The Digital Divide and Parenting TiME: Technology in Math Education*

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Extended Abstract

Math skills in early childhood are central to academic achievement later in life, and the gap in achievement between advantaged and disadvantaged children emerges before the start of formal schooling. Recent field experiments have shown that parental engagement and home-based technology such as digital tablets can improve children's math skills (Mayer et al. 2023). In this paper, we use both a lab experiment and a field experiment to understand the difference in technology use, and its impact on math skills, between advantaged and disadvantaged families.

The lab experiment was conducted with 234 parent-child pairs from Chicago preschools. Parents were asked to engage in a 10-minute math session with their child, which was video recorded. Parents were randomly assigned to either receive analog (control) or digital (treatment) math materials to use in their 10-minute session. Our primary outcome is the number of math words ("math talk") spoken by either the child, parent, or math app during the session. We find that the total number of words spoken was significantly higher (0.47 SD) in sessions with digital math materials relative to analog math materials. We also use a machine learning algorithm to detect the sentiment of the words spoken, and find that the average language sentiment is more likely to be positive (0.50 SD) in sessions with digital materials. However, we find that parents spoke fewer words in the sessions with digital materials. Whether digital materials are more productive than analog material would therefore depend on the relative effectiveness of the math talk from parents versus the math app at improving child skills.

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The field experiment was conducted over a six-month period with 472 parent-child pairs recruited from Chicago preschools. We use parental education as a proxy for SES. Our sample has 297 parents without a college degree (hereafter, "Non-BA") and 175 parents with a college degree ("BA"). Parents were randomly assigned to receive either 1) digital math apps, 2) analog math materials, or 3) non-math story book (control). Our primary outcomes are parental time investment and math skills. Specifically, parental time investment is a self-reported measure of how many minutes parents spend with their child engaging in math using analog and digital materials respectively. We measure math skills using the child's score on the Woodcock-Johnson Applied Problems at both baseline and endline. We find that providing math apps significantly increased the amount of time parents spent engaging with digital apps, but did not affect the total time spent on math; the increased time spent on digital materials was accompanied by an equivalent decrease in time spent on analog materials. This "first stage" was significant for both BA and non-BA parents.

The overall impact of digital apps on math skills was close to zero, but there was substantial heterogeneity in the point estimates: math apps led children of non-BA parents to a score improvement of 0.16 SD, while children of BA parents had a negative point estimate. Using the findings from the lab experiment, one interpretation of these results is that whether math apps improve skills depends on the relative quality of the math talk in the apps versus from the parent. If the quality of math talk in the apps is less than the average math talk quality for BA parents, but greater than that of non-BA parents, we would expect to find the results we did. Future work can explore whether parents "select on gains" and can recognize when math apps would be beneficial for their children's math skills depending on their perceived quality of math talk from parents versus apps.