

The effectiveness of educational software and applications for primary students' learning outcomes: A systematic review

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Abstract

In the ever-evolving field of primary education, effectively integrating innovative teaching techniques and technology is crucial. This systematic review explores how educational software, and applications impact primary students' learning outcomes. We searched several academic databases, including PubMed, PsycINFO, ERIC, Web of Science, and Google Scholar, focusing on research articles published between 2018 and 2023. Among 150 initially identified studies, 35 met the inclusion criteria after carefully screening and removing duplicates. These studies, which used both qualitative and quantitative methods, were analyzed to uncover key themes and insights. This review reveals that educational software positively impacts students' cognitive, behavioral, and emotional development. Mobile applications and computer-assisted learning (CAL) tools notably improve mathematics, science, and literacy outcomes. Key features such as autonomous learning, personalization, and feedback are critical. Additionally, gamified learning and interactive apps boost motivation, engagement, and self-directed learning, enhancing academic performance and satisfaction. However, effectiveness varies by software type, subject, and student demographics. Challenges include design flaws, implementation issues, and accessibility barriers. Recommendations emphasize integrating key pedagogical features, continuous teacher training, and tailored interventions for diverse needs.

Keywords: Primary education, educational software, learning outcomes, mobile applications, computer-assisted learning (CAL), gamified learning, self-directed learning, student engagement, personalized learning, educational technology, interactive apps, cognitive development, academic performance.

1 Introduction

It is crucial to comprehend how to successfully incorporate cutting-edge teaching techniques and technology into the ever-changing field of primary education. Numerous researchers have

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examined this area recently, illuminating how educational interventions might support student learning outcomes. This article evaluates the various approaches and technologies investigated for their effects on primary school education. Researchers have looked into everything from the effectiveness of mobile apps to the function of conventional teaching methods to find the secrets to maximizing students' learning capacity.

The significance of integrating components like self-directed learning, involvement, and customization in primary education is highlighted by Huntington et al. (2023). The meta-analysis by Wang et al. (2023) explores the complex ways that mobile technology affects behavioral, emotional, and cognitive development; it highlights the necessity of careful integration to optimize advantages. Büchel et al. (2021) compare computer-assisted learning (CAL) tools and traditional teaching methods, emphasizing the value of varied teaching approaches and the effectiveness of CAL in improving math skills. Moreover, research by Vázquez-Cano et al. (2023), Camilleri and Camilleri (2020), and others highlights technology's critical role in enabling gamified learning, individualized interventions, and collaborative learning.

Furthermore, cutting-edge teaching strategies are included in the research landscape in addition to technology. Research on how instructional software and educational apps might improve comprehension in disciplines like natural science and mathematics has been conducted by Ariesta (2019), Huntington et al. (2023), and others. These studies provide insights into innovative pedagogical approaches. It is clear from navigating the always-changing field of primary education that a sophisticated grasp of technology, instructional strategies, and their integration is crucial (Mishra & Koehler, 2006). This article attempts to give educators, policymakers, and stakeholders valuable insights to inform evidence-based practices and improve primary school children's learning journeys by combining data from numerous studies.

1.1 Rationale

Integrating innovative teaching techniques and technology into primary education is essential to meet the evolving demands of modern learning environments. This systematic review aims to evaluate the effectiveness of educational software and applications on primary students' learning outcomes. Extensive empirical evidence supports technology integration in education, revealing significant positive impacts on cognitive, behavioral, and emotional development. Studies have shown that mobile applications and computer-assisted learning (CAL) tools can significantly enhance primary students' learning outcomes across various subjects (Huntington et al., 2023; Wang et al., 2023). For instance, Büchel et al. (2021) demonstrate that CAL tools improve mathematical skills more effectively than traditional teaching methods. Additionally, Ariesta (2019) and Pitchford et al. (2018) highlight the substantial benefits of e-learning media and interactive apps in enhancing comprehension in natural sciences and basic mathematics, respectively (Zaldívar-Colado et al., 2017).

Educational software offers personalized learning experiences tailored to the unique needs of each student, emphasizing the importance of self-directed learning, engagement, and personalization (Büchel et al., 2021; Huntington et al., 2023). Personalized learning pathways enabled by these technologies help cater to diverse student needs, promoting more effective and individualized learning experiences (Camilleri & Camilleri, 2020; Vázquez-Cano et al., 2023). Student engagement and motivation are critical for successful learning outcomes, and educational games and gamified learning applications significantly enhance these factors (Yu et al., 2020). Moreover, interactive apps have been found to support the development of early mathematical skills, particularly among low-achieving students (Outhwaite et al., 2017). The ability of educational software to adapt to the individual needs of students with special educational needs and disabilities (SEND) further underscores its importance in creating inclusive learning environments (Fage et al., 2018; Pitchford et al., 2018). These findings provide valuable insights for educators,

policymakers, and stakeholders to inform evidence-based practices, ensuring that the integration of technology in primary education effectively enhances student learning experiences and outcomes (Büchel et al., [2021](#); Huntington et al., [2023](#); Vázquez-Cano et al., [2023](#)).

