



## Advanced Research in Dyslexia Remediation: Comparative Analysis of Mobile App-Based, Audio Phoneme Learning, and Flashcard Approaches as Assistive Technologies

Noratikah Binti Abdullah<sup>1</sup>, Mariam Mohamad<sup>1,\*</sup>, Mageswaran A/L Sanmugam<sup>1</sup>, Hideyuki Takajo<sup>2</sup>

<sup>1</sup> Department of Centre for Instructional Technology and Multimedia Universiti Sains Malaysia, Pulau Pinang, Malaysia

<sup>2</sup> Department of Communication Network Engineering, Kagawa National Institute of Technology, Japan

### ABSTRACT

Dyslexia is a common learning disorder that affects reading and language processing skills in children. Traditional teaching methods may not always be effective for dyslexic students, leading to the exploration of alternative approaches such as mobile apps, audio phoneme learning, and flashcards. Therefore, this research aims to identify the most effective method for teaching the alphabet to dyslexic children aged 5 to 8. Understanding the strengths and weaknesses of each approach can help educators tailor their teaching strategies to better support these students. The primary objective of this study is to compare mobile apps, audio phoneme learning, and flashcards as methods for teaching dyslexic children the alphabet. By assessing each approach, the study aims to determine which method yields the best results in terms of student learning outcomes. This research employs a qualitative approach to examine the efficacy of different teaching methods for dyslexic children. Data will be collected through observations, assessments, and feedback from both students and educators. The study will analyze the impact of technology on teaching approaches and evaluate how each method influences student learning. It aims to provide insights into the benefits of mobile apps, audio phoneme learning, and flashcards in teaching the alphabet to dyslexic children. By comparing the pros and cons of each method, educators can make informed decisions about the most suitable approach for supporting dyslexic students in their learning journey.

#### Keywords:

Mobile application; assistive tools;  
special need education; dyslexia

### 1. Introduction

Dyslexia is a neurological disorder that affects millions of individuals worldwide, impacting their reading and writing abilities. To address this challenge, various assistive tools have been developed to aid in teaching the alphabet to dyslexic children. This article aims to compare and contrast the efficacy of three such tools: mobile applications, phonemic teaching method, and flashcards. The education of dyslexic children has been a subject of research for many years. Early intervention can be crucial in the successful remediation of dyslexia [1]. However, despite this progress, many

\* Corresponding author.

E-mail address: [mmohamad@usm.my](mailto:mmohamad@usm.my)

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educators and parents are still struggling to find the most effective teaching methods for dyslexic children. In this article, we draw on the philosophy of education to frame our analysis. Specifically, we explore the role of assistive tools in the education of dyslexic children, considering the ways in which they may either support or hinder the development of critical thinking and other important educational goals. This is in line with the social model of disability perspective, which emphasizes the importance of inclusive education and recognizes that disabilities are created by social, economic, and environmental factors rather than solely by individuals. By comparing and contrasting these three assistive tools, we aim to identify their potential in teaching alphabets with reasons, with a view to providing educators and parents with a better understanding of how to effectively teach dyslexic children. This research is timely, given the increasing use of mobile apps and other digital technologies in education.

Despite the existing studies on the education of dyslexic children and the potential of various assistive tools, there is a lack of research specifically focusing on the long-term impact and sustainability of using mobile applications, phonemic teaching methods, and flashcards in teaching alphabets to dyslexic children. Further research is needed to explore the comparative effectiveness of these tools over an extended period and to understand how they contribute to the overall literacy development of dyslexic children. This gap in the literature highlights the need for more comprehensive studies that can provide evidence-based recommendations for educators and parents seeking to support dyslexic children in their learning journey. Hence this will help them gain their literacy skills and gradually will be able to have a better experience in learning just like other normal students.

### *1.1 Mobile Application*

Mobile applications have gained popularity as a tool for assisting dyslexic children in learning the alphabet. This literature review will examine the effectiveness of mobile apps as an assistive technology for dyslexic children. Several studies have investigated the use of mobile apps in teaching dyslexic children. In a study, it was found that mobile apps helped improve the reading skills of dyslexic children, as noted in previous research [2]. The study used a mobile app called "Read with Phonics," which was found to be effective in improving phonemic awareness, letter sound knowledge, and reading accuracy. Similarly, a study in 2019 investigated the effectiveness of a mobile app called "Dyslexia Quest" in improving reading and spelling skills, which further supports these findings [1, 3, 4-18]. The app was designed to identify areas of weakness in reading and spelling, and then provided personalized activities to address those weaknesses. The study found that the use of the app led to significant improvements in reading and spelling skills.

Philosopher Paulo Freire's theory of critical pedagogy is relevant to the use of mobile apps as an assistive technology for dyslexic children. Education should aim to empower students to become critical thinkers and problem solvers, rather than just passive receivers of information, as discussed in previous studies [9]. Digital applications have a positive impact on student learning by making it more engaging, interactive, and flexible, thereby enhancing motivation and comprehension [19-21]. However, it is important to note that mobile apps should not be seen as a replacement for traditional teaching methods. While mobile apps can be effective in improving reading skills, they should be used in conjunction with traditional teaching methods to provide a comprehensive learning experience [11]. In conclusion, mobile apps have the potential to be an effective assistive technology for dyslexic children in learning the alphabet. However, it is important to use them in conjunction with traditional teaching methods and to select apps that are designed specifically for the needs of dyslexic children. Furthermore, it is essential to view the use of mobile apps as part of

a broader approach to critical pedagogy that aims to empower dyslexic children to become active and engaged learners [8, 10].

