A Meta-analysis of Pre-K to Grade 3 Educational Apps: Are there Meaningful Effects on Student Achievement Outcomes?

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Background

Educational apps are an increasingly appealing tool for stimulating children's cognitive development because they can run on touch-screen tablets and smartphones. Educational apps are a ubiquitous feature of young children's lives both in school and at home. According to a recent study on app usage in school contexts, there are over 2,500 education apps that are available to principals and teachers (Baker, Gowda, & Erlanger, 2018). At the same time, educators, parents, and researchers have raised questions about whether apps that work on touch-screen tablets and smart phones help or hurt young children's cognitive development and mental health.

Purpose/Research Question

This work in progress focuses on the effectiveness of educational applications/computer programs (APPS) designed to help children in pre-kindergarten through third grade learn to develop literacy and math skills. The primary research questions guiding this meta-analytic review are:

1. Do reading and math APPS improve student outcomes in these domains from pre-K to Grade 3?
2. To what extent do widely used APPS foster (a) active, (b) engaging, (c) meaningful, (d) socially interactive activities, and (e) clear learning goals (as described in Hirsch-Pasek et al., 2015)? Is variation in study-specific effect sizes related to variation in the quality of the app as measured by these five dimensions?

Setting

The studies included in our review met the following selection criteria:

1. The study employed an experimental or quasi-experimental research design
2. The intervention was centered on an educational app for touchscreen device (e.g., a smartphone or tablet) or computer
3. The study measured a literacy or math outcome
4. The participants were aged three to nine years old (preK to 3rd grade)
5. The study was published between January 2008 and June 2019

Our review included both studies published in peer- reviewed journals and unpublished studies.

We focused on app-based interventions because of the ubiquity of apps in educational settings and the lack of evidence for their effectiveness. According to Baker and Gowda (2018), "the number of learning apps and webpages used at schools in the United States has skyrocketed, with … over 2,500 apps. … However, the evidence for which apps are effective has not expanded at nearly the same rate" (p. 3). We were interested in preK-3 interventions because younger children are increasingly using technology and the effects are less well understood.

To identify primary studies, we searched (a) electronic databases and targeted Internet sites, (b) reference lists of previous research syntheses, and (c) research reports from targeted state and local education agencies. Because the original iPhone was released in 2007, with Apple's

App Store and Google Play soon to follow in 2008, we limited our search to studies published after 2008. We searched the electronic databases of Academic Search Premier, Education Abstracts, ERIC, PsycINFO, EconLit, and ProQuest Dissertations and Theses database.

Intervention

Hirsch-Pasek, et al. (2015) articulate a framework for evaluating the educational quality of apps, namely, the app should support learning that is active, engaging, meaningful, and socially interactive, and also have clear educational goals. The authors also argue that the app should support a "learning goal". We wanted to test whether this framework was empirically supported by the literature. As such, we downloaded each app in our review and rated each as low, moderate, or high on the five criteria to create an average pillar score for each app. Our hypothesis was that the relationship between each study-specific effect size and the app pillar score would be positive.

Research Design

The goal of meta-analysis is to combine the results of independent studies and to identify potential study-level moderators that explain variability in treatment effects. To conduct a meta-analysis, each study-level treatment effect must be converted to a standardized mean difference, or effect size. In this study, we computed Hedges' *g* for each study (i.e., the difference between the treatment and control group divided by the pooled standard deviation, with an adjustment for sample size).

Data Collection and Analysis

Because app-based interventions vary along a number of dimensions and because we were interested in making inferences back to the population of studies from which our studies were sampled, we used a random effects model to pool effect sizes. The random effects model includes both a within-study weight (inverse of the study variance) and a between-study variance component.

Findings

Random-effects models combining results from the 24 studies yielded a mean effect size of ES = .38 (95% CI = .23/.53). There was more heterogeneity in mean effects that would be expected by sampling error alone (Chi-square = 92.93, df = 23, $p < .01$), underscoring the role of study-specific characteristics as potential sources of effect size variability.

We therefore conducted a meta-regression to explore relationships between the effect size outcome and the extent to which the App rested on the five pillars of the science of learning (i.e., fostered learning that was active, engaging, meaningful, and social interactions, and had clear learning goals). The pillar scored demonstrated variability (M = 2.39, SD = .33) ranging from a minimum of 1.8 to a maximum of 2.8. Results from the meta-regression provide suggestive evidence that effect sizes were positively associated with the app pillar score (coefficient = .38, standard error = .21, t = 1.75).

Conclusions

This study suggests that educational apps can have educationally meaningful effects on student achievement outcomes from preK to Grade 3. And apps that are designed based on the five pillars of the science of learning may contain active ingredients that further enhance the effectiveness of literacy and math apps.

References

Baker, R. S., Gowda, S. M., & Erlanger, S. (2018). The 2018 technology & learning insights report: Towards understanding app effectiveness and cost. Bright Bytes

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps lessons from the science of learning. Psychological Science in the Public Interest, 16(1), 3e34.