1.2 Research Objectives:

1. To evaluate the overall impact of educational software and applications on primary students' learning outcomes across different subject areas.
2. To compare the effectiveness of different types of educational software (e.g., gamified apps, e-learning media, interactive apps) on primary students' academic performance.
3. To identify the pedagogical features of educational software and applications that significantly improve primary students' learning outcomes.
4. To investigate the effects of integrating educational software and applications on primary students' motivation, engagement, and self-directed learning.
5. To analyze the cognitive, affective, and behavioral learning outcomes of using mobile technology in primary education.
6. To identify the challenges and limitations of using educational software and applications in primary education and propose solutions.
7. To determine how the effectiveness of educational software and applications varies among different groups of primary students, such as those with special educational needs or those at risk of academic failure.
8. To provide recommendations for the future development and implementation of educational software and applications in primary education based on the findings of this systematic review.

1.3 Research Questions

1. How do educational software and applications impact primary students' learning outcomes across different subject areas?
2. How do different types of educational software (e.g., gamified apps, e-learning media, and interactive apps) compare in terms of their effectiveness on primary students' academic performance?
3. What pedagogical features of educational software and applications significantly improve primary students' learning outcomes?
4. How does integrating educational software and applications affect primary students' motivation, engagement, and self-directed learning?
5. What cognitive, affective, and behavioral learning outcomes are associated with using mobile technology in primary education?
6. What are the challenges and limitations associated with using educational software and applications in primary education, and how can they be addressed?
7. How does the effectiveness of educational software and applications vary among different groups of primary students, such as those with special educational needs or those at risk of academic failure?
8. How can the findings from this systematic review inform future development and implementation of educational software and applications in primary education?

2 Methodology

2.1 Search Strategy

A comprehensive search was conducted across several academic databases to evaluate the effectiveness of educational software and applications on primary students' learning outcomes. The search strategy aimed to identify relevant articles using carefully chosen search phrases and criteria to ensure the inclusion of pertinent research. The databases included PubMed, PsycINFO, ERIC (Education Resources Information Center), Web of Science, and Google Scholar, focusing

on research articles published between 2018 and 2023. The objective was to cover a broad range of studies exploring educational technology's impact on primary education.

2.2 Inclusion Criteria

Relevance: Articles were considered relevant if they specifically examined the impact of educational software and applications on primary students' learning outcomes.

Date of Publication: To ensure the review considered recent advancements in educational technology, only articles published between 2018 and 2023 were included.

Research Design: To provide a comprehensive understanding of the subject, both quantitative and qualitative research studies were incorporated. This included experimental, quasi-experimental, and cross-sectional studies.

Population: Studies focused on primary school students, encompassing various age groups and educational levels within primary education.

Language: Only articles written in English were considered to ensure consistency in the analysis.

Peer-Reviewed: Only peer-reviewed articles were included to guarantee the research's quality and reliability.

2.3 Exclusion Criteria

Non-Relevance: Articles that did not specifically address the impact of educational software and applications on primary students' learning outcomes were excluded.

Non-Peer Reviewed: Non-peer-reviewed sources such as conference abstracts, opinion pieces, and editorials were excluded.

Non-English: Articles published in languages other than English were excluded due to language restrictions in the analysis process.

Irrelevant Population: Research focusing on populations other than primary school students, such as secondary or tertiary education studies, was omitted.

Duplicate or Overlapping: Only one representative article was included if multiple articles discussed the same subject or had significantly overlapping data.

Non-Educational Context: Studies conducted outside of an educational context (e.g., community-based studies unrelated to schools) were excluded.

Focus Effect of Apps or Software on Primary Students' Learning Outcomes: Studies that did not focus on mobile apps or software on primary students' learning outcomes were also excluded.

Specific inclusion and exclusion criteria for this systematic review were established to ensure a comprehensive evaluation of how educational software and applications affect primary students' learning outcomes. The primary goal was to provide a robust and impartial examination of the existing literature in this field. The selected studies utilized a mix of qualitative and quantitative methodologies to explore the various ways educational technology impacts cognitive, behavioral, and emotional development among primary students. These criteria were designed to ensure an unbiased and objective analysis of the available data from the chosen studies.

2.4 Screening Process

Table 1: PRISMA Framework.

