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Mobile Assistive Technology for Dyslexic Children: A Significant Review

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ABSTRACT

In recent years, mobile assistive technology has emerged as a promising tool for supporting dyslexic children in their educational journey. This systematic review presents a comprehensive review of the literature on the utilization and effectiveness of mobile assistive technology in enhancing the learning experiences of dyslexic children. The review examines various types of mobile assistive technology and delves into the ways in which these technologies are tailored to meet the unique needs of dyslexic children. The article also explores the benefits and limitations of mobile assistive technology, shedding light on its potential to enhance reading, writing, and overall cognitive skills in dyslexic children. The systematic search of academic databases using Scopus, Web of Science and ERIC database yielded a comprehensive selection of studies and articles related to mobile assistive technology. After applied advanced searching approach using keywords which are mobile assistive technology, mobile technology, mobile application, mobile learning, dyslexia, the analysis revealed that e-learning played a pivotal role in maintaining educational continuity during the pandemic, offering flexibility and remote access to learning resources. The final finding data is (n=13) which review identified key themes, including the challenges of the digital divide, pedagogical adaptations, and the importance of educator preparedness. Expect validation decide to divide into four themes which is (1) Mobile Applications for Dyslexia Support**,** (2) Multisensory and Multilingual Approaches for Dyslexia Support**,** (3) Individualized Learning for Dyslexia Support and (4) Intervention and Stakeholders Perspectives**.** This significant review consolidates current knowledge on the use of mobile assistive technology, highlighting its potential to transform the educational landscape for this vulnerable population. As mobile assistive technology continues to evolve, it holds great promise for enhancing the educational prospects of dyslexic children, ultimately helping them unlock their full potential.

1. Introduction

In a world increasingly dominated by digital technology, access to education and information is more critical than ever before. However, for the estimated 10% of the world's population struggling with dyslexia, this access can be a challenging and frustrating endeavour. Dyslexia, a

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neurodevelopmental disorder that affects reading, spelling, and writing, can hinder a child's academic progress and undermine their self-confidence. Fortunately, the rapid advancements in mobile assistive technology have opened new doors for dyslexic children, offering them innovative tools and strategies to overcome the obstacles they face as stated by Wai *et al.,* [1]. The purpose of this significant review is to delve deep into the realm of mobile assistive technology and its transformative impact on the lives of dyslexic children. By examining the latest innovations and applications, the review explores how these technological solutions can unlock their potential and help them thrive in the classroom and beyond.

Before we embark on this journey into the world of mobile assistive technology, it is essential to grasp the profound challenges faced by children with dyslexia. Dyslexia is not simply a matter of reversing letters or struggling with reading; it is a complex neurological condition that affects various aspects of language processing. Dyslexic individuals often experience difficulties in decoding words, recognizing phonemes, and spelling accurately specified by Zain and Murni Mahmud [2]. These challenges can lead to difficulties in comprehension, slower reading speeds, and an overall sense of frustration when trying to engage with written material. The impact of dyslexia extends beyond the classroom, affecting self-esteem and self-worth. Children with dyslexia often feel isolated and stigmatized, which can hinder their social and emotional development as mentioned by Abd Rauf *et al.,* [3]. Their potential for success is often underestimated, and they may internalize a sense of inferiority. However, it is essential to recognize that dyslexia is not related to intelligence; dyslexic individuals are often highly creative and possess a wide range of talents waiting to be unlocked.

The past two decades have seen an unprecedented proliferation of mobile technology, with smartphones and tablets becoming ubiquitous in our daily live addressed by Dawson *et al.,* [4]. These devices have become powerful tools that connect people, offer entertainment, and enhance productivity. In the realm of education, they have the potential to be transformative, providing personalized and accessible learning experiences for all students, including those with dyslexia. The dynamic nature of mobile technology means that assistive tools can be regularly updated, improved, and customized to meet the specific needs of dyslexic children. Developers have recognized the opportunity to create innovative solutions that harness the strengths of mobile devices, such as touchscreens, voice recognition, and multimedia capabilities, to assist children with dyslexia in ways never before possible as implied by Bigueras [5]. Mobile assistive technology for dyslexic children holds great promise. It can provide personalized support and empower these students to reach their full potential. The features and applications available on smartphones and tablets can address the various challenges dyslexic individuals face, including difficulties with reading, writing, organization, and concentration as described by Rajagopal [6].

