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Mobile Applications for Supporting Literacy and Communication Skills in Children with Dyslexia: A Systematic Literature Review

Alvons Habibie[1], Usman Pakaya[1]

[1]Doctoral Programme in Applied Linguistics, Gorontalo State University, Indonesia

Corresponding author: habibievons@iaingorontalo.ac.id

Abstract

Mobile applications have emerged as promising assistive technologies for supporting children with dyslexia; however, a comprehensive understanding of their effectiveness in enhancing literacy and communication-related skills remains fragmented. This systematic literature review synthesizes research from 2018 to 2024 on mobile application-based interventions for children with dyslexia, focusing on their impact on reading, phonological awareness, and related communication abilities. The search was conducted in Scopus, Web of Science, IEEE Xplore, ScienceDirect, ERIC, and Google Scholar using keyword combinations such as "dyslexia," "mobile application," "multisensory learning," "phonological awareness," and "reading intervention." Study quality was appraised using adapted criteria from the Critical Appraisal Skills Programme (CASP) and the Mixed Methods Appraisal Tool (MMAT). Following a systematic methodology, 161 candidate papers were identified through database searching and citation tracking, with 50 studies ultimately categorized as highly relevant for in-depth analysis. The review reveals that multisensory learning approaches dominate current intervention designs, frequently integrated with gamification elements and artificial intelligence-powered adaptive feedback systems to enhance user engagement and personalized learning experiences. Emerging technologies including augmented reality, virtual reality, and neurofeedback demonstrate promising potential for creating immersive and individually tailored learning environments. The findings indicate consistent improvements across diverse linguistic and orthographic contexts including English, Arabic, German, Spanish, and Sinhala, in core areas such as phonological awareness, reading fluency, and vocabulary mastery. However, significant gaps persist in the literature, including limited longitudinal data on sustained intervention effects, insufficient direct assessment of broader communication competencies beyond basic literacy skills, and a scarcity of comparative cross-linguistic studies. Methodological heterogeneity across studies, characterized by small sample sizes and non-standardized outcome measures, complicates systematic synthesis and generalization. This review concludes that while mobile applications represent a viable and engaging pathway for supporting children with dyslexia, future research must prioritize rigorous longitudinal designs, standardized assessment batteries, and expanded investigation of comprehensive communication outcomes to optimize intervention effectiveness across diverse cultural and linguistic settings.

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1. Introduction

Mobile application-based interventions for children with dyslexia have become a critical area of investigation, driven by the rising prevalence of dyslexia and the growing integration of digital tools in education (Mohamad et al., 2024; Politi-Georgousi & Drigas, 2020). Over the past decade, this field has evolved from basic assistive technology to advanced mobile applications that combine multisensory, gamified, and augmented reality approaches (Cahyana et al., 2021; Ahmad et al., 2021). This evolution reflects the practical significance of improved literacy and communication skills among dyslexic children, who represent about 5–15% of the global population (Faisal et al., 2023). The social and educational impact is quite significant, as the right actions can improve learning outcomes and confidence, thus encouraging the lifelong learning process. (Yaacob et al., 2024; Larco et al., 2021). Despite progress, children with dyslexia continue to face challenges in reading, spelling, and communicating, which have not been fully addressed by existing interventions (Lim, 2019; Aldousari, 2021).

A significant lack of understanding still exists regarding the comparative effectiveness of different mobile app features, such as neurofeedback, multi-sensory learning, and augmented reality, in a variety of language and cultural situations (Chauhan et al., 2024; Peña et al., 2024; Amado & Andrade-Arenas, 2023). In addition, there is debate about the best balance between technology-based and traditional teaching approaches, with some studies emphasizing the motivational benefits of gamification, while others emphasizing the importance of evidence-based individual phonological training (Eroglu et al., 2021; Holz et al., 2018; Wai et al., 2023).

The basic framework used in this review describes dyslexia as a neurodevelopmental disorder characterized by difficulty in recognizing words, decoding, and spelling, which hinders the ability to communicate. (Faisal et al., 2023; I et al., 2020). Mobile applications are conceptualized as assistive technologies that integrate multisensory, gamified, and adaptive learning strategies to support individualized interventions (Cahyana et al., 2021; Hany et al., 2024).

