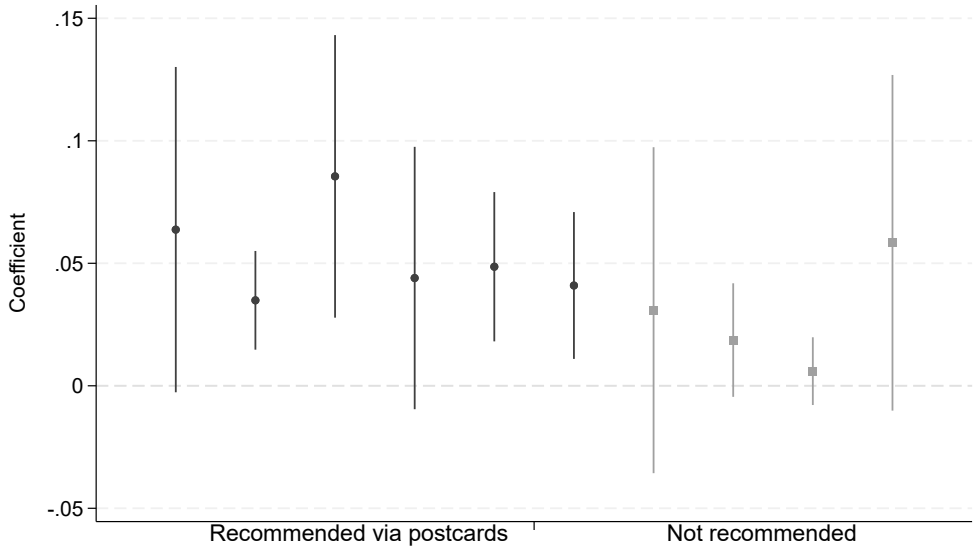


(b) by child characteristics



Notes: The figures plot the $\hat{\beta}_3$ coefficients from equation (4) with corresponding 90% and 95% confidence intervals, respectively. Each point estimate comes from a separate regression. All stratifying variables are measured at baseline.

Figure A4: Share of respondents reading books recommended by our team (in blue) and not recommended by our team (in red)



Notes: The figure presents the coefficients from ten separate regressions, each examining whether the child reported reading a specific book title. The dependent variables in each regression is equal to one if the child says they read the given book and zero otherwise. Coefficients and 95% confidence intervals. In the figure, dark points with confidence intervals represent the books that were recommended, while gray points represent those that were not. The results indicate a statistically significant increase in the likelihood that children in the treatment group reported reading five of the six recommended books. In contrast, no such effect was observed for the books that were not explicitly recommended.
In the first follow-up survey, participants from both the control and treatment groups were asked to complete a series of questions. Specifically, we presented them with a list of ten book titles and asked whether they had read any of them. Of these ten books, six were actively recommended to the children in the treatment group through postcards and videos from our research team. The control group did not receive these recommendations. The remaining four books were not mentioned in any of our communications to either group.

Table A1: Share of participants by federal states

State	Our sample	Germany
Baden-Wuerttemberg	14.2	13.3
Bavaria	17.0	15.8
Berlin	3.5	4.4
Brandenburg	4.4	3.0
Bremen	0.3	0.8
Hamburg	2.5	2.2
Hesse	6.6	7.5
Mecklenburg-Western Pomerania	3.0	1.9
Lower Saxony	8.9	9.6
North Rhine-Westphalia	19.1	21.6
Rhineland-Palatinate	3.8	4.9
Saarland	0.6	1.2
Saxony	6.5	4.9
Saxony-Anhalt	2.5	2.7
Schleswig-Holstein	4.2	3.5
Thuringia	2.8	2.6

Notes: Column (1) presents the share of students in the experimental sample by federal states. Column (2) presents the share of Germany's population by federal states. Source: German Statistical Office.

Table A2: Selective attrition in wave 3

	(1)	(2)	(3)
Treat	0.023	0.022	0.022
	(0.409)	(0.412)	(0.429)
Treat × baseline e-books			0.046
			(0.113)
Treat × baseline books			-0.049
			(0.107)
Treat × baseline reading comprehension			-0.003
			(0.912)
Treat × baseline math grade			0.002
			(0.960)
Treat × baseline German grade			0.002
			(0.962)
Baseline e-books		-0.002	0.018
		(0.907)	(0.331)
Baseline books		0.005	-0.019
		(0.750)	(0.358)
Baseline reading comprehension		-0.013	-0.012
		(0.589)	(0.671)
Baseline math grade		0.020	0.019
		(0.252)	(0.441)
Baseline German grade		0.033	0.034
		(0.056)	(0.181)
Number of observations	1,000	1,000	1,000
Covariates	No	Yes	Yes

Notes: The table shows the selective attrition analysis for the second follow-up survey (wave 3). All dependent variables are binary, taking the value one if the student participated in the second follow-up survey, and zero otherwise. In column (1), only the treatment status is included as an independent variable. In column (2), additional baseline covariates are added and, in column (3), all these baseline covariates are interacted with the treatment status variable. Math and German grades are dichotomized to take on the value one if the student has a (very) good grade, and zero otherwise. All specifications include strata fixed effects. Robust standard errors in parentheses.