This paper strives to achieve several significant objectives: (i) To conduct a comprehensive review of the existing literature on the utilization of mobile assistive technology for dyslexic children, with a focus on its application and efficacy in enhancing reading, writing, and language skills, (ii) To explore the potential benefits of mobile assistive technology in the context of empowering dyslexic children, offering insights into their improved academic performance, increased self-confidence, and enhanced overall quality of life, (iii) To identify the impediments and barriers to the integration and adoption of mobile assistive technology within educational settings for dyslexic children, (iv) To analyze the broader implications of mobile assistive technology for dyslexic children, not only in terms of educational outcomes but also in relation to societal inclusion, equity, and overall well-being, (v) To provide evidence-based insights and recommendations for educators, policymakers, and stakeholders to support dyslexic children by harnessing the potential of mobile assistive technology in their educational journey.

As we embark on this exploration of mobile assistive technology for dyslexic children, we will delve into specific applications and devices, highlight success stories, and assess the gap and evolving landscape of mobile assistive technology. By the end of this significant review, it is our hope that readers will gain a comprehensive understanding of the potential of mobile technology to empower dyslexic children and bridge the gap to a brighter future filled with success and confidence.

2. Background

Dyslexia is a prevalent neurodevelopmental disorder that affects the acquisition of reading, spelling, and writing skills, impacting an estimated 5-10% of the population worldwide. Dyslexic children often face substantial challenges in their academic and daily lives, hindering their educational progress and self-esteem as defined by Snowling *et al.*, [7]. The integration of mobile assistive technology into the educational landscape holds significant promise for addressing the unique needs of dyslexic children. However, despite the increasing availability of such technology, there is a need for a comprehensive review to understand the current state of mobile assistive technology for dyslexic children, its effectiveness, and the barriers to its implementation as discussed by Novia [8].While traditional paper-based interventions and individualized support systems have demonstrated some effectiveness, the limitations of such approaches necessitate a shift towards more accessible, adaptable, and personalized solutions. Mobile assistive technology, including applications, tablet devices, and augmented reality tools, offers a dynamic platform for enhancing the learning experience of dyslexic children as described by Abdul Samad [9]. These technologies can provide real-time feedback, personalization, and accessibility features that may better cater to their individual needs and learning styles as written by MacUlada *et al.*, [10].

Despite the increasing interest in mobile assistive technology for dyslexic children, there is a scarcity of comprehensive research that critically evaluates the current landscape. This knowledge gap necessitates the exploration of the following key issues: (i) Mobile applications for dyslexia support: To what extent do mobile applications improve reading, writing, and spelling skills in dyslexic children? What evidence-based practices are available?, (ii) Multisensory and multilingual approaches for dyslexia support: To what extent do multisensory and multilingual approaches improve reading, writing, and spelling skills in dyslexic children? What evidence-based practices are available?, (iii) Individualized learning for dyslexia support: To what extent do individualized learning improve reading, writing, and spelling skills in dyslexic children? What evidence-based practices are available?, (iv) Intervention and stakeholders perspectives: What are the attitudes and experiences of the stakeholders (dyslexic children, their parents, and educators) regarding the interventions applied to support dyslexic children such as mobile applications, multisensory and multilingual approaches and individualized learning? How can technology be designed to maximize user engagement and satisfaction? Understanding these key issues is crucial to guide the development, implementation, and further research on mobile assistive technology for dyslexic children. This significant review aims to consolidate the current state of knowledge in this field, ultimately contributing to more effective and inclusive educational strategies for dyslexic children.

3. Literature Review

Dyslexia, a language learning disorder, poses formidable challenges to children in developing their reading, spelling, and writing skills, despite having the cognitive capacity for these tasks. This literature review delves into a range of innovative studies and mobile applications dedicated to addressing dyslexia and related learning disabilities in children. These endeavours emphasize early

identification, multisensory techniques, and the transformative power of technology, ultimately improving learning outcomes and the quality of life for dyslexic children.

The 'Dyslexia Baca' mobile application is an exemplary tool that aims to help dyslexic children recognize and distinguish specific letters while making alphabet recognition engaging as stated by Daud and Abas [11]. Developed in the Malay language, this application incorporates a multisensory approach, creating a suitable learning environment for dyslexic children. It was lauded by multimedia experts, who conducted a heuristic evaluation, noting its well-designed nature and user-friendliness. Recognizing that dyslexic children often grapple with reading comprehension due to orthographic decoding demands and limited working memory capacity, the 'Auto Train Brain' mobile app was developed as mentioned by Eroglu [12] Utilizing neurofeedback and multisensory learning techniques, it seeks to enhance various reading abilities in children with dyslexia. A clinical study comparing the cognitive improvements in children using this app to those receiving traditional dyslexia training demonstrated notable enhancements in reading comprehension, phonemic awareness, and nonword spelling, challenging the conventions of special education.