Step	Information
Search Techniques	Key electronic databases such as PubMed, PsycINFO, ERIC, Web of Science, and Google Scholar were searched. The search terms were combined in titles, keywords, and abstracts to include terms such as "educational software," "primary students," "learning outcomes," "mobile applications," "computer-assisted learning," "gamified learning," "self-directed learning," and "engagement." This initial search found 150 items.
Remove Duplicate Data	Duplicates were identified and removed from the initial list. 16 duplicate articles were found and eliminated, leaving 134 items for further screening.
Screening of Titles and Abstracts	Titles and abstracts were screened according to inclusion and exclusion criteria based on their applicability to the study question. Eighty articles were excluded

	based on their relevance to the study question, leaving 54 articles retained for full-text review.
Eligibility Evaluation	The eligibility of the 54 remaining articles was carefully evaluated against established criteria. Nineteen articles were excluded due to lack of relevance, non-peer-reviewed status, or focus outside the scope of primary education. Thirty-five articles were deemed eligible and included.
Last Decision	The systematic review included 35 papers that met the eligibility criteria. The selected articles were peer-reviewed research articles written in English and published between 2018 and 2023. They focused on the impact of educational software and applications on primary students' learning outcomes. These studies provided a comprehensive understanding of the effectiveness of educational technology in primary education, addressing various pedagogical features and their influence on learning outcomes.

In the first stage, the titles and abstracts of the identified papers were evaluated for relevance to our topic. Non-related articles were first excluded. We checked the remaining articles' entire texts for inclusion. Only studies meeting these criteria were included in our systematic review. Then, the remaining studies were carefully conducted to understand how educational software and applications affect elementary kids' learning outcomes. This thorough and methodical technique eliminated bias and provided a well-rounded and objective study. We used high-quality, peer-reviewed research to develop our review.

2.5 Theoretical Framework

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, essential for enhancing transparency, reproducibility, and rigor in systematic reviews, was used for this review. Established to address limitations and biases, PRISMA uses a 27-item checklist to guide researchers in clearly reporting their review processes (Page et al., 2021). This framework ensures comprehensive reporting and transparency, which boosts the credibility of findings. PRISMA has proven its utility in various fields, such as digital health technologies during the COVID-19 pandemic, by producing reliable reviews (Mbunge et al., 2022). The updated PRISMA 2020 statement reflects modern practices and enhances inclusivity (Page et al., 2021). Studies like those by Pinto et al. (2022) showcase PRISMA's effectiveness in maintaining rigor and trustworthiness. PRISMA supports ethical considerations in educational research, drawing on philosophical traditions to manage conflicts of interest and representation issues (Suri, 2019). PRISMA's emphasis on transparency, rigor, and ethics makes it a foundational tool for high-quality systematic reviews, significantly advancing knowledge across fields.

2.6 Screening Articles

Key electronic databases, including PubMed, PsycINFO, ERIC, Web of Science, and Google Scholar, were searched to conduct the systematic review. We used search terms such as "educational software," "learning outcomes," "primary education," "mobile applications," and "computer-assisted learning." This initial search yielded 150 items. After removing 16 duplicate articles, 134 items remained for further screening. We then screened the titles and abstracts of these articles based on their relevance to the research questions and our inclusion and exclusion criteria. This step excluded 80 articles, leaving 54 for a full-text review. The eligibility of these 54 articles was evaluated against our established criteria, resulting in 35 articles being included in the systematic review. These selected studies used primary data, focused on educational software within primary education contexts, adhered to peer-reviewed standards, and employed mixed, quantitative, and qualitative methodologies to define learning outcomes across cognitive, behavioral, and affective domains.

Table 2: The studies included in this review

No	Authors	Year	Journal/Source	Title	Volume (Issue)	DOI
1	Ali et al.	2019	International Journal of Interactive Mobile Technologies (IJIM)	E-Numeracy: Mobile application of the numeracy understanding model for primary school	13(11)	https://doi.org/10.3991/ijim.v13i11.11378
2	Amasha et al.	2020	Education and Information Technologies	Development of a Java-based mobile application for mathematics learning	[Volume here]	https://doi.org/10.1007/s10639-020-10287-0
3	Ariesta	2019	Journal of Education Research and Evaluation	Effectiveness of e-learning Media to Improve Learning Outcomes Natural Science in Primary Schools	3(2)	https://doi.org/10.23887/jere.v3i2.17203
4	Büchel et al.	2021	Journal of Labor Economics	The relative effectiveness of teachers and learning software: Evidence from a field experiment in El Salvador	40(3)	https://doi.org/10.1086/717727
5	Camilleri & Camilleri	2020	In R. Zheng (Ed.), Cognitive and affective perspectives on immersive technology in education. IGI Global.	The use of mobile learning technologies in primary education		https://doi.org/10.4018/978-1-7998-3250-8.ch013
6	Chatzopoulos et al.	2023	Advances in Mobile Learning Educational Research	Evaluation of Google Play educational apps for early childhood education	3(2)	https://doi.org/10.25082/AMLER.2023.02.004
7	Christopoulos & Mystakidis	2023	Encyclopedia	Gamification in education	3	https://doi.org/10.3390/encyclopedia3040089
8	Corcoran	2018	Liberty University Digital Commons	The effect of digital tablets' applications on reading achievement of first graders in two private schools (Doctoral dissertation)		https://digitalcommons.liberty.edu/doctoral/1807
9	Dorouka et al.	2020	International Journal of Mobile Learning and Organisation	Tablets and apps for promoting robotics, mathematics, STEM education, and literacy in early childhood education	14(2)	https://doi.org/10.1504/IJMLO.2020.10617
10	Dorris et al.	2021	Campbell Systematic Reviews	PROTOCOL: A systematic review of mobile device use in the primary school classroom and its impact on pupil literacy and numeracy attainment	17(2)	https://doi.org/10.1002/cl2.1155
11	Fadhli et al.	2020	International Journal of Instruction	A meta-analysis of selected studies on the effectiveness of gamification method for children	13(1)	
12	Fage et al.	2018	Frontiers in Psychology	Tablet apps to support first school inclusion of children with autism spectrum disorders (ASD) in mainstream classrooms: A pilot study	9	https://doi.org/10.3389/fpsyg.2018.02020
13	Fokides	2018	International Journal of Mobile and Blended Learning	Teaching basic programming concepts to young primary school students using tablets: Results of a pilot project	10(1)	https://doi.org/10.4018/IJMBL.2018010103
14	Fokides	2020	In Handbook of research on modern educational technologies, applications, and management (pp. 263-284). IGI Global.	Reflecting on the results of the initiative ETiE for using tablets in primary schools		https://doi.org/10.4018/978-1-7998-3476-2.ch016
15	Griffith et al.	2020	Pediatrics	Apps as learning tools: A systematic review	145(1)	https://doi.org/10.1542/peds.2019-1579