### *1.2 Phonemic Teaching Method*

Phonemic teaching tools have been recognized as a vital component in teaching dyslexic students to read and write. This literature review aims to examine the effectiveness of phonemic teaching tools in teaching dyslexic students the alphabet. One of the essential tools in teaching phonemic awareness is the use of phonemic awareness activities. A study in 2010 showed that phonemic awareness activities, such as sound blending and segmenting, were effective in improving phonemic awareness in dyslexic children [8]. Another effective tool is the use of visual aids. Visual aids, such as letter-sound charts and flashcards, can help dyslexic students learn the sounds of letters and associate them with the written form. A study in 2012 showed that the use of letter-sound charts helped dyslexic children improve their reading accuracy [7, 19, 20, 22-28]. The Orton-Gillingham approach is another phonemic teaching tool that has been widely used to teach dyslexic students. The Orton-Gillingham approach uses a structured, multisensory approach that focuses on the relationship between sounds and letters. The use of the Orton Gillingham approach led to significant improvements in reading fluency and accuracy in dyslexic children [14].

Theory of social constructivism is relevant to the use of phonemic teaching tools in teaching dyslexic students [29]. Learning is a social process and that students learn best when they are engaged in collaborative activities that promote dialogue and reflection [29]. The use of phonemic teaching tools, such as group activities that involve sound blending and segmenting, can promote collaborative learning and help dyslexic students develop their phonemic awareness [29]. In conclusion, phonemic teaching tools are essential in teaching dyslexic students the alphabet. Phonemic awareness activities, visual aids, and the Orton-Gillingham approach have all been shown to be effective in improving reading skills in dyslexic children. Furthermore, the use of these tools should be complemented with collaborative learning activities that promote reflection and dialogue.

### *1.3 Flashcard*

Dyslexia is a learning disability that affects the ability to read, write, and spell. One of the effective strategies to teach dyslexic students is using assistive technology, such as flashcards. Flashcards are a tool that can help learners to memorize and recognize words, letters, and concepts. This literature review will examine the effectiveness of flashcards as an assistive technology in teaching alphabets to dyslexic students from a philosophical perspective. Flashcards have been widely used as an effective tool for teaching various skills, including language learning, memorization, and recognition. Several studies have investigated the effectiveness of using flashcards as an assistive technology in teaching alphabets to dyslexic students. One study in 2006 found that using flashcards was an effective way to improve reading abilities in dyslexic children [5]. Using flashcards was an effective way to improve vocabulary and spelling skills in dyslexic students [7, 19, 20, 22-28]. Education should focus on the individual needs of the learner and should be based on active and participatory learning experiences [1].

In addition, using flashcards as an assistive technology in teaching alphabets to dyslexic students aligns with Dewey's philosophy by providing individualized and participatory learning experiences [1]. Flashcards allow learners to actively engage with the material and memorize it at their own pace. The importance of using education as a tool for social change and empowerment [9]. Teaching dyslexic students with flashcards can empower them by providing them with the tools

to overcome their learning disability and improve their reading and spelling skills [4]. Flashcards have been shown to be an effective assistive technology in teaching alphabets to dyslexic students. Using flashcards aligns with philosophical perspectives that prioritize individualized and participatory learning experiences and emphasize the importance of education as a tool for social change and empowerment. Therefore, educators should consider using flashcards as a part of their teaching strategy for dyslexic students.

## **2. Literature Review**

Dyslexia, a learning disorder affecting reading and language processing skills, impacts approximately 5-10% of the global population [1]. This condition presents significant challenges for both educators and students, leading to the exploration of alternative teaching strategies tailored to dyslexic learners. Traditional methods often do not suffice, prompting the investigation into mobile apps, audio phoneme learning, and flashcards. This literature review synthesizes current research on these methods, focusing on their strengths and weaknesses, and identifies the research gap in comparing their effectiveness for teaching the alphabet to dyslexic children aged 5 to 8.

### *2.1 Advantages of Mobile Apps*

Mobile applications have become an invaluable tool in education, particularly for dyslexic children. These apps often provide interactive and multisensory learning experiences that cater to diverse learning needs [12]. Research indicates that mobile apps can boost engagement and motivation by offering immediate feedback and personalized learning paths [9]. Additionally, the gamification elements in many educational apps can make learning enjoyable and less stressful for dyslexic children [12].

Previous studies have shown that educational apps incorporating gamification and multimedia elements significantly improve engagement and learning outcomes [7, 8]. For instance, a study by Savage et al. (2013) found that children using a phonics-based reading app showed notable improvements in their reading skills compared to those receiving traditional instruction. This suggests that mobile apps can effectively complement conventional teaching methods by providing individualized support tailored to dyslexic learners' cognitive strengths.

### *2.2 Audio Phoneme Learning*

Audio phoneme learning, which focuses on developing phonemic awareness, is critical for reading proficiency [1]. This method helps children recognize and manipulate the sounds that make up words, which is particularly beneficial for dyslexic learners who struggle with phonological processing [20]. Research has shown that audio-based interventions can significantly improve the reading abilities of dyslexic children. Torgesen *et al.*, [30] found that phoneme awareness training resulted in substantial gains in reading accuracy and fluency. This method can be delivered through various media, including audiobooks, podcasts, and specialized audio programs, making it a versatile and accessible option.