In recent decades, dyslexia is no longer understood solely as reading difficulties. Many studies have shown that this disorder is also related to broader language development including phonological processing, verbal expression, and the ability to communicate effectively. For children, these barriers often arise in the classroom: they have difficulty following verbal instructions, expressing ideas in sequence, or understanding the structure of written language that then affects everyday communication. In this context, the development of digital technology, especially mobile applications, is beginning to be seen as a potential means of intervention because of its flexible, interactive, and easily accessible nature for children and educators.

A number of cutting-edge studies have begun to explore the use of mobile applications as an intervention medium for children with dyslexia. These applications generally combine various pedagogical approaches, such as multisensory learning, phonological awareness exercises, gamification, and the integration of artificial intelligence to provide adaptive feedback. Some studies report that these features can help improve reading and language comprehension, ultimately contributing to the development of children's communication skills. However, research findings are still spread across different disciplines and language contexts, so a comprehensive picture of the effectiveness of this approach is still not entirely clear (Yaacob et al., 2024; Aldousari, 2021).

Based on these conditions, this systematic review aims to synthesize the latest research on mobile app-based interventions for children with dyslexia, with a particular focus on their impact on improving communication skills. Through a review of a range of relevant empirical studies, this review seeks to identify the most effective technological and pedagogical approaches, as well as to map emerging research trends in this field. Thus, this study is expected to provide a conceptual basis for the

development of educational applications that are more responsive to the needs of children with dyslexia and provide practical implications for learning practices and educational interventions in the future.

More specifically, this review is directed to: (1) evaluate the current knowledge regarding the use of mobile applications designed to improve communication skills in children with dyslexia; (2) compare various existing mobile technologies based on design features, pedagogical approaches, and user engagement levels; (3) identify and synthesize the use of multisensory methods and artificial intelligence-assisted approaches in dyslexic intervention applications; (4) examine the effectiveness of mobile applications in different languages, orthographic systems, and cultural contexts; and (5) analyze the impact of mobile application-based interventions on children's early communication development, reading ability, and phonological awareness.

In line with these objectives, this review was formulated through several key research questions, namely:

1. How is research progressing on mobile app-based interventions aimed at children with dyslexia?
2. What technological features and pedagogical approaches are most commonly used in mobile apps to support communication skills in children with dyslexia?
3. What is the role of multisensory methods and artificial intelligence-based technologies in increasing the effectiveness of these interventions?
4. Are there differences in the effectiveness of mobile apps in different languages, orthographic systems, and cultural contexts?
5. To what extent do mobile app-based interventions contribute to improved communication, reading, and phonological awareness skills in children with dyslexia?

Through the formulation of these research objectives and questions, the study is expected not only to summarize existing empirical findings but also to identify research gaps that are still open, so that they can be a foothold for more targeted research and development of educational technology in the future.

It is important to clarify the scope of "communication skills" in this review. Although the term is often associated with oral expression and social interaction, this study adopts a broader, language-based conceptualization in which communication is understood as the integrated ability to encode and decode linguistic information across modalities. For children with dyslexia, foundational competencies such as phonological awareness, decoding, reading fluency, vocabulary mastery, and spelling are direct prerequisites for effective written and spoken communication: difficulties in these areas constrain a child's ability to follow verbal instructions, formulate ideas in sequence, and participate confidently in classroom interaction. Accordingly, this review uses literacy-related outcomes (reading, phonological processing, vocabulary, spelling) as proxy indicators for communication development, while also explicitly examining studies that report on broader communicative outcomes such as expressive language, listening comprehension, and confidence in social-academic interaction. This framing aligns the title's focus on communication with the empirical base of the included studies and is consistent with current language-development literature on dyslexia (Faisal et al., 2023; Peña et al., 2024).

2. Methodology

This study uses a systematic literature review (SLR) approach to identify, select, and synthesize relevant research on technology-based interventions for dyslexia that focus on the use of mobile applications for children and their impact on improving communication skills. The literature search process is carried out systematically through several stages which include the transformation of search queries, the

application of inclusion and exclusion criteria, paper screening, citation search, and relevance assessment.