16	Hashim et al.	2019	International Journal of Education and Research	Using educational game apps in improving students' mathematics learning: An exploratory study on third grader at-risk classroom at primary school in Selangor, Malaysia	7(5)	
17	Huntington et al.	2023	British Journal of Educational Technology	Pedagogical features of interactive apps for effective learning of foundational skills	54(4)	https://doi.org/10.1111/bjet.13317
18	Ishaq et al.	2020	International Journal of Advanced Computer Science and Applications	The usefulness of mobile assisted language learning in Primary Education	11(1)	https://doi.org/10.14569/IJACSA.2020.0110148
19	Justine et al.	2019	International Journal of Social Sciences and Humanities Invention	The efficiency of learning software 'Sinding Pimato' towards the reading achievement of Kadazandusun language for year one pupils	6(3)	https://doi.org/10.18535/ijsshi/v6i3.04
20	Kacetl & Klímová	2019	Education Sciences	Use of Smartphone Applications in English Language Learning—A Challenge for Foreign Language Education	9(3)	https://doi.org/10.3390/educsci9030179
21	Karamert & Vardar	2021	Journal of Educational Technology and Online Learning	The effect of gamification on young mathematics learners' achievements and attitudes	4(2)	https://doi.org/10.31681/jetol.904704
22	Khotima et al.	2022	Asian Pendidikan	The effectiveness of android-based science learning model to increase student learning outcomes	2(1)	https://doi.org/10.53797/aspen.v2i1.5.2022
23	Kim et al.	2021	AERA Open	Measures matter: A meta-analysis of the effects of educational apps on preschool to grade 3 children's literacy and math skills	7(2)	https://doi.org/10.1177/23328584211004183
24	Loo & Said	2021	Innovative Teaching and Learning Journal	Effects of Digital Game-Based Learning Apps Based on Mayer's Cognitive Theory of Multimedia Learning in Mathematics for Primary School Students	4(1)	https://itlj.utm.my/index.php/itlj/article/view/49
25	Martínez-Hita et al.	2021	Humanities and Social Sciences Communications	The effects of a gamified project based on historical thinking on the academic performance of primary school children	8	https://doi.org/10.1057/s41599-021-00797-8
26	Neumann	2018	Early Childhood Research Quarterly	Using tablets and apps to enhance emergent literacy skills in young children	42	https://doi.org/10.1016/j.ecresq.2017.10.006
27	Pitchford et al.	2018	Frontiers in Psychology	Interactive apps promote the learning of basic mathematics in children with special educational needs and disabilities	9	https://doi.org/10.3389/fpsyg.2018.00262
28	Sutrisni et al.	2022	Advances in Mobile Learning Educational Research	The effectiveness of the android-based Budiran game assisted by Smart Apps Creator 3 to improve science learning outcomes of fourth graders in theme 1	2(2)	https://doi.org/10.25082/AMLER.2022.02.017
29	Türkmen & Soybas	2019	Bartın University Journal of Faculty	The effect of the gamification method on	8(1)	https://doi.org/10.14686/buefad.424575

