International Journal of Linguistics and Translation Studies
Volume 5, Issue 3, 2024
Homepage: http://ijlts.org/index.php/ijlts/index
DOI: https://doi.org/10.36892/ijlts.v5i3.511

AraRead: A Mobile Application for Enhancing Arabic Reading Skills in Moroccan Children with Dyslexia

Driss El Bouda
University Mohamed V in Rabat, Morocco
elboudadriss1980@gmail.com

Aziz Ouladhadda
University Mohamed V in Rabat, Morocco
Hassan Malek
University Mohamed V in Rabat, Morocco

How to cite:
El Bouda, D., Ouladhadda, A. & Malek, H. (2024). AraRead: A Mobile Application for Enhancing Arabic Reading Skills in Moroccan Children with Dyslexia. *International Journal of Linguistics and Translation Studies* 5(3).292-318. https://doi.org/10.36892/ijlts.v5i3.511

ARTICLE HISTORY
Received: *03/06/2024*
Accepted: 01/08/2024

Keywords: *dyslexia, learning difficulties, educational neuroscience, reading ability, mobile applications.*

Abstract

This study explores the effectiveness of AraRead, a mobile application, designed to improve Arabic reading skills among children with dyslexia in Moroccan primary schools. The research aimed to investigate the impact of this application on reading ability and student motivation. Employing a pre-test/post-test design, the study involved 36 participants who used the application over a period of seven weeks. The findings validate previous research conducted in other contexts, demonstrating that such digital tools can significantly aid children with dyslexia in enhancing their reading skills. Additionally, the study revealed that AraRead not only improves reading proficiency but also increases motivation and fosters self-directed learning among learners. These results highlight the significant efficacy of mobile applications in overcoming learning challenges and enhancing student motivation, offering valuable insights for incorporating technology into educational practices specifically for children with dyslexia.

1. INTRODUCTION

Since ancient times, humans have sought to understand the brain, recognizing it as the origin of all cognitive processes. Every action taken and every word spoken emanates from this organ. Among these processes, language processing is perhaps the most significant, often regarded as the brain's primary function within the nervous system (Versace et al., 2018).

Recently, the field of language acquisition disorders and difficulties has garnered significant attention both internationally and nationally (MacDonald & Shirley 2009). This heightened interest stems from the increasing incidence of school dropouts and the

identification of a subset of learners with above-average intelligence who, despite not experiencing social issues, encounter challenges in acquiring language (Habib, 2021).

This situation has contributed to an increase in school dropouts among individuals with dyslexia. Traditional educational methods have often mischaracterized these individuals as unintelligent, distracted, and undesirable, exacerbating their suffering and that of their families. This issue is particularly problematic given the widespread misconceptions about dyslexia and its symptoms, which are frequently confused with general learning difficulties (Habib, 2021).

Previous studies in this field represent a significant accumulation of knowledge and references, which were utilized in the scientific and methodological construction of this research. This foundation enabled the researchers to employ their findings and recommendations in the development of a digital application which they named AraRead. This application aims to assist children with language and communication acquisition disorders in understanding the written linguistic system, improving their language abilities, and enhancing their literary experiences. It will address and overcome difficulties in decoding symbols, which require accuracy, fluency, and comprehension. To achieve this goal, we have examined a variety of research projects and studies in this field, with a particular emphasis on international studies.

1.1.Research Problem Statement

The selection of dyslexia as a focal model from a neuro-educational perspective derives from its profound societal significance. Positioned within the spectrum of invisible disabilities, dyslexia engenders misconceptions rooted in superficial and stereotypical perceptions of individuals grappling with language and communication acquisition challenges (Erbeli et. al 2021). These perceptions often foster judgmental attitudes that manifest as psychological distress, thereby impacting academic performance, contributing to elevated dropout rates, and fostering educational inefficiencies. Despite these challenges, individuals with dyslexia demonstrate cognitive prowess, intellectual capacity, and social acumen that facilitate functional adaptation across various life domains (Miciak & Fletcher 2020).

Globally, dyslexia affects 10% to 15% of the population, highlighting its widespread impact across diverse social strata (Snowling et. al, 2020). In Morocco, however, the absence of precise diagnostic tools complicates distinguishing between learning difficulties and language acquisition disorders, affecting approximately a quarter of schoolchildren, particularly those in vulnerable socio-economic conditions.