2.1 Search Query Transformation

The initial stage of this research began by formulating the main research question, namely regarding technology-based interventions for dyslexia that focus on mobile applications for children and their impact on improving communication skills. The research question was then developed into several more specific search queries. This transformation is carried out to ensure that the literature search process can cover various aspects related to the research topic without losing the main focus of the study.

Through this process, general research questions are expanded into several more targeted search statements, covering the topics of mobile app-based multisensory interventions for dyslexia, the use of artificial intelligence-based technologies in mobile apps, gamified learning approaches, and interventions applied in different languages, orthographies, and cultural contexts. The development of this query allows the literature search process to be more comprehensive while remaining systematically managed. The specific keyword combinations used included Boolean operators such as: ("dyslexia" OR "reading disability" OR "learning difficulty") AND ("mobile application" OR "mobile app" OR "tablet-based intervention" OR "assistive technology") AND ("children" OR "students" OR "learners") AND ("communication skills" OR "reading fluency" OR "phonological awareness" OR "literacy" OR "multisensory learning" OR "gamification" OR "augmented reality"). The searches were conducted across six major academic databases, namely Scopus, Web of Science, IEEE Xplore, ScienceDirect, ERIC, and Google Scholar, to ensure broad disciplinary and geographical coverage.

2.2 Inclusion and Exclusion Criteria

Once the search query has been formulated, the next step is to identify and implement inclusion and exclusion criteria to ensure that the studies obtained are appropriate to the research focus. The criteria used in this study are research publications published in the most recent time frame, namely between 2018 and 2024. The application of these criteria aims to ensure that the studies analyzed reflect the latest developments in research on technological interventions for children with dyslexia. More specifically, the inclusion criteria were: (a) peer-reviewed articles or full conference proceedings published between 2018 and 2024; (b) studies written in English; (c) studies involving children or school-age learners diagnosed with or at risk of dyslexia; (d) studies that examined a mobile, tablet-based, or smartphone-based application as the primary intervention; and (e) studies reporting empirical outcomes related to reading, phonological awareness, vocabulary, spelling, or communication skills. The exclusion criteria were: (a) studies focusing exclusively on adults with dyslexia; (b) studies on non-mobile or desktop-only software; (c) editorials, opinion pieces, and posters without empirical data; and (d) duplicate publications. The methodological quality of the selected studies was appraised using adapted criteria from the Critical Appraisal Skills Programme (CASP) checklist and the Mixed Methods Appraisal Tool (MMAT), with each study rated on study design, sample description, intervention clarity, outcome measurement, and reporting transparency.

2.3 Articles/Papers Screening

Each transformed search query is then executed by applying those inclusion and exclusion criteria to obtain a set of relevant candidate papers. The search process is carried out through six academic databases (Scopus, Web of Science, IEEE Xplore, ScienceDirect, ERIC, and Google Scholar), supplemented by a wider academic indexing platform containing more than 270 million scientific publications to capture interdisciplinary works. From this initial search process, 77 papers were obtained that met the initial criteria and were considered relevant to the research topic.

2.4 Citation Search

To expand the scope of the literature and ensure that no important studies are missed, a citation search process is also carried out. This process involves two main approaches. First, backward citation tracking, which is by reviewing the reference list of each core paper to identify previous research that is the basis for the study. This approach helps ensure that fundamental research relevant to the topic is not overlooked.

Second, forward citation tracking is carried out, namely by identifying newer research that cites core papers that have been found previously. This approach allows researchers to track the progress of research that builds on or builds on previous findings. Through this citation tracing process, 84 additional papers were found that were relevant to the study topic.

2.5 Relevance Assessment and Study Sequencing

After the entire search and citation search process was carried out, a total of 161 candidate papers were obtained, consisting of 77 papers from the initial search results and 84 papers from the citation search process. Furthermore, all of the papers were analyzed through a relevance assessment process to determine their suitability with the research question.

This assessment process resulted in 155 papers that were considered relevant to the research focus on mobile app-based interventions for children with dyslexia and their impact on communication skills. Of these, 50 papers are categorized as highly relevant studies because they directly address the use of mobile applications as a form of technological intervention for children with dyslexia and its implications for the development of communication skills.

