

Educational Apps and Learning: Current Evidence on Design and Evaluation

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Introduction

Educational applications (apps) are interactive software designed to support learning and are primarily used on a hand-held touch-screen tablet or smartphone device. These technologies are ubiquitous within children's school and home learning environments. Over 94% of children own or have access to touchscreen tablet devices in the UK and USA, and children in low- and middle-income countries, such as South Africa, are more likely to have access to a tablet device, compared to a laptop or television (Marsh et al., 2020). The use of educational apps to support learning has further increased (Ofcom, 2020; Muller & Goldenberg, 2021), with COVID-19 related school closures affecting 1.5 billion children around the world (UNESCO, 2020). However, with over half a million educational apps available within the leading app stores (Google Play and Apple App Store) (Educational App Store, 2022), determining whether or what kind of apps provide a high-quality learning experience is a significant and pressing challenge.

While some specific maths and literacy educational apps have been evaluated (see Outhwaite et al., 2022; Griffith et al., 2020 for reviews), important questions remain relating to how apps may work to support children's learning, who they work for best, and under what circumstances. In particular, previous studies call for more research examining the role of app content and design features (Griffith et al., 2020), as well as how different factors, such as

implementation, may impact learning outcomes (Outhwaite et al., 2019). It is vital to develop a high-quality evidence base within the field of educational technology to support teachers, parents, and policy makers to make evidence-informed decisions relating to the use of apps with their children, as well as for app developers to ensure their technologies are grounded in learning science.

New evidence

In response, this special section brings together seven studies, which provide new evidence on the instructional design and rigorous evaluation of educational apps on children's learning outcomes. Specifically, this special section aimed to address: 1) How can educational apps be *designed* to improve learning? and 2) How can educational apps be *implemented* to improve learning?

How can educational apps be designed to improve learning?

Despite the promising evidence base on the impact of educational apps on children's maths and literacy outcomes (Outhwaite et al., 2022; Griffith et al., 2020), there are a range of factors within a multi-level education system that can influence their success, starting first with the underpinning pedagogy (Outhwaite et al., 2019). Five studies in this special section directly address this issue by examining how educational apps can be designed to optimise educational outcomes.

First, Huntington et al. (2023) conducted comparative judgements of the design features of the five educational apps evaluated as part of the Global Learning XPRIZE in remote Tanzania. Results showed the two apps that produced the strongest learning outcomes on foundational literacy and maths skills shared six pedagogical features. These included features to support autonomous learning, accessibility for children's developing fine motor skills, a well-established task structure, support for engagement in the learning process, reduced language demands, and personalised levelling.

Evidence from Outhwaite et al. (2023) compliments these findings with a qualitative comparative analysis of eight educational maths apps. These maths apps were identified through a previous systematic review, and all reported significant learning gains for typically developing children in the first three years of education in England, the USA, and United Arab Emirates (see Outhwaite et al., 2022). The results presented in this special section showed learning outcomes with these maths apps were enhanced when the apps combined a scaffolded and personalised learning journey (i.e., programmatic levelling) and explanations of why answers were right or wrong (explanatory feedback), as well as praise, such as “Great job!” (motivational feedback).

Further to the type of feedback, Benton et al. (2023) presented an experimental study with 8-11-year-olds with reading difficulties in England. They examined whether additional prior instruction combined with feedback could enhance children’s engagements with an app-based literacy programme. The findings from this study showed that educational apps should highlight key features of the learning content and explicitly make connections with the target learning objective, as well as include elaborative feedback.

Boggio et al. (2023) also conducted an experimental study with a mixed ability sample of 6-7-year-olds in France. Overall, no added benefit of the researcher-developed educational app was observed on children’s spelling outcomes, compared to a paper-based version of the same activities. However, the spelling app was shown to be particularly beneficial for struggling learners, and the authors, consistent with Benton et al. (2023), highlight the value of feedback and gamified features for supporting these children.

So far, the included studies have focused on learning outcomes with educational apps. Amaefule et al. (2023) expands this focus by examining the role of enjoyment for supporting continued use of these new learning technologies with 9-14-year-olds in Germany. They present a longitudinal experimental design with ambulatory assessment to compare the impact

of three different learning activities within one educational app used in children's natural environments. Results showed that indeed children's perceived enjoyment of the app impacted on their intention to continue to use the app and thus highlights the importance of designing apps that are not only effective for supporting learning (as discussed above) but are also enjoyable.

How can educational apps be implemented to improve learning?

It is often proposed that the effectiveness of app-based learning also relies on the quality of training and support for practitioners and caregivers who support their implementation with children (Cheung & Slavin, 2013). A lack of this additional support can be a significant barrier to the success, integration, and adoption of new technologies (Picton, 2018). Despite this argued necessity, few studies have empirically examined what kinds of support is most effective for supporting implementation fidelity and learning outcomes with app-based interventions.

For example, previous research shows the app-based Headsprout Early Reading intervention can improve reading skills with typically developing children and those with special educational needs, compared to a range of control groups (see Roberts-Tyler et al., 2023). Roberts-Tyler et al. (2023) extends this evidence by presenting a cluster randomised control trial with 4-7-year-olds and their teachers in Welsh classrooms. Results showed additional support for teachers throughout the year-long intervention period had no impact on their delivery of the core elements of the reading programme and did not significantly improve children's reading outcomes, compared to initial training only.

Similarly, Vanbecelaere et al. (2023) presented a meta-analysis of 72 studies from 17 high-, middle- and low-income countries, which evaluated the impact of educational apps within the context of core reading instruction (i.e., Tier 1). Results corroborated previous findings with a positive, but small effect, compared to standard teaching practice. However,

moderation analysis showed that a range of implementation factors did not have a significant impact on the overall reported effect size. These factors included the active involvement of the teacher during implementation and professional development coaching for the teacher. These two studies have important implications for the cost-effective scaling of successful app-based interventions and draws attention for the need for further research in this area.

Directions for future research

Overall, this special section highlights three priorities for future research. First, there is a relatively stronger focus on the design of educational apps within the included studies, compared to research on implementation factors. Currently, these topics have been considered in silos. Therefore, future studies need to examine how features of educational apps and their implementation in different settings interact with each other in the learning process.

Second, this special issue also emphasises the need for an increased and specialised focus on implementation factors within the context of studies evaluating educational apps, as well as other educational interventions. This will be particularly vital to further understanding the circumstances in which interventions are most conducive to learning, and for informing the cost-effective scaling of successful interventions.

Finally, the use of innovative research methods, including ambulatory assessments, should be prioritised. These approaches will help understand and accommodate for learner viability with educational apps. It will also contribute to ensuring that educational apps are designed and used in ways that address, rather than exacerbate inequalities in learning.

Conclusion

Collectively, the seven studies in this special section summarise the latest evidence on how educational apps can be designed and implemented in optimal ways to support learning and engagement across a range of subject domains and age groups. It contributes to the international evidence base in these areas across a range of high-, middle- and low-income

countries with an inclusive population focus, including typically developing children, children with special educational needs, and marginalised children in informal contexts. It also provides important directions for future research in educational apps and interventions.

Overall, this special section will be of interest to a broad range of academics across different disciplines in this area, as well as app developers and decision makers around the world, so that educational apps can be designed, used, and scaled to improve learning equity for all children.

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