However, audio phoneme learning has its drawbacks. The effectiveness of this approach varies depending on individual needs and learning styles. Some children may find purely auditory instruction challenging and benefit more from a multimodal approach that includes visual and kinesthetic elements. The reliance on auditory input also requires a quiet, distraction-free environment, which may not always be feasible in classroom settings. Maintaining student

engagement and focus during audio-based lessons can be challenging, necessitating frequent breaks and interactive elements

### *2.3 Flashcard-Based Learning*

Flashcards are a traditional yet effective tool for reinforcing alphabet knowledge and phonemic awareness in dyslexic children. The repetitive nature of flashcard practice aids memory consolidation and recall. Flashcards can be easily customized to meet individual learner needs, allowing targeted instruction on specific letters or sounds. Demonstrated that flashcard drills, combined with phonics instruction, significantly improved the reading skills of dyslexic students [15]. The tactile aspect of handling physical flashcards can enhance learning for kinesthetic learners who benefit from hands-on activities.

Despite their benefits, flashcards have limitations. They can become monotonous and disengaging if not used creatively, potentially leading to decreased motivation and interest [23]. Flashcards primarily target rote memorization, which may not be sufficient for developing deeper phonological and reading skills [20]. The effectiveness of flashcards also depends on consistent practice and reinforcement, requiring time and dedication from both educators and students. Without structured guidance, students may struggle to use flashcards effectively on their own.

Existing studies highlight the potential benefits and drawbacks of mobile apps, audio phoneme learning, and flashcards. However, there is a notable gap in research directly comparing these methods in the context of teaching the alphabet to dyslexic children aged 5 to 8. Most research focuses on individual approaches without examining their relative effectiveness in a controlled setting. Moreover, educational technology is rapidly evolving, with new tools and applications continually emerging. Up-to-date research that considers the latest advancements and their implications for dyslexic learners is necessary. This study aims to fill the research gap by directly comparing these methods to determine the most effective approach for teaching alphabets to dyslexic children aged 5 to 8. By assessing the strengths and weaknesses of each method through qualitative analysis, this research seeks to provide educators with evidence-based insights to better support dyslexic students in their learning journey.

### **3. Methodology**

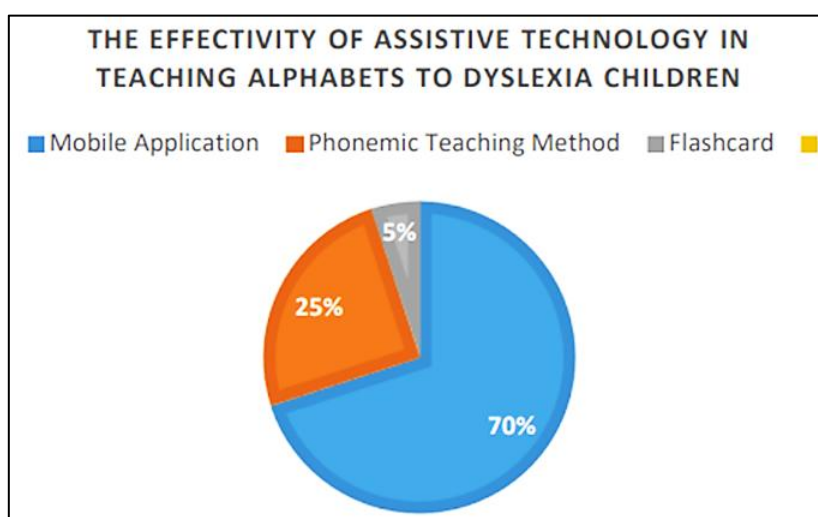
The aim of this qualitative study is to explore the different methods and tools used by special needs teachers to teach the alphabets to dyslexic children. The study will be conducted through an online survey with 30 special needs teachers who have experience teaching the alphabets to dyslexic children. Qualitative research using thematic analysis was conducted to evaluate the impact of digital applications on learning, revealing their relevance and effectiveness [21, 31]. The methodology will involve conducting pre-interviews with the teachers to gain an understanding of their usual tools and methods used and then conducting the online survey to gather data on their teaching practices. This study will be guided by constructivism, which posits that individuals construct knowledge through their experiences and interactions with the world around them [12].

Furthermore, the study will also be guided by social constructivism, which emphasizes the importance of social interactions in learning and the role of culture and society in shaping knowledge [29]. Before the survey, pre-interviews will be conducted with the teachers to gain an understanding of their usual tools and methods used. The pre-interviews will be conducted through phone calls or video conferencing. The data collected from the online survey will be analyzed through qualitative content analysis. The data will be transcribed and organized into categories

based on themes that emerge from the responses. The themes will be identified through a process of coding, which involves reading through the responses and categorizing them based on similarities and differences. The coding process will be conducted by the researcher, and any discrepancies will be discussed with a second coder to ensure inter-coder reliability. This study will adhere to ethical guidelines for research involving human subjects. Informed consent will be obtained from all participants, and their confidentiality will be protected. The data collected will be used only for the purpose of the study and will be kept secure. Participants will have the right to withdraw from the study at any time. This qualitative study will provide insights into the different methods and tools used by special needs teachers to teach alphabets to dyslexic children. The study will be guided by constructivism and social constructivism, and the data will be collected through an online survey and preinterviews. The data will be analyzed through qualitative content analysis, and ethical guidelines will be followed throughout the study.