			of Education	students' achievements and attitudes toward mathematics		
30	Tzur et al.	2021	European Journal of Educational Research	Learning supported by technology: Effectiveness with educational software	10(3)	https://doi.org/10.12973/eu-jer.10.3.1139
31	Wang et al.	2023	Journal of Computer-Assisted Learning	The effects of mobile technology usage on cognitive, affective, and behavioral learning outcomes in primary and secondary education: A systematic review with meta-analysis	39(2)	https://doi.org/10.1111/jcal.12759
32	Xie et al.	2018	Frontiers in Psychology	Can touchscreen devices be used to facilitate young children's learning? A meta-analysis of touchscreen learning effect	9	https://doi.org/10.3389/fpsyg.2018.02580
33	Yesilyurt	2021	Journal of Primary Education	Meta-analysis of the effect of technologies on primary school	3(2)	https://doi.org/10.52105/temelegitim.3.2.3
34	Yıldırım & Şen	2019	Educational Technology Research and Development	The effects of gamification on students' academic achievement: A meta-analysis study	67(6)	https://doi.org/10.1080/10494820.2019.1636089
35	Yu et al.	2020	Journal of Educational Computing Research	The effect of educational games on learning outcomes, student motivation, engagement and satisfaction	59(3)	https://doi.org/10.1177/0735633120969214

Table 3: Data Extraction and Analysis

Study	Methodology	Objectives	Participants	Key Findings
Ali et al. (2019)	Exploratory study	Assess E-Numeracy mobile application	Primary school students	Limited success in reaching higher stages of numeracy understanding
Amasha et al. (2020).	Experimental study	Develop Java-based mobile app for math learning	Primary school students (Saudi Arabia)	More effective than traditional methods in improving mathematical abilities
Ariesta (2019)	Quasi-experimental	Evaluate e-learning media on natural science learning	Primary school students	Significant improvement in comprehension with e-learning media
Büchel et al. (2021).	Field experiment	Effectiveness of teachers and learning software	Primary school students (El Salvador)	Learning software showed significant positive effects on learning outcomes.
Camilleri & Camilleri (2020)	Reflective study	Use of mobile learning technologies	Primary education	Emphasized the importance of immersive technology for engagement
Chatzopoulos et al. (2023).	Evaluation study	Evaluate Google Play educational apps	Early childhood students	Systematic framework provided for assessing app quality
Christopoulos & Mystakidis (2023).	Encyclopedia entry	Gamification in education	General	Highlights the benefits and strategies of gamification in education
Corcoran (2018)	Quasi-experimental	Assess tablet apps on reading achievement	First graders	Significant improvement in reading achievement with tablet apps
Dorouka et al. (2020)	Evaluation study	Tablets and apps for promoting STEM education	Early childhood education	Effective in promoting STEM education and literacy

Dorris et al. (2021).	Systematic review	Mobile device use in the primary classroom	Primary school students	Identified positive impacts on literacy and numeracy attainment
Fadhli et al. (2020).	Meta-analysis	Effectiveness of gamification methods	Children (6-10 years)	Gamification improves knowledge, skills, and attitudes
Fage et al. (2018).	Pilot study	Tablet apps for the inclusion of children with ASD	Children with ASD	Improvements in socio-adaptive behaviors and social response
Fokides (2018)	Pilot project	Teaching basic programming concepts using tablets	Primary school students	Tablets and apps positively impact learning outcomes
Fokides (2020)	Reflective study	Reflecting on the use of tablets in primary schools	Primary school students	Tablets and apps linked to positive learning outcomes, dependent on teaching methods
Griffith et al. (2020)	Systematic review	Apps as learning tools	Children under six years old	Apps can effectively support early learning, design features critical
Hashim et al. (2019)	Exploratory study	Educational game apps on math learning	At-risk third graders	Positive impact on mental calculation and exercise completion time
Huntington et al. (2023)	Quantitative study	Impact of interactive apps on foundational skills	Primary school children	Six key features identified positively impacting learning outcomes
Ishaq et al. (2020)	Qualitative study	Mobile Assisted Language Learning (MALL)	Primary school students	Enhanced language learning, interactive content critical
Justine et al. (2019)	Quasi-experimental	Learning software on reading achievement in Kadazandusun	Year One pupils	Significant enhancement in reading achievement
Kacetl & Klímová (2019)	Qualitative study	Smartphone applications in English language learning	Primary school students	Identified challenges and benefits in foreign language education
Karamert & Vardar (2021)	Quantitative study	Gamification of young mathematics learners' achievements	Primary school students	Significant improvement in math achievements and positive attitudes
Khotima et al. (2022)	Quasi-experimental	The android-based science learning model	Primary school students	Significant improvement in learning outcomes with Android-based model
Kim et al. (2021).	Meta-analysis	Educational apps on literacy and math skills	Preschool to Grade 3 children	Positive association with improvements in literacy and math skills
Loo & Said (2021).	Quantitative study	Digital Game-Based Learning (DGBL) apps on math	Primary school students	Significant enhancement in motivation, problem-solving, and math performance
Martínez-Hita et al. (2021)	Quasi-experimental	Gamified project on historical thinking	4th-year primary students	Significant improvements in academic performance with gamified projects
Neumann (2018)	Pre-post test study	Literacy apps on emergent literacy skills	Young children (2-5 years)	Significant improvements in letter name, sound knowledge, and emergent writing
Pitchford et al. (2018).	Observational study	Interactive apps on essential math learning for SEND children	Children with SEND (Malawi)	Effective promotion of learning, slower progress for severe disabilities
Sutrisni et al. (2022)	Pretest-posttest	Android-based Budiran game on science learning outcomes	4th-grade primary students	Significant improvement in science learning outcomes
Türkmen & Soybas (2019)	Quasi-experimental	Gamification method on	Primary school students	Significant improvement in math