Through this methodological stage, the literature review is expected to be able to provide a comprehensive overview of the development of research related to mobile application-based interventions for dyslexia and its contribution to improving communication skills in children.

To ensure transparency and replicability, the quality of the 50 highly relevant studies was further appraised using adapted criteria from the Critical Appraisal Skills Programme (CASP) checklist and the Mixed Methods Appraisal Tool (MMAT, version 2018). Each study was independently rated by both authors on five dimensions: (1) clarity of research aims, (2) appropriateness of study design, (3) participant selection and sample description, (4) clarity of intervention and outcome measures, and (5) reporting of findings and limitations. Disagreements were resolved through discussion until consensus was reached. Studies meeting at least four of the five criteria were considered of acceptable methodological quality and were retained for synthesis. This appraisal step was added to strengthen the rigor of the review and to allow readers to evaluate the trustworthiness of the synthesized evidence.

3. Result and Discussion

This section maps the landscape of literature research on technology-based interventions for dyslexia focused on mobile apps for children and their impact on improving communication skills, highlighting a diverse range of mobile apps designed to support the reading, spelling, and communication skills of dyslexic children. These studies cover a wide range of pedagogical approaches including multisensory learning, gamification, AI-based personalization, and neurofeedback, with geographic coverage that includes a variety of languages and orthographies such as English, Arabic, Sinhala, German, and Spanish.

The reviewed studies provide robust evidence for the effectiveness of mobile-based interventions in enhancing literacy skills across diverse linguistic and orthographic contexts. A synthesis of 30 studies reveals consistent, measurable improvements in core areas such as reading ability, communication, and phonological awareness following intervention. Notably, these gains extend beyond mere skill acquisition, with several studies reporting significant boosts in children's motivation, confidence, and overall engagement. This effectiveness is demonstrated across a wide array of languages, including English, Arabic, German, and Chinese, underscoring the adaptability of these tools to different writing systems and cultural settings. While most interventions focus on tangible literacy outcomes, emerging technologies like neurofeedback show promise in inducing positive electrophysiological and cognitive changes, though further research is needed to directly correlate these with reading performance.

The success of these interventions is largely attributed to sophisticated, learner-centered pedagogical approaches deeply integrated with advanced technology. Multisensory learning, which engages multiple modalities, stands out as a dominant and effective strategy, frequently enhanced by gamification, narrative-driven content, and AI-powered personalization to sustain high levels of child engagement and cater to individual learning needs. The integration of cutting-edge technologies such as voice recognition, virtual and augmented reality, and tangible user interfaces creates immersive and interactive learning environments. Furthermore, the use of artificial intelligence and machine learning for adaptive feedback and personalized learning paths represents a significant step forward in providing tailored support. Crucially, high usability ratings from standardized scales and positive feedback from children, parents, and educators confirm that these feature-rich applications are not only engaging but also accessible and well-received in real-world educational settings.

3.1 Critical Analysis and Synthesis

The literature reviewed on technology-based interventions for dyslexia, particularly mobile apps targeting children's communication skills, reveals a growing interest in multisensory, gamified, and AI-based approaches. Strengths include a diversity of technological modalities and the integration of adaptive learning features that cater to individual needs. However, limitations remain in methodological rigor, sample size, and cross-lingual applicability.

A comparison across the reviewed studies suggests that not all intervention approaches are equally effective, and their relative strengths depend on the targeted skill and learner profile. Multisensory mobile applications (e.g., Cahyana et al., 2021; Eroglu et al., 2021) consistently produced the strongest gains in phonological awareness and decoding, likely because they engage visual, auditory, and kinesthetic pathways simultaneously, which is theoretically aligned with the multi-component deficit model of dyslexia. Gamified applications (e.g., Holz et al., 2018; Tiede et al., 2022) showed clear advantages in sustaining motivation and time-on-task, but their impact on transferable literacy outcomes appears more modest unless gamification is combined with structured phonics or multisensory content. AI-based adaptive systems (e.g., Hany et al., 2024; Mastropavlou et al., 2020) demonstrated promise for personalization and progress tracking, yet most studies remain at the prototype or feasibility stage and lack controlled outcome comparisons with non-adaptive apps. Augmented and virtual reality applications (e.g., Ahmad et al., 2021; Amado & Andrade-Arenas, 2023; Caballero & Albina, 2023) tend to maximize engagement and immersion, but their efficacy on long-term reading transfer is less well established than that of phonics-based multisensory tools.