Table A3: Items of the Strength and Difficulties Questionnaire (SDQ)

Item	Not true	Some-what true	Certainly true
I try to be nice to other people. I care about their feelings.			
I am restless, I cannot stay still for long.			
I get a lot of headaches, stomach-aches or sickness.			
I usually share with others, for example CDs, games, food.			
I get very angry and often lose my temper.			
I would rather be alone than with people of my age.			
I usually do as I am told.			
I worry a lot.			
I am helpful if someone is hurt, upset, or feeling ill.			
I am constantly fidgeting or squirming.			
I have one good friend or more.			
I fight a lot. I can make other people do what I want.			
I am often unhappy, depressed, or tearful.			
Other people my age generally like me.			
I am easily distracted, I find it difficult to concentrate.			
I am nervous in new situations. I easily lose confidence.			
I am kind to younger children.			
I am often accused of lying or cheating.			
Other children or young people pick on me or bully me.			
I often offer to help others (parents, teachers, children).			
I think before I do things.			
I take things that are not mine from home, school, or elsewhere.			
I get along better with adults than with people my own age.			
I have many fears, I am easily scared.			
I finish the work I'm doing. My attention is good.			

Table A4: Summary statistics of (baseline) variables used for heterogeneity analysis

	Mean	Number of observations
Panel A. Home environment		
Low versus very low socioeconomic status	0.535	712
High household income	0.300	693
Good learning environment	0.886	694
Parents help with homework	0.511	704
Talks to parents if problems at school	0.616	701
School lockdown: parents helped	0.710	701
School lockdown: talked to parents	0.614	697
Summary home environment index	4.179	661
Panel B. Child characteristics		
Female	0.515	712
Older child	0.412	712
Migration background	0.236	698
Good reader	0.630	699
No need to read texts multiple times	0.384	698
Understands stories very well	0.353	703
Good or very good German grade	0.660	703
Good or very good math grade	0.671	651
Reads on most days of the week	0.634	700
High reading comprehension	0.549	710
Summary reading quality index	3.912	628

Notes: All variables are measured at baseline, prior to randomization.

Table A5: Effect of e-book reading intervention on main outcomes, TOT

	Set 1		Set 2		Set 3	
	TOT	p-value of randomized inference	TOT	p-value of randomized inference	TOT	p-value of randomized inference
Summary index	0.336	0.000	0.356	0.000	0.352	0.000
Inverse-covariance-weighted index	0.500	0.000	0.528	0.000	0.519	0.000
Academic achievement						
Summary index	0.170	0.002	0.168	0.010	0.158	0.008
Inverse-covariance-weighted index	0.218	0.014	0.219	0.016	0.200	0.028
SDQ						
Summary index	-0.113	0.078	-0.109	0.074	-0.106	0.082
Inverse-covariance-weighted index	-0.165	0.076	-0.157	0.082	-0.152	0.104
Self-efficacy						
Summary index	0.040	0.512	0.049	0.368	0.049	0.420
Inverse-covariance-weighted index	-0.053	0.590	-0.042	0.676	-0.036	0.730

Notes: This table shows the impact of the treatment on four indices: reading behavior, academic achievement, personality, and behavior. All indices are standardized with the mean and standard deviation of the control group. Inverse-covariance-weighted index implements the generalized least-squares method of index construction proposed by Anderson (2008). All regressions control for strata (randomization block) fixed effects. Only observations with observed outcomes are included.

The Research Project

The research project was launched in fall 2020. In the empirical survey, students from different classes and one parent or other guardian from Social Code II and Social Code III households are interviewed. The basis for the SGB II sample is Unemployment Benefit II Recipient History (LHG) and for the SGB III sample, the Integrated Employment Biographies (IEB). The main target groups are students at the age of transition from primary to secondary school (grades 4–6) and students at the age at which they plan to transition to vocational training after completing their regular schooling if they are not aiming for a university entrance qualification (grades 9–11 or corresponding age groups). The study intentionally oversampled households with children from those grades and SGB-II benefit recipients. The mother or, if applicable, another parent or legal guardian is contacted via snail mail. Regardless of the target person, all children in grades 4–11 living in the household are surveyed. The survey is conducted online. The duration of individual interviews is about 20 minutes. Respondents were incentivized by announcing a lottery for all participants, which offered 25 vouchers for online shops, worth 25 Euros each.