In the realm of technology and learning, the study by MacUlada *et al*., [10] combines mobile development with virtual reality to create an Android-based, speech-controlled game designed to assist children with phonological dyslexia. Employing the Orton-Gillingham multisensory approach, this study found a significant average improvement in phonological awareness, underscoring the potential of virtual reality as an alternative platform to traditional learning. The study by Rupasinghe *et al.*, [13] recognizes the fundamental role of language in human communication and explores the use of mobile games as an alternative to traditional interventions, especially in regions with limited access to specialized treatment centers. Supported by expert interviews, observations, and literature findings, the study proposes mobile games as a promising means of intervention, shedding light on the potential of mobile technology in making interventions more accessible.

With learning disabilities, including dyslexia, often being overlooked due to a lack of awareness and limited access to appropriate medical care, the 'Helply' interactive and collaborative mobile application created by Muthumal *et al.*, [14] is introduced to help children enhance various skills while reducing dyslexic disorders. This application utilizes a robotic-based simulation with the NAO Robot for voice and image recognition, effectively targeting specific disorders and achieving high training accuracy. Early identification of dyslexia is crucial for effective treatment, and the 'DYPA' mobile application developed by Zhong *et al.*, [15], efficiently pre-screens Chinese children for dyslexia, addressing the lack of specialists and the high cost of diagnosis. This app collects data through interactive reading and writing tests, employing machine learning for comprehensive cognitive-linguistic analysis, and trials have validated its high predictive accuracy, sensitivity, and specificity.

In conclusion, these studies and applications collectively underscore the significance of early identification and intervention in addressing dyslexia and related learning disabilities in children. They showcase the immense potential of technology, innovative approaches, and multisensory methods in aiding children in overcoming language-related challenges. This ongoing effort continues to elevate the quality of education and support available to children with dyslexia and related learning disabilities, ultimately enhancing their learning outcomes and overall quality of life, demonstrating the transformative power of technology in reshaping the landscape of dyslexia interventions and special education.

4. Methodology

4.1 Identification

This study used PRISMA approach. The systematic review process consists of three basic phases

that were used to choose many relevant papers for this study. The first phase entails the identification of keywords and the search for associated, related terms using thesaurus, dictionaries, encyclopaedias, and prior research. Following the selection of all pertinent terms, search strings on the Scopus, Web of Science and ERIC databases (see Table 1) have been developed. The current study project was able to successfully obtain 36 papers from these databases during the first stage of the systematic review process.

Table 1
Identification of keywords

Scopus	TITLE-ABS-KEY (("mobile learning" OR "mobile technology" OR "mobile application") AND dyslexi*) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023))
WOS	("mobile learning" OR "mobile technology" OR "mobile application") AND dyslexi*****(Title) and Article (Document Types)
ERIC	("mobile learning" OR "mobile technology" OR "mobile application") AND dyslexia

4.2 Screening

Duplicate papers were eliminated during the first screening stage. Scholarly inclusion and exclusion criteria were used to assess 36 papers after the first phase of the study rejected 101 publications. The literature, including research articles, was the main focus. Furthermore, only English-language publications were included in the review. It is important to remember that the five year period between 2019 and 2023 is covered by this plan. 65 publications in total were disqualified according to these particular standards.

4.3 Eligibility

A total of seventeen articles have been prepared for the third step, which is called eligibility. At this point, the titles and important content of every article were carefully examined to make sure that the inclusion criteria were met and that the articles fit into the current study and its goals. As a result, three articles were disregarded since they did not constitute pure science articles supported by empirical data. Lastly, Table 2 indicates that 13 articles are available for review.