Official data from the Ministry of National Education and the Higher Council for Education and Training underscore persistently low reading proficiency levels relative to students' chronological and mental ages, despite ongoing educational reforms and substantial investments aimed at enhancing literacy acquisition (CSEFRS, 2008). Notably, Morocco ranked unfavorably in recent international assessments such as the Progress in International Reading Literacy Study (PIRLS), underscoring critical concerns regarding the efficacy of current pedagogical methods and interventions tailored to address persistent cognitive challenges (Mullis et al., 2023)

Amidst this educational landscape, there exists a notable dearth in the integration of cognitive sciences, including neuroscience, informatics, and artificial intelligence, which could potentially revolutionize educational practices. Digital tools, renowned for their engaging and motivational attributes, have emerged as promising aids in cognitive rehabilitation, yet their systematic integration within educational frameworks remains limited.

To address these gaps, this study proposes a rigorous scientific investigation employing procedural and field experimental methodologies grounded in neuroscience. The primary objective is to evaluate AraRead, the designed digital application, based on robust scientific principles aimed at supporting children with reading difficulties, particularly those with dyslexia. By bridging natural and artificial cognitive systems, this research seeks to harness the transformative potential of cognitive neuroscience within educational contexts.

1.2. Significance of the Study

This study holds significant importance as it proposes practical solutions to address and support issues related to decoding the Arabic linguistic system among children with special needs, particularly those with dyslexia. Its relevance can be summarized as follows:

1. **Relevance of the topic**: The study addresses current issues in both diagnosis and support for children with reading difficulties.
2. **High incidence rates**: There is a rising number of students experiencing challenges in reading and language acquisition.
3. **Introduction of modern scientific approaches**: The study introduces the latest cognitive and educational neuroscience approaches to understanding and addressing language acquisition issues in both typical children and those with dyslexia.
4. **Highlighting the importance of digital interventions**: It underscores the significance of digital interventions based on cognitive and educational neuroscience findings to alleviate and mitigate language disorders in both special needs and typical children.

5. **Debunking long-standing myths**: The study aims to dispel persistent misconceptions (Neuromyths) about brain structure and learning disabilities that have endured for decades.
6. **Lack of specialists**: There is a shortage of specialists and practitioners in Morocco who have the necessary expertise to effectively address language acquisition disorders.

1.3. Research Questions

The researchers formulated the following two research questions to guide their investigation, thereby ensuring a structured and focused approach to the study as a whole:

1. What is the impact of the regular use of AraRead on individualizing and treating certain forms of language acquisition disorders in dyslexic children?
2. To what extent do AraRead and similar tools enhance students' motivation and promote self-directed learning?

1.4. Research Objectives

The current study aims to achieve a set of objectives that motivated the researchers to conduct this study:

- Exploring cognitive neuroscience and applying its digital advancements to address learning difficulties among both typical and reading-challenged children, promoting inclusive education.
- Emphasizing the importance of self-directed learning and interactive teaching methods, including educational games and digital applications that engage multiple senses. These approaches aim to develop compensatory neural networks and modify structural and functional brain patterns.
- Measuring the effectiveness of AraRead as a digital application in enhancing reading skills and abilities in children with dyslexia.

1.5. Research Hypothesis

In our research, we investigated the effectiveness of an intervention using AraRead to enhance reading skills in individuals with dyslexia, employing a pre-test and post-test methodology. Our hypotheses were as follows:

- **Null Hypothesis (H_0):** There is no significant difference between the pre-test and post-test scores, implying that any observed differences are attributable to random chance rather than the effect of the digital application.
- **Alternative Hypothesis (H_1):** There is a significant difference between the pre-test and post-test scores, suggesting that the observed differences are due to the intervention provided by the digital application rather than random variability.