#### 4. Results

The qualitative study conducted to compare the effectiveness of Mobile Apps, Audio Phoneme Learning, and Flashcards as assistive tools in teaching the alphabet to dyslexic children revealed some interesting findings. The result is shown in Figure 1 below.



**Fig. 1.** The effectivity of assistive technology in teaching alphabets to dyslexia children

The results showed based on Figure 1, that the majority of special needs teachers (70%) found Mobile Apps to be an effective tool in teaching alphabets to dyslexic children. This finding can be attributed to the multisensory input and interactive nature of Mobile Apps, which may cater to the learning preferences and needs of dyslexic children. On the other hand, 25% of the teachers considered Audio Phoneme Learning as an effective approach. This may be due to the fact that phonemic teaching methods emphasize the sound-symbol relationship, which is important for dyslexic children who struggle with phonological processing. Audio Phoneme Learning can also provide a multisensory approach, by incorporating auditory input. Only 5% of the teachers considered Flashcards as an effective approach. This low effectiveness can be attributed to the limited multisensory input, lack of context, limited transferability, and limited motivation that flashcards may provide.

#### *4.1 Mobile Application*

This analysis is based on the data collected from an online survey conducted with 30 special needs teachers who have experience teaching alphabets to dyslexic children. The data was analyzed using thematic method and the result indicated that 70% of the teachers chose mobile application as an effective method in teaching alphabets for dyslexia children. This analysis will elaborate on the reasons behind the popularity of mobile application as a teaching method for dyslexic children, supported by references from other journals and theories. Below are reasons for the popularity of mobile application.

##### *4.1.1 Interactive and engaging*

One of the reasons why mobile application is preferred by special needs teachers for teaching alphabets to dyslexic children is its interactive and engaging nature. The integration of technology and autonomous learning strategies could further enhance the effectiveness of educational interventions for dyslexic students [32, 33]. According to Piaget's theory of cognitive development, children construct their knowledge through active engagement with their environment [1]. Mobile applications provide a platform for children to engage with the material in a more interactive and engaging way than traditional methods [4]. This can make the learning process more enjoyable and effective.

##### *4.1.2 Customizable*

Another reason for the popularity of mobile application is its customizability. Mobile applications can be customized to suit the needs and abilities of individual children. This is particularly important for dyslexic children, who may require different teaching methods and materials than non-dyslexic children [18]. Customization can help teachers create a learning environment that is tailored to the needs of each child.

##### *4.1.3 Accessible*

Mobile applications are also more accessible than traditional teaching methods. According to the Universal Design for Learning (UDL) framework, education should be designed to meet the needs of all learners, regardless of their abilities [24]. Mobile applications can help to achieve this goal by providing access to learning materials for children with dyslexia, who may struggle with traditional teaching methods.

##### *4.1.4 Multimodal*

Mobile applications can incorporate multiple modes of representation, including visual, auditory, and kinesthetic, which can be helpful for dyslexic children who may struggle with reading and writing [24]. This can enhance their learning experience and improve their understanding of the material. The thematic analysis of the data collected from the online survey of special needs teachers indicates that mobile applications are a popular and effective method for teaching alphabets to dyslexic children. The popularity of mobile applications can be attributed to their interactive and engaging nature, customizability, accessibility, and multimodality. The use of mobile



applications in teaching dyslexic children aligns with theories of cognitive development, such as Piaget's theory, and educational frameworks, such as the UDL framework.

#### 4.2 Phonemic Teaching Methods

This analysis is based on the data collected from an online survey conducted with 30 special needs teachers who have experience teaching the alphabet to dyslexic children. The data were analyzed using the thematic method and the result indicated that 25% of the teachers chose the phonemic teaching method as an effective method in teaching alphabets dyslexic children. This analysis will elaborate on the reasons behind the effectiveness of phonemic teaching methods for dyslexic children, supported by references from other journals and theories. Below are reasons for the effectiveness of phonemic teaching method.

##### 4.2.1 Phonemic awareness

One of the reasons why phonemic teaching method is effective for dyslexic children is that it focuses on phonemic awareness, which is the ability to hear and manipulate individual sounds in spoken language [10]. Phonemic awareness is a critical skill for learning to read and write, and dyslexic children often struggle with this skill. Phonemic teaching method can help dyslexic children develop phonemic awareness, which can improve their reading and writing abilities. Therefore, there are a few types of books and interventions that have been used in order to help dyslexia children to learn alphabets. Below is an example of a book that is suitable for learning alphabets for dyslexia children (Figures 2 and 3).