Table 2
The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2019 – 2023	< 2019
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Subject Area	Education, Computer and Education as well Special Needs Education	Besides Education, Computer and Education as well as Special Needs Education

4.4 Data Abstraction and Analysis

In this research, an integrative analysis method was applied as one of the evaluation techniques to scrutinize and integrate a variety of research designs, encompassing quantitative, qualitative, and mixed methods. The primary aim of the expert evaluation was to pinpoint pertinent subjects and

subtopics. The initial phase of theme development commenced with the collection of data. As depicted in Figure 1, the authors conducted a meticulous examination of 13 publications, searching for statements and content that pertained to the subjects under investigation. In the subsequent stage, the authors delved into the exploration of mobile technology's role in dyslexia intervention while identifying and establishing meaningful categories. Two central themes emerged from this process, focusing on detection and the impact of classification. The authors then continued to elaborate on each established subject, along with any associated themes, concepts, or ideas. Collaborating with co-authors, the writer worked to craft themes based on the evidence within the scope of this research. During the data analysis phase, a log was maintained to document analyses, perspectives, inquiries, or any other insights relevant to data interpretation. Ultimately, the authors conducted a comparative analysis of the results to identify any incongruities in the theme development process. It's important to note that any disparities in concepts were addressed through internal discussions among the authors. The resulting themes were subsequently refined to ensure their consistency. In order to validate the findings, experts with expertise in special needs education and educational technology conducted the analysis. This expert review phase, aimed at establishing domain validity, served to confirm the clarity, significance, and appropriateness of each sub-theme. Based on feedback and professional assessments, the writer made necessary adjustments to their judgments.