		students' achievements and attitudes		achievements and positive attitudes
Tzur et al. (2021).	Quantitative study	Effectiveness of educational software	Primary school students	Significant improvement in understanding and application of material
Wang et al. (2023).	Meta-analysis	Mobile technology impact on learning outcomes	Primary and secondary students	Medium positive effects on cognitive, affective, and behavioral learning outcomes
Xie et al. (2018).	Meta-analysis	Touchscreen devices facilitating young children's learning	Young children	Effective in promoting early learning, design, and content-critical
Yesilyurt (2021)	Meta-analysis	Advanced technologies' impact on academic achievement	Primary school students	Significant increase in academic achievement
Yıldırım & Şen (2019)	Meta-analysis	Gamification of students' academic achievement	Primary school students	Significant positive impact on academic achievement

3
Common Themes and Patterns

3.1 Impact on Learning Outcomes

Educational software and applications significantly impact primary students' learning across various subjects, enhancing academic performance in mathematics, science, and literacy. In mathematics, for instance, Büchel et al. (2021) discovered that computer-assisted learning (CAL) tools are more effective than traditional teaching methods in boosting mathematical skills. Similarly, Hashim et al. (2019) found that educational game apps improve mental calculation and exercise completion time for at-risk third graders. Regarding science, Ariesta (2019) showed that e-learning media dramatically enhances students' understanding of natural sciences compared to traditional methods. Neumann (2018) also reported significant improvements in emergent literacy skills among young children using literacy apps (Herodotou et al., 2017).

3.2 Types of Educational Software

Different types of educational software, including gamified apps, e-learning media, and interactive apps, show varying levels of effectiveness on primary students' academic performance. Gamified apps, for example, have been found by Vázquez-Cano et al. (2023) and Fadhli et al. (2020) to play a crucial role in boosting students' motivation, engagement, and overall learning outcomes. On the other hand, Ariesta (2019) demonstrated that e-learning media are particularly effective in enhancing students' comprehension abilities in natural sciences. Furthermore, Huntington et al. (2023) highlighted the importance of key features in interactive apps, such as autonomous learning and personalization, which significantly support and improve learning outcomes. These findings suggest that while all these types of educational software can be beneficial, their impact can vary depending on the specific features and the context in which they are used.

3.3 Pedagogical Features

Several vital pedagogical features of educational software and applications significantly improve primary students' learning outcomes, including autonomous learning, personalization, engagement, feedback provision, and task structure. Huntington et al. (2023) highlighted the importance of features like autonomous learning and personalization in supporting better learning outcomes. Additionally, Vázquez-Cano et al. (2023) emphasized the importance of feedback provision in gamified apps, which helps maintain student motivation and engagement. Effective task structure and engagement are also crucial for enhancing learning effectiveness, as noted by Huntington et al. (2023). These elements create a more personalized, interactive, and practical learning experience for primary students.

3.4 Motivation, Engagement, and Self-Directed Learning

Integrating educational software and applications positively impacts primary students' motivation, engagement, and self-directed learning. Yu et al. (2020) found that educational games boost student motivation and engagement and increase their overall satisfaction with learning. Huntington et al. (2023) also observed that apps enhance self-regulated learning by improving students' organizational and procedural skills. Mobile technology in primary education is linked to beneficial cognitive, emotional, and behavioral outcomes. Wang et al. (2023) reported that mobile technology has moderately positive effects on cognitive learning outcomes. Moreover, studies by Neumann (2018) and Wang et al. (2023) showed that using mobile technology in educational settings improves students' emotional well-being and behavior, making learning a more positive and practical experience.

3.5 Challenges and Limitations

Using educational software and applications in primary education has several challenges and limitations, including design features, implementation fidelity, and accessibility issues. For instance, Huntington et al. (2023) pointed out that apps sometimes fall short of helping students grasp complex scientific concepts. Similarly, Fage et al. (2018) stressed the importance of modifying software to support students with severe disabilities, who often face unique challenges. Ensuring that these tools are both accessible and user-friendly for their effective implementation, as emphasized by Vázquez-Cano et al. (2023). Addressing these issues is crucial to making educational software genuinely beneficial for all students, allowing them to fully engage and succeed in their learning experiences.