Taken together, these comparisons suggest that the most effective designs are not those that adopt a single technological feature, but rather those that integrate evidence-based pedagogical content (e.g., systematic phonological training) with engagement-enhancing layers (gamification, AR, AI adaptivity). Studies that combined multiple approaches (e.g., Eroglu et al., 2021, integrating neurofeedback and multisensory learning; Peña et al., 2024, combining tablet-based delivery with explicit linguistic targets) tended to report broader gains, including improvements that extended beyond decoding to early communicative behaviors. Conversely, studies relying primarily on novelty features without explicit

linguistic scaffolding reported gains that were largely confined to motivation or short-term engagement. This pattern indicates that the "why" behind effectiveness lies less in the technology itself and more in how the technology operationalizes established principles of dyslexia intervention.

Table 1. Strengths and Weaknesses

Aspects	Strength	Disadvantages
Methodological Approach	Some studies use robust experimental designs such as pre-test/post-test and randomized controlled trials, increasing the validity of the findings.	Many studies have small sample sizes and short intervention durations, limiting generalizations and conclusions of long-term effectiveness.
Technology and Design Features	The integration of multisensory learning, gamification, and AI-based adaptive feedback is a standout strength, enhancing engagement and personalized learning.	Despite innovative features, some apps lack comprehensive customization options or fail to address the full spectrum of dyslexia challenges.
Impact on Communication Skills	Some interventions showed improvements in phonological awareness, reading fluency, and vocabulary mastery, which are the basis for communication skills.	Few studies directly measure broader communication skills such as expressive language and social communication.
Cross-Language Application	The research included interventions across multiple languages and orthographies, demonstrating the adaptability of mobile apps to different linguistic contexts.	The lack of comparative studies that systematically evaluate the effectiveness of cross-language and orthography, limited the evidence on the transferability of interventions.
User Engagement	Gamification elements, narrative storytelling, and reward systems effectively increase user engagement and motivation.	Engagement metrics are often self-reported or short-term, with limited longitudinal data on ongoing motivation.
Integration of AI and Adaptive Technology	AI-powered systems show promising capabilities in personalized learning, screening, and adaptive feedback.	The complexity of AI integration raises concerns about transparency, user trust, and ethical considerations that are still underexplored.

3.2 Thematic Review of the Literature

Research on technology-based interventions for dyslexia in children highlights several key themes including the effectiveness of mobile apps in improving reading and communication skills, the integration of multisensory and gamified learning approaches, and the role of AI and evolving neurofeedback technologies.

Table 2. Thematic Literature Review

Theme	Appears in	Description
The Effectiveness of Mobile Apps in Improving Reading and Communication Skills	30/50 Papers	Mobile apps showed significant improvements in reading fluency, phonological awareness, and early communication skills among dyslexic children.
Multisensory and Gamified Intervention Approaches	22/50 Papers	Multisensory learning methods combined with gamification elements have been widely adopted in mobile apps to improve engagement and learning outcomes.
AI-Based Adaptive Technology and Neurofeedback	12/50 Papers	Artificial intelligence and neurofeedback are emerging as innovative tools, providing real-time adaptive feedback and personalized learning paths.
Cross-Language and Cultural Application of Mobile Technology	13/50 Papers	Several studies investigated interventions in different languages and orthographic systems, including Arabic, Sinhala, German, Chinese, and Spanish.
Augmented and Virtual Reality Apps for Dyslexia	10/50 Papers	AR and VR technologies are increasingly integrated into dyslexic interventions to create immersive and interactive learning environments.
Mobile-Based Screening and Diagnostic Tools	8/50 Papers	The mobile app is used for early screening and identification of dyslexia risk factors using machine learning algorithms.
User Interface Design and Usability for Dyslexic Children	7/50 Papers	User-centric design including accessibility features such as font selection, color scheme, and intuitive navigation is essential in mobile app development.
Impact on Early Language Development and Phonological Processing	6/50 Papers	Tablet-based interventions targeting toddlers and preschoolers showed promising results in improving early language proficiency and phonological processing.
Personalized Learning Systems and Adaptive Feedback Mechanisms	6/50 Papers	Personalized learning systems that adjust content and difficulty levels based on user performance increase the effectiveness of dyslexia interventions.
Challenges in Technology Access and Educator Readiness	5/50 Papers	The issue of digital divides, lack of educator training, and variations in technology availability present challenges for the effective implementation of mobile interventions.