By articulating these questions, the researchers aim to systematically explore the underlying issues and contribute to the broader body of knowledge in the field. The first research question will be investigated using data obtained from pretest and posttest assessments taken by participants before and after using the digital learning application developed by the researchers. In contrast, the second research question will be explored through direct observation of participants during their interaction with AraRead

1.6.Definition of Key Concepts

Dyslexia

Snowling et al. (2020) note that "dyslexia is a difficulty in learning to decode (read aloud) and to spell" (p501). It is a specific learning disorder characterized by difficulties with accurate and/or fluent word recognition, poor spelling, and decoding abilities. These challenges typically result from a deficit in the phonological component of language, which is often unexpected in relation to other cognitive abilities and effective classroom instruction. In the context of the current study, students with dyslexia are children between the ages of 6 and 12 at the primary school level. This stage is crucial for developing reading fluency and proficiency in the language. In the Moroccan education context, there is a three-year preschool period that precedes primary education. This preschool period aims to familiarize students with the school system and prepare them for formal schooling.

Learning Disabilities

The diagnosis of reading difficulties often confuses reading difficulties with reading disorders. Learning disabilities are defined as an individual's inability to benefit from the regular educational program despite having normal intellectual abilities, without any signs of neurological or physiological dysfunction. The individual may also experience difficulties in expressive or linguistic communication and struggle with reading or arithmetic within the framework of the prescribed curriculum. This can occur at any age or socioeconomic level (Corsini, R.J., 1994).

Cognitive Sciences

Moeschler (2004). Jack Mushlar states that cognitive sciences (psychology, linguistics, philosophy of mind, and neuroscience) emerged in response to the behavioral movement, highlighting the role and importance of the mind/brain in the knowledge acquisition process. The human mind, in particular, acquires, develops, and uses knowledge based on mental states.

Others, including Gardner, also define cognitive science as the study of the mind that aims to establish explanatory foundations for conceptual systems, with language being a general study of the brain and mind (Kornhaber, 2002). Cognitive sciences seek to understand

perception, thinking, memory mechanisms, language comprehension, learning, and other mental phenomena, such as observing children's behaviour, examining computer programming, and solving complex problems, as well as analyzing the nature of meaning.

Educational Neuroscience

Educational neuroscience is a field dedicated to translating findings from studies on the neural mechanisms involved in the learning process into practical approaches and practices used in educational settings. It focuses on studying the brain mechanisms associated with teaching and learning processes within classrooms, with the aim of accelerating learning and addressing learning challenges, particularly in language acquisition (Michael et al., 2018).

2. LITERATURE REVIEW

2.1.Gamification and Motivation in Learners with Dyslexia

Educational research provides a rich array of studies addressing the significance of gamification in language learning, with particular emphasis on its application to children with dyslexia. The body of literature on this topic is extensive and diverse, reflecting a broad interest in how gamification strategies can enhance educational outcomes. While it is beyond the scope of our research to be exhaustive in reviewing all relevant studies, we aim to highlight a selection of key works that are particularly pertinent to our investigation. This approach allows us to provide a focused analysis of the most relevant findings and trends in the field, thereby offering a comprehensive overview of the current state of research on gamification in language education and its specific impact on dyslexic learners.

Gooch et al. (2016), as a first example, explore the potential benefits of gamification for a specific cohort: children with dyslexia transitioning from primary to secondary education. The authors assert that "one of the main opportunities for using gamification has been in the field of educational technology" (p. 970). In their study, they employed ClassDojo, a gamification platform, to assess its impact on enhancing students' motivation. The findings indicate that the platform significantly contributed to improvements in self-confidence, independent work, perseverance, and overall motivation. Additionally, it positively affected dyslexia-related challenges, such as reading speed, fluency, and accuracy.

Similarly, Khaleghi et al. (2022) noted that “the current treatments are expensive and should be performed with school homework, resulting in children's demotivation” (p.1). The study concluded that serious games offer promising opportunities to engage children with dyslexia in therapeutic activities. By leveraging gamification, these game-based interventions can boost motivation, which is critical for effective dyslexia treatment. For Khaleghi et al., a

key element of successful game-based approaches is the provision of constructive feedback, as it helps guide progress and maintain engagement. It is also important to minimize negative feedback to avoid discouraging the children. Ensuring that positive reinforcement is abundant further enhances the effectiveness of these interventions, supporting better outcomes in dyslexia treatment.