3.6 Variability among Different Groups

The effectiveness of educational software and applications varies among different groups of primary students, such as those with special educational needs or those at risk of academic failure. Pitchford et al. (2018) found that interactive apps effectively promote learning in children with special educational needs and disabilities, although students with severe difficulties may require additional software modifications. Similarly, Hashim et al. (2019) demonstrated that educational game apps improve learning outcomes for at-risk third graders. These findings highlight the importance of tailoring educational technologies to meet the diverse needs of students to ensure that all learners can benefit from these tools.

3.7 Recommendations for Future Development and Implementation

The findings from this systematic review offer valuable guidance for the future development and implementation of educational software and applications. To be most effective, these tools should incorporate key pedagogical features such as personalization, feedback provision, and engagement, as emphasized by Huntington et al. (2023) and Vázquez-Cano et al. (2023). Addressing accessibility issues is also crucial to ensure that all students can benefit. Moreover,



continuous assessment and teacher training are essential for successfully using these technologies, as Vázquez-Cano et al. (2023) highlighted. These common themes underscore the significant potential of educational software and applications to enhance primary education. They provide critical insights for educators, policymakers, and developers aiming to optimize the use of technology in educational settings, ultimately making learning more effective and inclusive for all students.

3.8 Correlation

This systematic review centers on the relationship between integrating educational software and applications and primary students' learning outcomes. The analysis shows a strong positive correlation, meaning that using these technologies is consistently linked to better academic performance across various subjects. For example, Büchel et al. (2021) found that computer-assisted learning tools significantly improve mathematical skills, while Ariesta (2019) highlighted their role in enhancing scientific understanding. Similarly, due to educational apps, Neumann (2018) and Huntington et al. (2023) demonstrated significant improvements in literacy and foundational skills. Wang et al. (2023) and Yu et al. (2020) also suggest that mobile technology and educational games boost not only cognitive outcomes but also affective and behavioral aspects of learning, such as motivation and engagement. These findings emphasize the importance of thoughtfully integrating technology into primary education to maximize learning benefits and meet diverse educational needs. The consistently positive results across multiple studies provide strong evidence supporting the effectiveness of educational software and applications in fostering improved learning outcomes for primary students.

3.9 Variations

The effectiveness of educational software and applications can vary widely across different groups of primary students and subject areas. The studies reviewed show that while these technologies generally improve learning outcomes, their impact can differ based on several factors, including the type of software, the subject matter, and the specific needs of the student population. For instance, Büchel et al. (2021) found that computer-assisted learning tools were particularly effective in boosting mathematical skills. In contrast, Ariesta (2019) observed more significant comprehension gains in natural sciences using e-learning media. Additionally, Pitchford et al. (2018) noted that interactive apps greatly benefited students with special educational needs and disabilities. However, those with severe difficulties often required tailored software modifications for the best results. These variations highlight the importance of customizing educational technologies to meet the diverse needs of students and maximize their educational benefits. The effectiveness of gamified apps, as reported by Vázquez-Cano et al. (2023) and Fadhli et al. (2020), is influenced by factors such as student engagement levels and the provision of personalized feedback. Additionally, Camilleri and Camilleri (2020) pointed out that while mobile learning technologies can enhance relational and communicative skills, their impact varies depending on individual learning abilities. These findings underscore the importance of customizing educational software to meet primary students' diverse needs and contexts, thereby maximizing their educational potential.

4 Discussion

The findings from this systematic review highlight the transformative potential of educational software and applications in primary education. The analysis shows that these digital tools significantly enhance learning outcomes across various subjects, particularly mathematics and science. The success of these tools largely depends on integrating key pedagogical features such as autonomous learning, personalization, and engagement. Huntington et al. (2023) and Wang et al. (2023) emphasize the complex but positive impact of mobile technology on cognitive, affective, and behavioral development, suggesting that thoughtful implementation can maximize these

benefits. However, it is essential to note that the effectiveness of these technologies is not uniform and can vary based on the type of software, the subject matter, and the demographics of the students. Studies like those by Büchel et al. (2021) and Ariesta (2019) illustrate that while CAL tools and e-learning media can significantly improve academic performance, their impact is influenced by the instructional context and the specific educational needs they address. Furthermore, the critical role of gamified learning, as emphasized by Vázquez-Cano et al. (2023) and Camilleri and Camilleri (2020), points to the importance of engagement and motivation in enhancing learning experiences. Despite the promising potential of educational software, challenges remain. Pitchford et al. (2018) emphasize the need for accessible and inclusive design, while Tzur et al. (2021) highlight the necessity for continuous teacher training and support to ensure effective implementation. Future research should aim to refine these technologies to meet diverse learning needs and explore their long-term impacts on students' academic and developmental trajectories. The insights from this review offer a valuable framework for educators, policymakers, and developers to optimize the use of educational software in primary education, ultimately striving to create more dynamic, engaging, and effective learning environments.