3.3 Chronological Review of the Literature

The evolution of technology-based interventions for dyslexia, especially mobile apps targeting children, has been marked by a steady increase in sophistication and diversity over the past few years.

Table 3. Chronological Literature Review

Period of Project	Research Direction	Description
2018–2019	Basic Mobile Apps and Gamified Learning	Initial research focused on the development of basic mobile apps and serious games aimed at improving reading and spelling skills for dyslexic children.
2020–2021	Multisensory Enhanced Mobile Interventions and Neurofeedback	Emerging research includes multisensory approaches and neurofeedback technologies in mobile applications to improve reading comprehension and phonological awareness.
2022–2023	Augmented Reality, AI Personalization, and Multilingual Adaptation	This period saw augmented reality recognition and more advanced AI-powered personalized learning systems. The application of multilingualism and cross-cultural has received attention.
2024	Comprehensive AI-Based and Multisensory Mobile Solutions	The latest study focuses on AI-based personalized learning systems and comprehensive mobile assistive technologies that combine multisensory, gamification, and adaptive feedback.

The theoretical implications of this body of research significantly advance our understanding of how technology-mediated learning can address the neurocognitive and developmental dimensions of dyslexia. The consistent success of multisensory and gamified mobile applications provides robust support for established theories positing that engaging multiple sensory pathways enhances phonological processing and foundational literacy acquisition. Furthermore, the integration of AI-driven adaptive feedback and neurofeedback mechanisms offers compelling evidence for technology's capacity to induce beneficial neurocognitive changes, such as modulating brain activity patterns associated with reading. These findings not only reinforce motivational and engagement theories by demonstrating the power of gamification and augmented reality to sustain learner interest but also challenge traditional pedagogical paradigms by suggesting that well-designed technological interventions can, in some contexts, match or even surpass conventional special education methods. The emerging evidence across diverse languages and orthographies also underscores the need for continued theoretical development regarding how specific linguistic features must shape the design and efficacy of these tools.

On a practical level, these insights translate into clear, actionable guidance for educators, clinicians, developers, and policymakers. For practitioners, the findings strongly advocate for the purposeful integration of mobile applications featuring multisensory, gamified, and AI-adaptive elements as powerful complements to traditional intervention programs. Developers are urged to anchor their work in user-centered design principles, ensuring content is culturally relevant, linguistically tailored, and accessible to maximize impact. The demonstrated benefits of early, technology-based intervention highlight a critical opportunity for early childhood education programs to harness tablet-based learning during sensitive developmental windows. Moreover, the positive reception and motivational boosts associated with augmented reality and gamified applications make a compelling case for their formal inclusion in both school curricula and therapeutic regimens. Finally, for policymakers, particularly in under-resourced areas, the evidence supports investing in the deployment and support of these effective and engaging digital tools to broaden access to quality literacy support.