Another study within the Spanish context confirmed the effectiveness of digital applications in addressing challenges related to dyslexia. Rodríguez-Ferrer et al. (2023) found that gamification and game-based learning offer engaging and motivating educational experiences. Their review suggests that incorporating these playful strategies can be especially beneficial for students with dyslexia. By integrating game-like elements and interactive activities into the learning process, educators can create an environment that not only captures and retains students' attention but also supports their unique learning needs. These methods leverage the inherent appeal of games to enhance engagement and retention, potentially helping students with dyslexia overcome some of their challenges. Rodríguez-Ferrer et al.'s findings indicate that the experimental group showed a statistically significant improvement in reading abilities compared to the control group. This suggests that the interventions used with the experimental group were effective in advancing their reading skills. The statistical significance of these results highlights the efficacy of the experimental treatment and its potential for positively impacting reading development in the targeted population.

2.2. Impact of Intervention Programs on Language Proficiency

Antoniou and Souvignier (2007) conducted a study aimed at using an educational strategy to enhance reading comprehension among students with reading difficulties. The sample consisted of 73 students from fifth to eighth grade, divided into an experimental group and a control group. The experimental group was exposed to the proposed program, while the control group received no intervention. The researchers used an intelligence test and a reading comprehension test in addition to the proposed educational program, which included two strategies: one for reading comprehension and the other for self-regulation during reading.

The study found statistically significant differences in the improvement of reading comprehension and self-regulation during reading in favor of the experimental group. The study recommended the importance of self-comprehension strategies and teaching metacognitive awareness strategies (awareness of cognitive processes and inhibition of incorrect responses) and their relationship to explicit instruction.

Nourbakhsh et al. (2013) conducted a study aimed at investigating the effectiveness of the multisensory approach and sensory perception skills training in improving the reading abilities of students with dyslexia. The sample was divided into three groups: the first experimental group (20 students), the second experimental group (20 students), and the control group (20 students). The researchers used the RTD tests to measure dyslexia, the Bender Visual-Motor Gestalt Test (BVMGT), and the Rey-Osterrieth Complex Figure (ROCF) test. The study results showed an improvement in the reading performance of students in the first experimental group compared to the control group due to the use of multisensory training. However, the study did not show any improvement in the reading performance of students in the second experimental group compared to the control group when using sensory perception training.

Cohen et al. (2021) conducted a study indicating that certain levels of language processing can be influenced by diverting attention to a different sensory modality. Using whole-brain functional magnetic resonance imaging (MRI), they investigated how language-specific regions are modulated when attention is directed to another sensory modality (e.g., visual attention during auditory sentence presentation, or vice versa). They tested the hypothesis that inattention might disrupt sentence-level integration and eliminate top-down effects.

In both written and spoken modalities, language processing was significantly affected by attentional distraction. However, the impact of inattention varied greatly depending on the region and the hierarchical level of language processing. Under inattention, early modality-specific areas, particularly in the superior temporal regions for spoken language, showed continued bottom-up activation, but the distinction between sentences and word lists disappeared.

The study concluded that inattention prevents syntactic and semantic integration at the sentence level but preserves some degree of cross-modal top-down processing and a significant level of bottom-up modality-specific processing, including occipital and temporal specialization for letter strings in familiar alphabets.

2.3.The Research Gap

Many research studies have emphasized the importance of digital applications in learning, particularly those employing games to facilitate language acquisition for both typically developing children and those with learning disorders such as dyslexia. However, the

number of applications specifically designed for children with dyslexia remains limited compared to those for typically developing children. Additionally, there is a scarcity of digital applications that address the challenges of acquiring the Arabic language, in contrast to the abundance available for other foreign languages, particularly English and French. This gap has spurred our interest in contributing to Arabic language learning by designing and testing a mobile application aimed at improving language proficiency in children with dyslexia.

3. RESEARCH METHODOLOGY

3.1.Approach

The current study is situated within the quantitative research tradition, which offers several notable advantages. This approach is renowned for its emphasis on objectivity, as it relies on numerical data and statistical analysis to draw conclusions (Cohen et al., 2000). This methodological rigor helps to minimize bias and enhance the reliability of the findings. Additionally, quantitative research allows for the systematic examination of patterns and relationships within data, providing a clear and precise understanding of the phenomena under investigation (Creswell, 2012). These attributes make quantitative methods particularly valuable for producing generalizable and replicable results, contributing to the robustness of the study's conclusions (Jonker & Pennink, 2010).