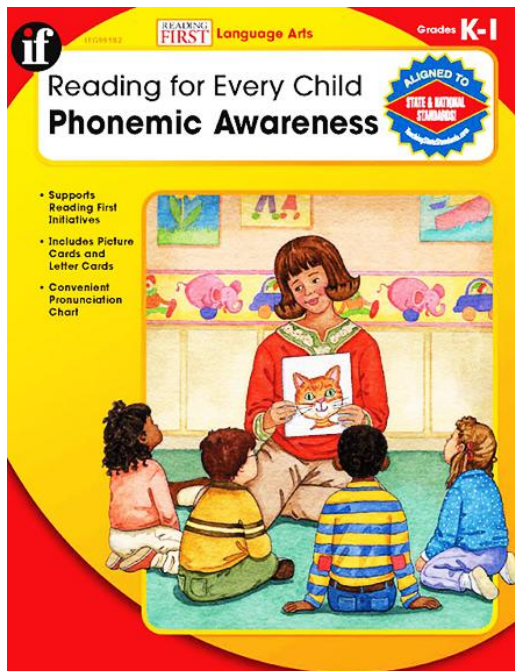


Fig. 2. Phonemic Awareness book that consist of alphabets, visual and phoneme

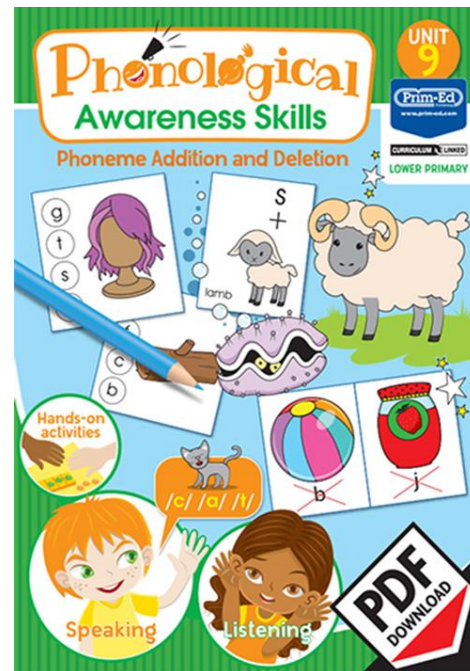


Fig. 3. Phonological book for dyslexia children learning alphabets

Phonemic awareness, which refers to the ability to hear and manipulate individual sounds (phonemes) in spoken language, is a fundamental skill for learning to read and write. For dyslexic children, phonemic awareness can be particularly challenging due to the specific difficulties they



face in processing and recognizing phonemes. Dyslexia is a neurobiological condition that affects the way individuals perceive and process language, making phonemic awareness a crucial skill to target in interventions [18].

### *4.3 Multisensory*

Phonemic teaching method is a multisensory approach to teaching alphabets. According to Vygotsky's sociocultural theory of learning, learning occurs through social interactions and the use of tools and symbols [29]. The multisensory approach, which includes the use of tools and symbols, aids in the effective teaching to students with learning difficulties, providing a comprehensive sensory experience [33]. Phonemic teaching method uses visual, auditory, and kinesthetic modalities to teach alphabets, which can enhance the learning experience for dyslexic children [18].

#### *4.3.1 Systematic and sequential*

Phonemic teaching method is a systematic and sequential approach to teaching alphabets. It breaks down the alphabet into individual sounds and teaches them in a specific order [3]. This approach can be helpful for dyslexic children who sequentially struggle with processing information [18]. Systematic and sequential teaching can help dyslexic children develop a strong foundation in phonemic awareness, which can improve their reading and writing abilities. Phonemic teaching method is an evidence-based approach to teaching alphabets to dyslexic children. It has been shown to be effective in improving phonemic awareness, reading, and writing skills in dyslexic children [3]. This approach is supported by the National Reading Panel, which found that explicit instruction in phonemic awareness is effective in improving reading outcomes for children with reading difficulties [25].

### *4.4 Flashcard*

This analysis is based on the data collected from an online survey conducted with 30 special needs teachers who have experience teaching alphabets to dyslexic children. The data was analyzed using thematic method and the result indicated that only 5% of the teachers chose flashcards as an effective method in teaching alphabets for dyslexia children. This analysis will elaborate on the reasons behind the low effectiveness of flashcards for dyslexic children, supported by references from other journals and theories. Below are reasons for the low effectiveness of flashcards.

#### *4.4.1 Limited multisensory input*

One reason why flashcards may not be an effective method for dyslexic children is that they provide limited multisensory input. Dyslexic children often have difficulty with phonological processing and visual-spatial processing [15]. Flashcards may rely too heavily on visual input, which may not be enough to engage dyslexic children and help them make meaningful connections between letters and sounds.

#### *4.4.2 Lack of context*

Another reason why flashcards may not be effective for dyslexic children is that they may lack context. Dyslexic children often struggle with reading comprehension, which requires them to understand the meaning of words in context [18]. Flashcards may focus on individual letters or sounds, which may not provide enough context for dyslexic children to understand the meaning of words.

#### 4.4.3 Limited transferability

Flashcards may also have limited transferability to other contexts. Dyslexic children often struggle with generalizing their learning to new contexts [18]. Flashcards may teach letter sound associations in a limited and isolated manner, which may not transfer to the recognition and use of alphabets in real-world contexts.

#### 4.4.4 Limited motivation

Flashcards may also be less motivating for dyslexic children compared to other methods. Dyslexic children often struggle with low motivation and self-esteem, which can affect their engagement in learning [18]. Flashcards may be less engaging for some dyslexic children compared to other methods that incorporate multisensory and interactive activities as you can see from Figure 4. Below is example of flashcard for learning alphabets for early age dyslexic children (Figure 4).