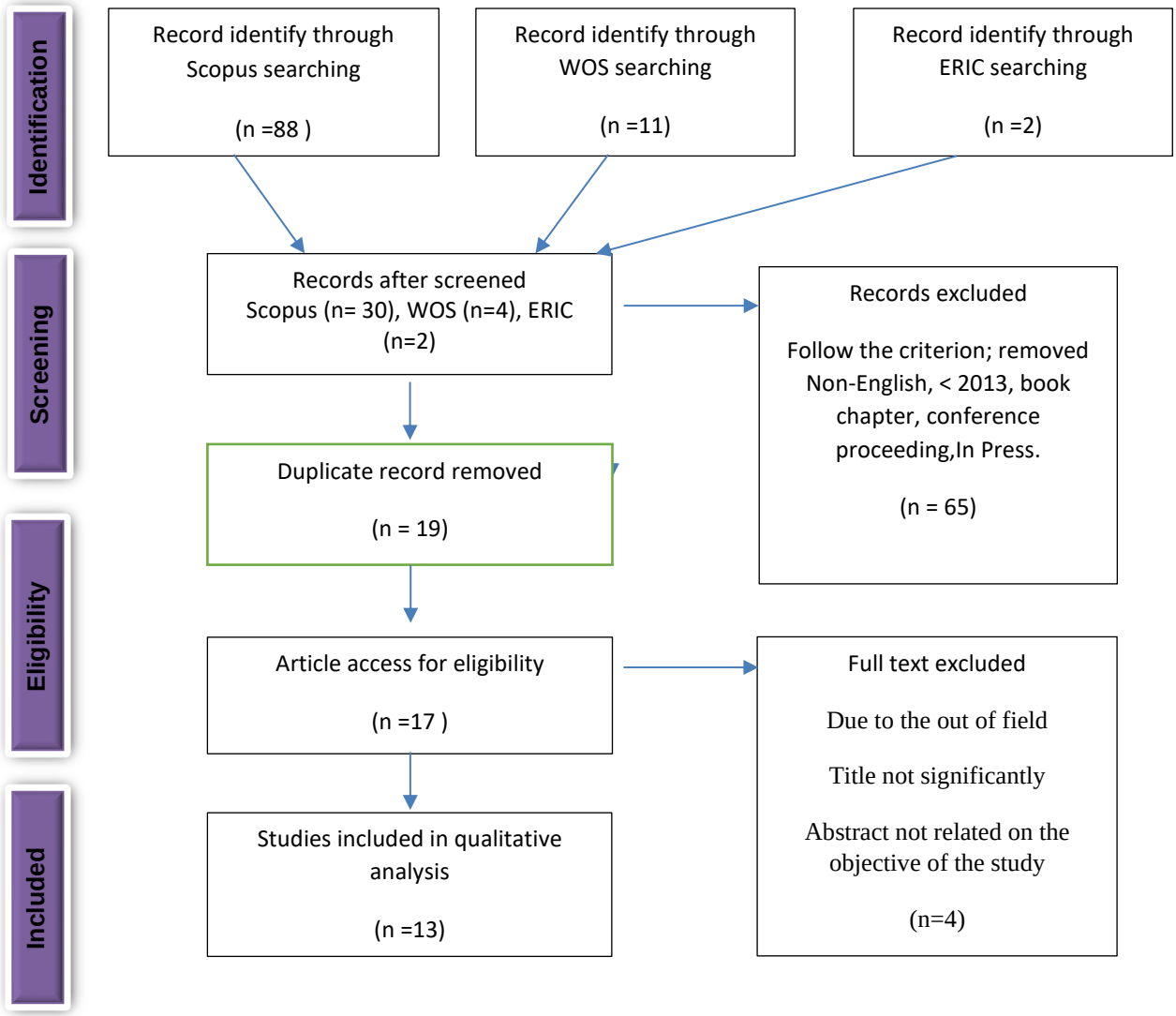

Fig. 1. Flow diagram of the proposed searching study as described by Moher *et al.*, [16]

5. Results and Finding

Mobile assistive technology offers substantial potential for enhancing the growth of diverse skills due to their widespread availability and ease of access. Consequently, many experts and families have integrated these tools into educational and therapeutic approaches for children with dyslexia. Considering the distinct needs of this group, conducting a thorough evaluation of these technology becomes crucial. The analysis revealed four themes based on the proposed searching criterion and have been validated by experts in the field. The themes are interconnected in 2 ways: (i) Theme 1-Mobile applications for dyslexia support, (ii) Theme 2- Multisensory and multilingual approaches for dyslexia support and (iii)Theme 3- Individualized learning for dyslexia support, explores the various intervention to support dyslexia children. On the other hand, Theme 4- Intervention and stakeholders perspectives explores how stakeholders perceive the intervention as explored in Theme 1-Mobile applications for dyslexia support, Theme 2-Multisensory and multilingual approaches for dyslexia support and Theme 3- Individualized learning for dyslexia support.

5.1 Mobile Applications for Dyslexia Support

Several of the titles revolve around the development, evaluation, and use of mobile applications specifically designed to support children with dyslexia. The titles are presented in Table 3 as depicted below:

Table 3
Mobile Applications for Dyslexia Support

Authors	Title	Year	Source title	Method	Findings
Lazo-Amado M.; Andrade-Arenas L.	"Designing a Mobile Application for Children with Dyslexia in Primary Education Using Augmented Reality"	2023	International Journal of Interactive Mobile Technologies	In the use of the methodology, Design Thinking is used to provide innovative ideas for children with dyslexia in such a way that it is divided into 5 stages (Empathize, Define, Ideate, Prototype and Testing), therefore, in these stages tools will be provided to develop the solution to the problem so that this section is completed.	The augmented reality mobile prototype will undergo validation from five experts, demonstrating a 91% acceptance rate. Its usefulness will be regularly assessed.
Eroğlu G.; Teber S.; Ertürk K.; Kırmızı M.; Ekici B.; Arman F.; Balcisoy S.; Özcan Y.Z.; Çetin M.	"A mobile app that uses neurofeedback and multi-sensory learning methods improves reading abilities in dyslexia: A pilot study"	2022	Applied Neuropsychology: Child	For thirty minutes, sixteen dyslexic children received 60 applications of Auto Train Brain. Fourteen dyslexic youngsters who continued their special education but did not receive remedial instruction using Auto Train Brain made up the control group.	A comparison of the pre- and post-TILLS test results showed that the experimental group's reading comprehension was statistically considerably better than the control group's when neurofeedback and multisensory learning techniques were applied.

Seiler A.; Leitão S.; Blosfelds M.	"WordDriver-1: evaluating the efficacy of an app-supported decoding intervention for children with reading impairment"	2019	International Journal of Language and Communication Disorders	Eight kids with chronic word-reading difficulties (ages 7:6–8:11) were randomised to either of two intervention sequences at random.	Based on researcher-developed non-word lists and standardised measures of accuracy and efficiency in non-word reading, the findings indicated that every participant had made significant progress in non-word reading.