3.2.Research Design

The current study employs an experimental design to collect data and address the research questions. This systematic approach investigates the impact of one or more independent variables on dependent variables (Jonker & Pennink, 2010). It involves careful planning of experiments to ensure that the results are valid, reliable, and capable of providing clear answers to the research questions.

The experimental design is grounded in positivism, which posits that knowledge should be derived from empirical evidence—observable and measurable phenomena. This perspective emphasizes that reality exists independently of our perceptions and can be objectively measured using scientific methods (Creswell, 2018).

In this study, a pre-test and post-test approach is used to assess the extent to which a digital application improves reading performance among learners with dyslexia.

3.3. The Study Sample

The study sample includes 36 participants, with 12 females and 24 males. Their ages range from 6 to 12 years, and they were selected randomly. Detailed characteristics of the sample are presented in Tables 1, 2, and 3 below:

Table 1: Age distribution of participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	From 6 and 7 years old	12	33,3	33,3	33,3
	From 8 and 9 years old	14	38,9	38,9	72,2
	From 10 and 11 years old	5	13,9	13,9	86,1
	More than 11 years old	5	13,9	13,9	100,0
	Total	36	100,0	100,0	

Table 2: Gender distribution of participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	24	66,7	66,7	66,7
	Female	12	33,3	33,3	100,0
	Total	36	100,0	100,0	

Table 3: Grade level of participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	First grade of primary school	13	36,1	36,1	36,1
	Second grade of primary school	8	22,2	22,2	58,3
	Third grade of primary school	6	16,7	16,7	75,0
	Fourth grade of primary school	5	13,9	13,9	88,9
	Fifth grade of primary school	4	11,1	11,1	100,0
	Total	36	100,0	100,0	

It is worth noting that all participants have a medical diagnosis classifying them as children with reading difficulties. Additionally, the majority have accumulated experiences of failure throughout their educational journey.

3.4.Research Ethics

Ethical considerations are paramount in this study. Prior to initiating the research, authorization was obtained from the local school administration to conduct the investigation. Informed consent was secured from parents, who agreed to allow their children to participate in the study. Participants were fully informed of their right to withdraw from the study at any time without penalty, ensuring that participation remained voluntary throughout. Additionally, measures were taken to protect participants' privacy, with all identifying information kept confidential and not revealed in any reports or publications.

3.5. Data Collection

3.5.1. The Pre-test

The pre- test consists of four levels. The first level assesses students' ability to recognize and read Arabic letters, particularly those that look similar. Arabic script includes several letters that may appear similar but have different forms depending on their position within a word. The pretest features examples of such letters to evaluate this skill. Here are a few examples:

- ب (B): A dot below.
- ن (N): A dot above.
- ت (T): Two dots above.
- ي (y): Two dots below.
- س (S): A simple curve with no dots.
- ش(Sh): The same curve as Seen but with three dots above.
- خ(KH): A dot above.
- ج (J): A dot below.
- ر (R) : no dot
- ز (z) : A dot above.

The second level is dedicated to word recognition. To meet the criteria for this level, students must read at least eight of the following words fluently:

منزل: House	**بنت: Girl**
عسل: Honey	**خروف: Sheep**
قمر: Moon	**بيت: Home**
كتاب: Book	**جرس: Bell**
مدرسة: School	**شمس :sun**

The third level assesses paragraph reading. To qualify at this level, students must read the following paragraph fluently, making no more than three mistakes:

Arabic	English translation

اجتمعت العائلة حول مائدة طعام الافطار. صبت الام كؤوس الشاي الساخن . أخذت أميمة قطعة خبز من الشعير ونقعتها في زيت الزيتون. قال احمد:" ما ألذ مذاق الخبز الطازج بطعم زيت الزيتون!".	[The family gathered around the breakfast table. The mother poured cups of hot tea. Oumaima took a piece of barley bread and soaked it in olive oil. Ahmad said, "How delicious the taste of fresh bread with olive oil is!]