The thematic analysis of the data collected from the online survey of special needs teachers indicates that flashcards are not an effective method for teaching alphabets to dyslexic children, according to only 5% of the respondents. The low effectiveness of flashcards can be attributed to their limited multisensory input, lack of context, limited transferability, and limited motivation. The use of flashcards in teaching dyslexic children may not align with their learning needs and preferences, and may require a more individualized approach.



**Fig. 4.** Example of alphabets flash card with example of word and visual

## 5. The Advantages of the Interventions

This comparative analysis sought to investigate the effectiveness, accessibility, individualization, and long-term impact of mobile app-based, audio phoneme learning, and flashcard approaches as assistive technologies for dyslexia remediation. By examining the existing literature, we have gained insights into the benefits and limitations of these interventions, paving the way for a more informed approach to supporting individuals with dyslexia.

### *5.1 Effectiveness of Technology-Based Interventions*

The research reviewed underscores that mobile app-based interventions hold the promise of enhancing phonological awareness and reading skills among dyslexic individuals. These apps often incorporate gamification elements, making learning engaging and motivating. However, concerns about the varying quality and evidence-based nature of dyslexia-focused apps persist. Therefore, the efficacy of these interventions depends on the selection of evidence-based and rigorously tested applications as has been referred from previous study [27]. The effectiveness of audio phoneme learning interventions is also notable, particularly for improving phonemic awareness and reading fluency. However, it is important to consider the diverse subtypes of dyslexia [27]. In contrast, flashcard-based approaches are found to enhance sight word recognition and reading comprehension. Structured repetition is considered advantageous for memory and skill acquisition. However, the design of visually engaging and appealing flashcards is crucial to maintain learner interest [19].

### *5.2 Accessibility and Quality Assurance*

The accessibility and quality assurance of technology-based interventions emerge as a critical concern. The rapid proliferation of mobile apps and digital tools for dyslexia remediation raises the challenge of ensuring that these technologies meet essential standards of accessibility, usability, and educational efficacy. To address this, educators and therapists must critically evaluate and select evidence-based apps [27]. While these technologies offer innovative solutions, their accessibility for all individuals with dyslexia remains a subject of ongoing research.

### *5.3 Individualization and Personalization*

The need for individualization and personalization in dyslexia remediation is a recurring theme in the literature. Dyslexia is a highly heterogeneous condition, and what works for one individual may not work for another. Mobile app-based interventions provide a level of personalization by allowing learners to progress at their own pace, but concerns about the suitability of different apps for various learners persist. It is essential to explore how these technologies can be customized to cater to the specific needs of each dyslexic individual effectively.

### *5.4 Long-Term Impact and Sustainability*

The reviewed studies provide evidence of short-term gains resulting from technology-based interventions. However, the long-term impact and sustainability of these approaches are areas that require further exploration. For example, while mobile app-based interventions may yield immediate benefits, it is unclear whether these improvements persist over time or translate into lasting improvements in reading skills and academic performance. Additionally, questions regarding the cost-effectiveness and scalability of these technological solutions remain largely unaddressed. Understanding the sustainability and long-term outcomes of these interventions is vital for educational planning and resource allocation.

This comparative analysis reveals the dynamic landscape of technology-based interventions for dyslexia remediation, offering educators, parents, and researchers valuable insights into the advantages and limitations of these approaches. Mobile app-based interventions provide engaging and flexible learning experiences, with the potential to enhance phonological awareness and reading skills. However, the variability in app quality and the need for evidence-based selection demand careful consideration. Audio phoneme learning interventions harness auditory processing, with positive effects on phonemic awareness and reading fluency. Yet, their effectiveness may differ among various subtypes of dyslexia, highlighting the importance of personalized intervention plans. Flashcards, with visually appealing design, can improve sight word recognition and reading comprehension through structured repetition. Nevertheless, they may be less engaging for some learners, necessitating creative design approaches.

Accessibility, quality assurance, and individualization remain ongoing challenges in the use of technology-based interventions for dyslexia remediation. It is imperative for educators and researchers to consider the specific needs and preferences of dyslexic individuals when selecting remediation strategies. Ultimately, the sustainability and long-term impact of these interventions require further investigation to inform evidence-based practices. To address the diverse needs of dyslexic individuals effectively, a personalized approach, combining elements from different interventions, may offer the most promising path forward. This research underscores the importance of continued exploration and refinement of technology-based approaches for dyslexia remediation to support individuals on their educational journeys.

## **6. Conclusion**

This qualitative study has compared the effectiveness of three different assistive tools: mobile apps, audio phoneme learning, and flashcards in teaching the alphabet to dyslexic children. The findings indicate that a significant majority of special needs teachers (70%) believe mobile applications are effective for this purpose. This effectiveness is likely due to the interactive and multisensory features of mobile apps, which engage dyslexic children and offer a more personalized learning experience. Additionally, the study found that 25% of special needs teachers recognize the benefits of phonemic teaching methods. This approach, which emphasizes the relationship between letters and sounds, can enhance the reading and writing skills of dyslexic children. Conversely, only 5% of teachers found flashcards to be effective, possibly due to their limited multisensory input and lack of context, which may not meet the learning needs and preferences of dyslexic children.