Table 4. Limitations of the Literature

Limitation Areas	Limitations Description	Related Papers
Small Sample Size	Many studies use small groups of participants, limiting the power of statistics and generalizations.	Bouda et al., 2024; Eroglu, 2023; Peña et al., 2024; Faisal et al., 2023
Limited Longitudinal Data	Few studies included long-term follow-up to assess the sustained effects of interventions.	Bouda et al., 2024; Peña et al., 2024; Faisal et al., 2023
Language and Cultural Bias	Research mostly focuses on specific languages or cultural contexts, limiting cross-linguistic application.	Sandathara et al., 2020; Saram et al., 2023; Chauhan et al., 2024
Methodological Constraints	Some studies lack rigorous experimental designs, such as randomized controlled trials or control groups.	Filho et al., 2024; Borhan et al., 2018; Gupta et al., n.d.
Intervention Heterogeneity	The wide variation in the type of intervention, application features, and outcome size makes synthesis and comparison difficult.	Mohamad et al., 2024; Politi-Georgousi & Drigas, 2020; Yaacob et al., 2024
Inadequate Focus on Communication Skills	Many studies emphasize improved reading and spelling but provide a limited direct assessment of broader communication skills.	Mohamad et al., 2024; Wai et al., 2023; Peña et al., 2024
Lack of Standard Outcome Size	Diverse and non-standardized assessment tools reduce comparability and may affect the reliability of reported intervention effects.	Mohamad et al., 2024; Politi-Georgousi & Drigas, 2020

Tabel 5. Gaps and Future Research Directions

Gap Areas	Description	Research Direction	Priorities
Longitudinal Impact on Communication Skills	Most studies focused on reading and phonological skills but lacked long-term data on broader communication skills.	Conduct a longitudinal study that assesses the impact of interventions on comprehensive communication skills.	Height
Cross-Language and Orthography Transferability	Scarcity of comparative studies evaluating effectiveness across different languages and orthographies.	Design a cross-language controlled test that compares the effectiveness of mobile apps across diverse orthographic systems.	Height
Wider Integration of Language Skills	Today's apps primarily target reading and decoding, with an inadequate focus on writing, spelling, and spoken language development.	Develop and evaluate integrated applications that simultaneously handle reading, writing, spelling, and spoken language skills.	Height

Standardization of Yield Measures	Inconsistencies in assessment tools and outcome measures across studies.	Establish and adopt a standardized validated assessment battery to evaluate mobile app interventions.	Height
Accessibility in a Low Resource Environment	Advanced technologies such as VR, AR, and AI may not be accessible in low-resource areas.	Develop low-cost, offline-capable applications with multisensory features and scalable gamification.	Height
Early Intervention and Age-Specific Design	Few interventions targeted toddlers and preschoolers.	Design and test age-appropriate mobile apps for early childhood, focusing on vocabulary and pre-reading skills.	Height

4. Conclusion

The overall literature on technology-based interventions for dyslexia, with a focus on mobile apps for children, reveals a strong trend toward the use of multisensory, gamified, and AI-based approaches to improve communication-related skills. Multisensory learning methods dominate pedagogical strategies, often integrated with gamification and personalized adaptive feedback to increase engagement and motivation, thereby facilitating the improvement of basic skills such as phonological awareness, reading fluency, and vocabulary mastery.

Technological innovation plays a crucial role in tailoring interventions to individual learners' profiles. AI and machine learning technologies enable dynamic adjustments in content difficulty levels and provide personalized feedback, improving the accuracy and usability of interventions. Augmented and virtual reality further enhance engagement by creating an immersive learning experience.

Wide cross-language coverage, spanning languages with varying orthographic complexities such as English, Arabic, Sinhala, German, Spanish, Malay, and Chinese, was observed across the reviewed studies. While this diversity confirms the adaptability of mobile apps, comparative studies testing cross-lingual effectiveness are still scarce, limiting understanding of transferability and scalability.

User engagement was consistently high in interventions that combined gamification, tangible interfaces, and multisensory elements, with positive feedback from children, parents, and educators. However, longitudinal data on sustained motivation and long-term learning retention are limited.

The methodological heterogeneity across studies, including sample sizes, intervention durations, and varied assessment tools, complicates direct comparison and synthesis. More rigorous longitudinal and cross-cultural research using standardized, multidimensional outcome measures is needed to validate and optimize mobile app interventions.

Overall, technology-based mobile apps represent a promising path to supporting children with dyslexia, with the potential to improve basic language skills and engagement. However, expanding coverage to include broader communication capabilities, addressing cultural challenges, and improving accessibility remain essential priorities for future research and development. In particular, future studies

should move beyond reading and decoding outcomes to directly assess expressive language, listening comprehension, and pragmatic communication, so that the promise of mobile applications can be evaluated against the full range of communication needs of children with dyslexia.

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