4.1 Implications

The insights from this systematic review hold significant implications for stakeholders in primary education. For educators, the findings emphasize the value of integrating educational software and applications into teaching practices to boost student engagement, motivation, and learning outcomes. Features like personalized learning, autonomous learning, and gamified elements should be prioritized in educational technologies. For policymakers, the review highlights the need to support schools adopting technology by providing adequate funding, access to high-quality digital resources, and teacher professional development. Policies should also focus on inclusivity, ensuring educational software is accessible to all students, including those with special educational needs and those at risk of academic failure. Educational software developers can use these findings to create more effective tools by incorporating features that enhance engagement, provide feedback, and offer personalized learning experiences. Addressing the challenges identified in the review, such as supporting conceptual understanding and ensuring accessibility for diverse student needs, is crucial. Ongoing research and continuous evaluation are essential to understand the long-term impacts of educational technology. Collaboration between researchers, educators, and developers will help refine these tools to meet the evolving needs of primary education. By leveraging these insights, stakeholders can foster a more effective, engaging, and inclusive educational environment, maximizing technology's potential to improve student learning outcomes.

4.2 Limitations

Despite the promising findings of this systematic review, several limitations must be acknowledged. The review only included studies published in English, which might exclude relevant research in other languages and limit the global applicability of the results. Additionally, many studies used quasi-experimental and observational designs, introducing biases and limiting causal inferences. Differences in sample sizes, intervention durations, and measurement tools among the included studies also affect the consistency and comparability of the results. Moreover, the rapid pace of technological advancement means that educational software can quickly become outdated, requiring ongoing updates and evaluations.

4.3 Findings

The findings of this systematic review reveal several key insights into the impact of educational software and applications on primary students' learning outcomes. Mobile applications and computer-assisted learning (CAL) tools consistently enhance academic performance in

mathematics, science, and literacy. Studies by Huntington et al. (2023) and Wang et al. (2023) highlight the positive effects of mobile technology on students' behavioral, emotional, and cognitive development, emphasizing the need for thoughtful integration to optimize benefits. Key pedagogical features contributing to the effectiveness of educational software include autonomous learning, engagement, personalization, and feedback provision. Huntington et al. (2023) and Vázquez-Cano et al. (2023) underscore the importance of these features in supporting foundational skills and fostering a conducive learning environment. Gamified learning has proven to be particularly effective, with studies by Vázquez-Cano et al. (2023) and Fadhli et al. (2020) showing improvements in motivation, engagement, and learning outcomes. Individualized interventions are also crucial for meeting diverse needs, especially for students with special educational needs or those at risk of academic failure (Hashim et al., 2019; Pitchford et al., 2018). However, challenges remain, such as design flaws, implementation issues, and accessibility barriers (Fage et al., 2018; Falloon, 2017). These findings highlight the significant potential of educational technology to enhance learning outcomes in primary education when thoughtfully designed and implemented with students' specific needs in mind. This review provides valuable guidance for educators, policymakers, and developers aiming to use technology to improve educational experiences for primary school children (Ou, 2015).

4.4 Significance

This systematic review emphasizes the benefits and considerations of using educational software in primary education. The review adds to the ongoing discussion about integrating technology best to enhance learning outcomes and prepare students for future challenges by pinpointing key features and proving their effectiveness. The findings underscore the need for more research into the long-term effects of educational technologies on learning outcomes, including academic performance, motivation, and cognitive development. It is also crucial to explore how these technologies impact diverse student populations, such as those with special educational needs, learning disabilities, language barriers, or socio-economic challenges, to ensure that educational software meets their unique needs. Future research should also identify pedagogical features that make educational software effective, such as autonomous learning, personalization, and feedback provision. Additionally, there is a need to look into emerging technologies like AI and AR to tailor learning experiences further and improve outcomes. Understanding the role of teacher professional development in successfully implementing educational technologies is essential, notably in understanding how training and resources can support teachers. Lastly, comprehensive studies on the cost-effectiveness of educational technologies are necessary to help policymakers and institutions make informed decisions about resource allocation, ensuring substantial benefits for students and schools.

4.5 Conclusion

A thorough review of research on educational solutions in primary schools underscores the vital role technology plays in enhancing student learning. Studies have consistently demonstrated that educational apps, software, and digital tools significantly aid students in various areas, from excelling in math to improving collaboration and overall academic performance. Furthermore, research comparing different teaching methods, such as computer-assisted learning (CAL) software versus traditional methods, indicates that technology can particularly enhance learning in subjects like math and science. These findings highlight the necessity for interactive educational technology to incorporate vital pedagogical elements and be thoughtfully designed to maximize effectiveness. Additionally, research on teachers' and students' perceptions of mobile learning tools reveals that different learners require tailored strategies to meet their needs and preferences. Most studies suggest integrating technology into elementary schools can create dynamic and engaging classrooms, fostering student motivation, interest, and academic success. To ensure that technology integration meets educational goals and enhances learning for all students, it is crucial

to plan its implementation and continuously assess its impact.

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