Consequently, this study suggests that mobile applications and phonemic teaching methods are more effective than flashcards for teaching the alphabet to dyslexic children. However, it's important to acknowledge that each dyslexic child is unique, with different learning needs and preferences. Therefore, a personalized approach may be the most effective way to teach the alphabet to dyslexic children. This comparative analysis highlights the dynamic landscape of technology-based interventions for dyslexia remediation, providing valuable insights for educators, parents, and researchers. Mobile app-based interventions offer engaging and flexible learning experiences, with the potential to improve phonological awareness and reading skills. The use of digital tools can significantly enhance learning experiences [21, 30].

Therefore, the variability in app quality and the need for evidence-based selection require careful consideration. Audio phoneme learning interventions leverage auditory processing, positively impacting phonemic awareness and reading fluency. Nevertheless, their effectiveness may vary among different subtypes of dyslexia, emphasizing the need for personalized intervention

plans. Flashcards, while visually appealing, can improve sight word recognition and reading comprehension through structured repetition. Yet, they may be less engaging for some learners, necessitating creative design approaches. The use of comprehensive surveys and data collection methods in evaluating educational apps underscores the potential of combining traditional and technological teaching methods for a holistic learning experience [8, 11]. Accessibility, quality assurance, and individualization remain ongoing challenges in the use of technology-based interventions for dyslexia remediation. It is essential for educators and researchers to consider the specific needs and preferences of dyslexic individuals when selecting remediation strategies. Ultimately, the sustainability and long-term impact of these interventions require further investigation to inform evidence-based practices. To effectively address the diverse needs of dyslexic individuals, a personalized approach that combines elements from different interventions may offer the most promising path forward. This research underscores the importance of continued exploration and refinement of technology-based approaches for dyslexia remediation, supporting individuals on their educational journeys.

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### References

- [1] Ehri, Linnea C., Simone R. Nunes, Dale M. Willows, Barbara Valeska Schuster, Zohreh Yaghoub-Zadeh, and Timothy Shanahan. "Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis." *Reading research quarterly* 36, no. 3 (2001): 250-287. <https://doi.org/10.1598/RRQ.36.3.2>
- [2] Nelson, Jason M., Will Lindstrom, and Patricia A. Foels. "Test anxiety among college students with specific reading disability (dyslexia) nonverbal ability and working memory as predictors." *Journal of learning disabilities* 48, no. 4 (2015): 422-432. <https://doi.org/10.1177/0022219413507604>
- [3] Ashton, Tamarah M. "Assistive technology." *Journal of Special Education Technology* 15, no. 3 (2000): 35-38. <https://doi.org/10.1177/016264340001500304>
- [4] Dewey, John. *Democracy and education: An Introduction to the philosophy of education*. Columbia University Press, 2024. <https://doi.org/10.7312/dewe21010-003>
- [5] Elbro, Carsten, and Dorthe Klint Petersen. "Long-term effects of phoneme awareness and letter sound training: An intervention study with children at risk for dyslexia." *Journal of educational psychology* 96, no. 4 (2004): 660. <https://psycnet.apa.org/doi/10.1037/0022-0663.96.4.660>
- [6] Eunice Kennedy Shriver National Institute of Child Health. "Human Development, NIH, DHHS. (2000)." *Report of the National Reading Panel: Teaching Children to Read: Reports of the Subgroups (00-4754)*. Washington, DC: US Government Printing Office (2007).
- [7] Nicolson, Roderick I., Angela J. Fawcett, Rebecca L. Brookes, and Jamie Needle. "Procedural learning and dyslexia." *Dyslexia* 16, no. 3 (2010): 194-212. <https://doi.org/10.1002/dys.408>
- [8] Abd Kadir, Kauthar, Nurrohdiah Idris, and Alya Izzati Anuar. "Exploring Surah Ad-Dhuha: A fun and educational tafsir app for kids." *International Journal of Advanced Research in Future Ready Learning and Education* 34, no. 1 (2024): 31-52. <https://doi.org/10.37934/frle.34.1.3152>
- [9] Freire, Paulo. "From pedagogy of the oppressed." *Race/ethnicity: multidisciplinary global contexts* 2, no. 2 (2009): 163-174.
- [10] Gillon, Gail T. *Phonological awareness: From research to practice*. Guilford Publications, 2017.
- [11] Hodges, Georgia Wood, Lu Wang, Juyeon Lee, Allan Cohen, and Yoonsun Jang. "An exploratory study of blending the virtual world and the laboratory experience in secondary chemistry classrooms." *Computers & Education* 122 (2018): 179-193. <https://doi.org/10.1016/j.compedu.2018.03.003>
- [12] Habgood, MP Jacob, and Shaaron E. Ainsworth. "Motivating children to learn effectively: Exploring the value of intrinsic integration in educational games." *The Journal of the Learning Sciences* 20, no. 2 (2011): 169-206. <https://doi.org/10.1080/10508406.2010.508029>
- [13] Brewer, Sarah M., and David R. Erickson. "A tale of two classrooms." *Journal of Computing in Teacher Education* 13, no. 3 (1997): 20-22.