5.2 Multisensory and Multilingual Approaches for Dyslexia Support

The following titles suggest a theme of adopting multisensory and multilingual approaches to cater to diverse learning needs among students with dyslexia. Table 4 indicates the titles:

Table 4
Multisensory and Multilingual Approaches for dyslexia support

Authors	Title	Year	Source title	Method	Findings
EL_Rahman S.A.	"A Game-Based Learning for Teaching Arabic Letters to Dyslexic and Deaf Children"	2021	Studies in Systems, Decision and Control	To aid in the child's letter learning, the system teaches the Arabic alphabet to them in a methodical, sequential fashion, beginning with the first letter and concluding with the last.	It makes learning and studying easier for kids with dyslexia and deaf kids by using an engaging interface and interactive games to create a positive learning environment.
Fung K.; Perrault S.T.; Lee L.; Fung K.; Song S.	"Can Students with Dyslexia Learn Independently? A Seven-Week Study of Chinese Character Learning in an Informal Learning Environment"	2022	IEEE Transactions on Learning Technologies	Students first pick up new Chinese characters. Students then work to retain the Chinese characters they have learned. At last, the students are able to recall the Chinese characters they have learned.	Learning with the three-condition design resulted in a notable improvement in dyslexic students.
Hu X.; Liu Y.	"Chinese Online Language Dissemination from the Perspective of Mobile Information System"	2022	Mobile Information Systems	Using them as examples, the study looks at how dyslexic students use online neologisms to address problems.	The findings indicate that while 30% of students do not understand new words found on the Internet, 50% of students can accept them very well.
Zhong S.; Song S.; Tang T.; Nie F.; Zhou X.; Zhao Y.; Zhao Y.; Sin K.F.; Chan S.-H.G.	"DYPA: A Machine Learning Dyslexia Pre-screening Mobile Application for Chinese Children"	2023	Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies	DYPA uses machine learning to gather multimodal data from kids and conduct a thorough analysis of their cognitive-linguistic abilities.	Its excellent specificity (82.71%), sensitivity (74.27%), and predictive accuracy (81.14%) have been validated by numerous trials involving over 200 students in Hong Kong.

Aborokbah M.	"Using augmented reality to support children with dyslexia"	2021	International Journal of Cloud Computing	The study defines the research problem and establishes what is needed to address dyslexia issues.	The product helps kids with dyslexia learn more and develop their foundational skills.
Cahyana; Hidayati H.; Sanjaya M.B.; Pangestu A.S.; Sundawa A.A.; Aritakalam	"Leady: A Multisensory Approach in Mobile Application for Dyslexic Children"	2021	CommIT Journal	Five dyslexia carers from a Bandung dyslexia school—teachers or parents—are shown Leady.	Everyone interviewed agreed that Leady can assist dyslexic students in learning to read. The majority of them concur that Leady's approach is appropriate for dyslexic students.
Tejero P.; Pi-Ruano M.; Roca J.	"Better read it to me: Benefits of audio versions of variable message signs in drivers with dyslexia"	2020	Annals of Dyslexia	There were twenty adult dyslexics and twenty matched controls that took part. They had to categorize the messages that were posted along a fictitious route on VMS.	The findings demonstrated that in order for the dyslexic participants to correctly classify the message, they had to be closer to the VMS than the controls.

5.3 Individualized Learning for Dyslexia Support

The following titles as presented in Table 5 focus on personalized, individualized learning approaches for children with dyslexia:

Table 5
Individualized Learning for Dyslexia Support

Authors	Title	Year	Source title	Method	Findings
Burac M.A.P.; Dela Cruz J.	"Development and Usability Evaluation on Individualized Reading Enhancing Application for Dyslexia (IREAD): A Mobile Assistive Application"	2020	IOP Conference Series: Materials Science and Engineering	The usability questionnaire was completed by the ten participants who were special education teachers.	Based on the results of the study, the researcher can attest that Individualized Reading Enhancing Application for Dyslexia (IREAD), a mobile assistive application that can support dyslexic learners can be an alternative in teaching reading and writing lessons for learners with special needs. With the design considerations that specifically address the needs of the learners, it provides individualized learning which composes interesting and engaging activities.

5.4 Intervention and Stakeholders Perspectives

The following titles explore the perspective of stakeholders regarding the intervention provided to the dyslexic children. These titles are presented in Table 6:

Table 6
Intervention and Stakeholders Perspectives

Authors	Title	Year	Source title	Method	Findings
Lim W.W.; Yeo K.J.; Handayani L.	"The perception of special education teacher in teaching students with dyslexia"	2022	International Journal of Evaluation and Research in Education	Three participants from three primary schools participated in a semi-structured interview session as part of the Special Education Integration Programme (SEIP) Dyslexia Programme.	The results showed that because special education teachers lacked the necessary resources and effective teaching strategies, teaching dyslexic students was difficult for them.
Ariffin M.M.; Halim F.A.A.; Arshad N.I.; Mehat M.; Hashim A.S.	"Calculic kids© mobile app: The impact on educational effectiveness of dyscalculia children"	2019	International Journal of Innovative Technology and Exploring Engineering	A quasi-experimental study utilizing pre- and post-tests was conducted to evaluate Calculic Kids©' efficacy.	It was observed that the Calculic Kids© is useful and might be implemented in Malaysian classrooms to help children with dyscalculia perform better.