Upon successfully completing the third level, students advance to the final level of the pre- test: a short story accompanied by two comprehension questions. The first question assesses understanding of information explicitly stated in the story, while the second question evaluates the ability to infer implicit information and read between the lines. Here is the story that was used for this purpose:

Arabic	English translation
جاء فصل الصيف، وصارت السماء صافية من الغيوم، وأصبح الجو حارا يغري بالسباحة في البحر. قررت اسرة اميمة ان تقضي اليوم على شاطئ البحر. شرعت الام في اعداد أكلات خفيفة، بينما انشغل الاب وايمن في وضع الشمسية والكراسي والمبرد المحمول داخل السيارة. أدار ابي محرك السيارة، وانطلقنا بلهفة نحو الشاطئ. كانت الفرحة والابتسامة تكسو وجوه عائلتي. **ها نحن بين أحضان البحر الهادئ ورماله الذهبية ومياهه الزرقاء. وماهي الا لحظات قليلة حتى كنت انا واختي اميمة نسبح في مياهه الباردة ونداعب امواجه الهادئة.** **ما أروع السباحة في فصل الصيف!** • **اسئلة الفهم :** - **ما هو الفصل الذي يتحدث عنه النص** - **لماذا كانت تعلو الفرحة والابتسامة وجوه أسرة ايمن؟**	[The Summer has arrived, and the sky has cleared of clouds, and the weather became hot, tempting us to swim in the sea. Oumaima's family decided to spend the day at the beach. The mother began preparing light meals, while the father and Ayman busied themselves setting up the sunshade, chairs, and cooler in the car. My father started the car, and we eagerly set off for the beach. Joy and smiles lit up my family's faces. Here we are amidst the calm sea, its golden sands, and blue waters. In just a few moments, my sister Oumaima and I were swimming in the cool water and playing with its gentle waves. How wonderful it is to swim in the summer!] • **Comprehension questions:** - What season is the text talking about?

	- Why were Ayman's family's faces filled with joy and smiles?

3.5.2. The Post Test

Similar to the pre-test, the post-test is structured into four distinct levels. The first level evaluates students' ability to recognize and read Arabic letters, particularly those that look similar, using the same target letters as in the pre-test. The second level introduces new words for recognition, different from those used in the pre-test. The third level assesses students' skills in reading and understanding paragraphs. The final stage features a short story followed by two comprehension questions: the first measures the students' understanding of explicit information, while the second assesses their ability to infer implicit details and interpret between the lines. Table 4 below outlines the contents of the post-test and provides English translations.

Table 4. The posttest

Level one: The alphabets	ش ز ج ن ت	س ر خ ب ي
Level two: words	حديقة - Garden مدرسة - School أشجار - Trees بيت - House جمل - Camel	أرنب - Rabbit كرة - Ball فراشة - Butterfly قمر - Moon مكتب - Desk
Level three: the paragraph	On a sunny day, the rabbit "Nuno" went out to play in the field. Nuno saw a blue butterfly fluttering around him. He decided to follow the butterfly and enjoy its beauty. When he returned home, he was	**في يوم مشمس، خرج الأرنب "نونو" للعب في الحقل.** **رأى نونو فراشة زرقاء تطير حوله.** **قرر" نونو" أن يتبع الفراشة ويستمتع بجمالها.**

	happy and told his mother about his delightful adventure.	عاد إلى المنزل، سعيدًا وأخبر أمه عن مغامرته الجميلة.
Level four: the story with comprehension questions	On a spring day, a little cat named "Mishmish" went out to play in the garden. While playing, she discovered a beautiful butterfly fluttering nearby. Mishmish began to chase the butterfly, running after it among the flowers and trees. After a while, Mishmisha felt tired and sat down to rest under a large tree. Suddenly, she heard a small voice say, "Hello, Mishmisha!" She looked around and saw a little bird perched on a branch of the tree. The bird asked, "Do you need help getting back?" Mishmish smiled and replied, "Yes, I enjoyed my playtime, but now I want to go home." Mishmisha happily returned to her home and told her family about her delightful adventure. • Comprehension questions: - **What season is described in the text?** - **What made the cat "Mishmisha" happy when she returned home?**	في يوم من أيام فصل الربيع، خرجت قطة صغيرة تُدعى "مشمشة". للعب في الحديقة. أثناء لعبها، وجدت فراشة جميلة تطير بالقرب منها. بدأت مشمشة تلاحق الفراشة، وتركض وراءها بين الأزهار والأشجار. بعد قليل، شعرت مشمشة بالتعب وجلست لتستريح تحت شجرة كبيرة. فجأة، سمعت صوتًا صغيرًا يقول: "مرحبا، مشمشة!" نظرت حولها ورأت عصفورًا صغيرًا على غصن الشجرة. قال العصفور: " هل تحتاجين إلى مساعدة للعودة؟" ابتسمت مشمشة وقالت: "نعم، لقد استمتعت بلعبتي ولكنني أريد العودة إلى البيت الآن.». عادت "مشمشة" سعيدة إلى منزلها، وأخبرت عائلتها عن مغامرتها الجميلة. • اسئلة الفهم - ما هو الفصل الذي يتحدث عنه النص؟ - ما سبب سعادة القطة «مشمسة" عند عودتها الى المنزل؟