- [14] Johnson, David W., and Roger T. Johnson. "Cooperative learning: The foundation for active learning." *Active learning—Beyond the future* (2018): 59-71. <https://doi.org/10.5772/intechopen.81086>
- [15] Xu, Yaoying, Christopher Chin, Evelyn Reed, and Cynthia Hutchinson. "The effects of a comprehensive early literacy project on preschoolers' language and literacy skills." *Early Childhood Education Journal* 42 (2014): 295-304. <https://doi.org/10.1007/s10643-013-0613-6>
- [16] Kincheloe, Joe L., and Peter McLaren. "Rethinking critical theory and qualitative research." In *Key works in critical pedagogy*, pp. 285-326. Brill, 2011.
- [17] Hussain, Arshad, Mansoor Ahmad Dar, Rayees Ahmad Wani, Majid Shafi Shah, Mohd Muzzaffar Jan, Yasir A. Malik, Rajesh Kumar Chandel, and Mushtaq Ahmad Margoob. "Role of lamotrigine augmentation in treatment-resistant obsessive compulsive disorder: a retrospective case review from South Asia." *Indian Journal of Psychological Medicine* 37, no. 2 (2015): 154-158. <https://doi.org/10.4103/0253-7176.155613>
- [18] Maehler, Claudia, Christina Joerns, and Kirsten Schuchardt. "Training working memory of children with and without dyslexia." *Children* 6, no. 3 (2019): 47. <https://doi.org/10.3390/children6030047>
- [19] Shaywitz, Sally E., and Bennett A. Shaywitz. "Dyslexia (specific reading disability)." *Biological psychiatry* 57, no. 11 (2005): 1301-1309. <https://doi.org/10.1016/j.biopsych.2005.01.043>
- [20] Poirier, Mark, Jeremy M. Law, and Anneli Veispak. "A spotlight on lack of evidence supporting the integration of blended learning in K-12 education: A systematic review." *International Journal of Mobile and Blended Learning (IJMBL)* 11, no. 4 (2019): 1-14. <https://doi.org/10.4018/IJMBL.2019100101>
- [21] Ismail, Safinah, Aemy Elyani Mat Zain, Haslina Ibrahim, Nazneen Ismail, Nur Aisyah Abu Hassan, and Fatin Farzana Dass Meral. "Kepentingan aplikasi digital dalam pembelajaran anak muda era industri 4.0: The importance of digital applications in young children's learning industry era 4.0." *Semarak International Journal of STEM Education* 1, no. 1 (2024): 28-38. <https://doi.org/10.37934/sijste.1.1.2838>
- [22] Noorhidawati, Abdullah, S. Ghazal Ghalebandi, and R. Siti Hajar. "How do young children engage with mobile apps? Cognitive, psychomotor, and affective perspective." *Computers & Education* 87 (2015): 385-395. <https://doi.org/10.1016/j.compedu.2015.07.005>
- [23] Pressley, Tim, Richard L. Allington, and Michael Pressley. *Reading instruction that works: The case for balanced teaching*. Guilford Publications, 2023.
- [24] Patel, Mimansa, and Nitin Patel. "Exploring research methodology." *International Journal of Research and Review* 6, no. 3 (2019): 48-55.
- [25] Riddick, Barbara. "Dyslexia and inclusion: time for a social model of disability perspective?." *International studies in sociology of education* 11, no. 3 (2001): 223-236. <https://doi.org/10.1080/09620210100200078>
- [26] Rose, David H., and Anne Meyer. *Teaching every student in the digital age: Universal design for learning*. Association for Supervision and Curriculum Development, 1703 N. Beauregard St., Alexandria, VA 22311-1714 2002.
- [27] Sewell, Alexandra, Anastasia Kennett, and Victoria Pugh. "Universal Design for Learning as a theory of inclusive practice for use by educational psychologists." *Educational Psychology in Practice* 38, no. 4 (2022): 364-378. <https://doi.org/10.1080/02667363.2022.2111677>
- [28] Pauen, Sabina, and Friedrich Wilkening. "Children's analogical reasoning about natural phenomena." *Journal of Experimental Child Psychology* 67, no. 1 (1997): 90-113. <https://doi.org/10.1006/jecp.1997.2394>
- [29] Moores, Elisabeth, Rizan Cassim, and Joel B. Talcott. "Adults with dyslexia exhibit large effects of crowding, increased dependence on cues, and detrimental effects of distractors in visual search tasks." *Neuropsychologia* 49, no. 14 (2011): 3881-3890. <https://doi.org/10.1016/j.neuropsychologia.2011.10.005>
- [30] Snowling, Margaret J., and Charles Hulme. "Evidence-based interventions for reading and language difficulties: Creating a virtuous circle." *British Journal of Educational Psychology* 81, no. 1 (2011): 1-23. <https://doi.org/10.1111/j.2044-8279.2010.02014.x>
- [31] Vygotsky, Lev Semenovich, and Michael Cole. *Mind in society: Development of higher psychological processes*. Harvard university press, 1978.
- [32] Saad, Sharina, Berlian Nur Morat, Amelia Abdullah, and Yasmin Farani. "Empowering ESL learners: Unleashing autonomy through project-based learning." *International Journal of Advanced Research in Future Ready Learning and Education* 35, no. 1 (2024): 1-8. <https://doi.org/10.37934/frle.35.1.18>
- [33] wahida Amran, Fatma, and Mardzelah Makhsin. "Inovasi Cerdik Jawi Menggunakan Pembelajaran Kinestetik dan Kooperatif meningkatkan kemahiran menulis jawi dalam kalangan murid sekolah rendah: Inovasi cerdik jawi using kinesthetic and cooperative learning in improving jawi writing skill among primary pupils." *Semarak International Journal of Innovation in Learning and Education* 2, no. 1 (2024): 25-35. <https://doi.org/10.37934/sijile.2.1.2535>