6. Discussion

6.1 Mobile Applications for Dyslexia Support

The discussed papers collectively enhance our understanding of mobile applications for children with dyslexia, addressing various aspects of development and effectiveness. (Lazo-Amado and Andrade-Arenas 2023) [17] utilized design thinking and augmented reality in their app creation, emphasizing collaboration and user-centred design, with parental involvement for issue identification. They stressed the significance of technology tools, particularly augmented reality, in providing an interactive learning experience. Iterative improvement through user feedback and usability testing was deemed essential. Eroglu [12] conducted a pilot study on the Auto Train Brain app, featuring neurofeedback and multi-sensory learning. They found that traditional special education improved phonemic and vocabulary awareness but not reading comprehension. The Auto Train Brain app led to significant improvements in reading comprehension, underlining the potential value of such apps in dyslexia interventions. Seiler *et al.*, [18] explored app-supported decoding interventions for word-reading impairment, showing significant gains in non-word reading accuracy and efficiency. While improvements in other word-reading skills were less consistent, this approach seemed efficient, especially for individuals who had not responded to prior interventions. However, challenges in generalizing improvements were noted, emphasizing the need for tailored interventions and long-term studies.

In summary, the discussed studies collectively contribute to our understanding of mobile applications for dyslexia by showcasing diverse methodologies, emphasizing collaboration, user-centred design, neurofeedback, and multisensory learning. While each study brings valuable insights, the challenges and opportunities identified underscore the evolving nature of dyslexia interventions through technology. These findings emphasize the importance of continuous improvement, tailored interventions, and the necessity for long-term studies to fully comprehend the impact of mobile applications on dyslexia interventions.

6.2 Multisensory and Multilingual Approaches for Dyslexia Support

The discussed studies emphasize the importance of employing multisensory and multilingual approaches to meet the varied learning needs of students with dyslexia. These approaches leverage technology and innovative methods to create more inclusive and effective learning environments. El Rahman [19] illustrates how technology can provide a multisensory approach to teaching Arabic letters to dyslexic and hearing-impaired children, offering an engaging and interactive learning experience with multilingual support. This adaptable approach can be applied to different languages and alphabets, benefiting diverse student populations. Fung *et al.*, [20] demonstrates the effectiveness of independent learning with a multisensory approach in Chinese character learning, accommodating different learning styles and needs for students with dyslexia. Hu and Liu [21] recognizes the multicultural and multilingual aspects of learning and how technology and mobile information systems can bridge linguistic and cultural gaps. It highlights the need to consider language diversity when developing educational technology. Zhong *et al.*, [15] underscores the role of machine learning in early dyslexia detection, adaptable for various languages, making it more accessible and scalable, particularly in regions with a shortage of clinical specialists. Aborokbah [22] explores the potential of augmented reality to enhance the learning experiences of dyslexic children through multisensory, interactive learning scenarios, which can be adapted to various languages and educational settings. Cahaya *et al*., [23] focuses on the development of "Leady," a mobile application designed to aid dyslexic students in learning to read. Employing a multisensory approach, it provides early intervention for dyslexic learners and incorporates design features tailored to their specific needs. Feedback from dyslexia caretakers indicates that Leady is well-received and effective in assisting dyslexic students in learning to read. Tejero *et.al,* [24] concentrates on adults with dyslexia and their difficulties in reading variable message signs (VMS) while driving. The study conducted a driving simulation experiment to assess the advantages of offering complementary audio versions of VMS to drivers with dyslexia. Results indicate that audio versions of VMS significantly assist dyslexic drivers in correctly interpreting messages and enhance overall driving performance. Additionally, the study mentions the development of the "READit VMS" mobile application as an example of technology designed to provide real-time audio versions of VMS. In summary, these studies underscore the significance of individualized learning approaches for individuals with dyslexia, highlighting the potential of technology and innovative methods to improve their educational experiences and address specific learning challenges.

In conclusion, these studies collectively stress the significance of employing multisensory and multilingual approaches to meet the diverse needs of students with dyslexia and related learning challenges. By incorporating technology, innovative methodologies, and customized educational tools, educators and researchers can better address the specific learning requirements of diverse student populations, enhancing their academic performance and overall educational experience. This underscores the importance of inclusivity and accessibility in education, ensuring that every child, regardless of their learning profile, has the opportunity to thrive.

6.3 Individualized learning for Dyslexia Support

The mentioned studies all emphasize individualized learning approaches for children with dyslexia, offering innovative methods and technologies tailored to their unique educational requirements. Burac and Dela Cruz [25] discusses IREAD, a mobile application utilizing text-to-speech technology to enhance reading skills for dyslexic learners. The study found that IREAD's usability was

highly positive, indicating its potential to significantly enhance the learning experience for dyslexic students.

In summary, the paragraph highlights the commitment of the study to personalized learning approaches, and the specific case of IREAD exemplifies how technology, in this instance, text-to-speech functionality, can be harnessed to enhance the reading skills and overall learning experience for children with dyslexia. This approach signifies a tailored and adaptive methodology that holds promise in addressing the unique challenges faced by individuals with dyslexia in their educational journey.

6.4 Intervention and Stakeholders Perspectives

These studies collectively examine various aspects of special education and stakeholder perspectives, with a primary focus on innovative approaches and technology to address the needs of students with dyslexia and related learning difficulties. The study by Lim *et al.*, [1] highlights the essential role of special education teachers in assisting dyslexic students in overcoming language learning challenges. The study suggests the adoption of multisensory approaches and mobile learning applications to enhance language instruction for these students. The study conducted by Mohd Ariffin *et al*., [26] focuses on the effectiveness of a mobile app designed for Dyscalculia children, who struggle with math and numbers. The stakeholders agreed that the app has the potential to improve the performance of Dyscalculia children in Malaysia.

In summary, the paragraph emphasizes the broader landscape of special education and the perspectives of stakeholders, giving attention to the essential role of educators and the promising impact of technology in addressing the diverse challenges faced by students with dyslexia and related learning difficulties. The studies presented reflect a commitment to innovative approaches that acknowledge the importance of both personalized instruction and technological interventions to enhance the educational experiences of these students.

7. Conclusions

In examining the diverse facets of dyslexia interventions through technology, the discussed studies collectively illuminate the evolving landscape and underscore the multifaceted nature of addressing the unique needs of students with dyslexia. First of all, some studies reveal various mobile applications while emphasizing collaboration, user-centred design, and iterative improvement, providing valuable insights into creating effective and engaging dyslexia interventions via mobile applications. The findings not only highlight the potential value of apps like Auto Train Brain in enhancing reading comprehension but also bring attention to the challenges and opportunities inherent in this dynamic field. Continuous improvement, tailored interventions, and the necessity for long-term studies emerge as key considerations for the future of dyslexia interventions through mobile applications.

In addition, the importance of multisensory and multilingual approaches is also underscored. These studies leverage technology to create inclusive learning environments, providing engaging and interactive experiences. The adaptable nature of these approaches, as demonstrated in teaching Arabic letters, Chinese character learning, and augmented reality interventions, signifies their potential to benefit diverse student populations. The studies recognize the need to consider language diversity in educational technology, and the role of machine learning in early dyslexia detection opens avenues for accessibility in regions with limited clinical resources.

Moreover, there was a study which exemplified a commitment to personalized learning approaches for dyslexic learners. The positive usability findings indicate the potential of text-to-speech technology to significantly enhance the reading skills and overall learning experience for children with dyslexia. This approach reflects a tailored and adaptive methodology, holding promise in addressing the unique challenges faced by individuals in their educational journey.

Finally, the papers also explores special education and stakeholder perspectives, emphasizing the pivotal role of educators and the promising impact of technology. Multisensory approaches and mobile learning applications emerge as valuable tools to overcome language learning challenges. For example, the effectiveness of a mobile app for dyscalculia children, acknowledged by stakeholders, further underscores the potential of technology to enhance the performance of students with specific learning difficulties.

In conclusion, these studies collectively advocate for the significance of employing diverse and tailored approaches to meet the diverse needs of students with dyslexia. The incorporation of technology, innovative methodologies, and customized educational tools enables educators and researchers to better address the specific learning requirements of diverse student populations, enhancing their academic performance and overall educational experience. This underscores the importance of inclusivity and accessibility in education, ensuring that every child, regardless of their learning profile, has the opportunity to thrive in an inclusive learning environment.

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