3.5.3. Observation

Observation was used as a primary data collection instrument in this research, with a focus on assessing children's motivation while using a mobile application designed to aid in learning Arabic. By closely monitoring participants' interactions with the app—paying attention to their engagement levels, frequency of use, and any visible signs of enjoyment or frustration—valuable insights were gathered. This method facilitated a naturalistic assessment of the children's behavior in a real-world setting, offering a comprehensive understanding of their motivational responses. Systematically recorded observational data played a crucial role in evaluating the application's effectiveness and the overall learning experience it provided. Additionally, this observational data were instrumental in addressing the second research question, providing key evidence and insights.

4. DESCRIPTION OF THE DIGITAL APPLICATION

4.1.The Game Menu

The AraRead application features five games, with additional ones theoretically planned but not yet implemented due to time constraints. The following image illustrates the game menu within the application, with an English translation provided next to the figure:

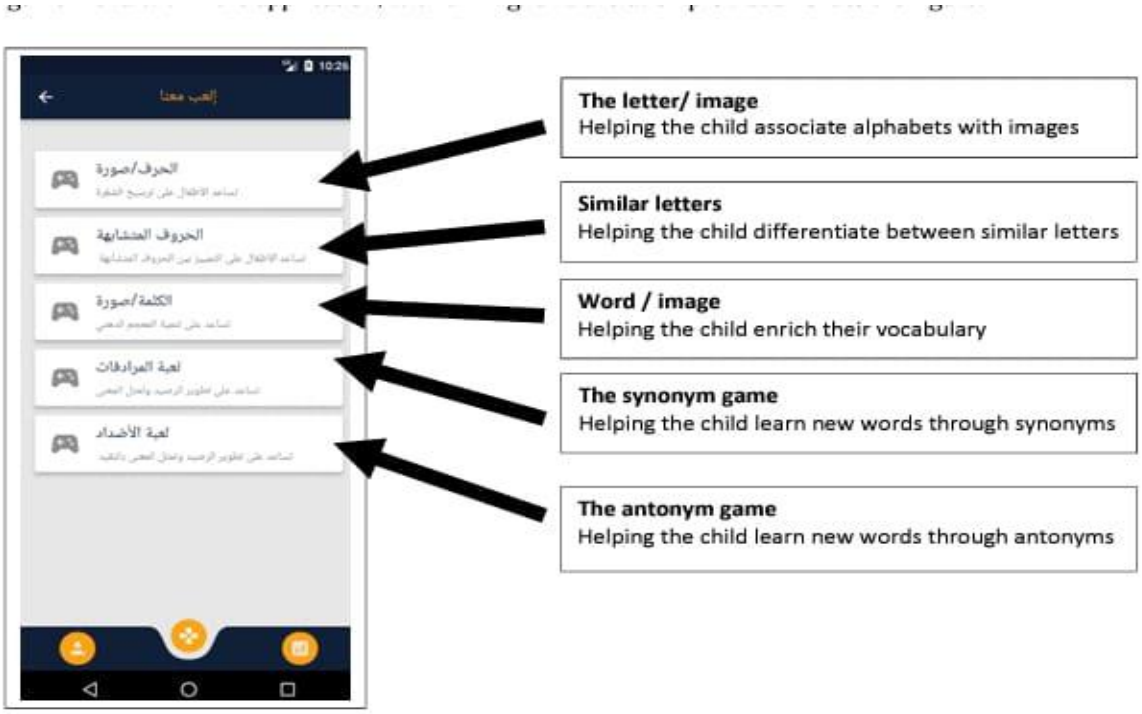


Figure 1. The game's main menu

4.2.The Letter/ Image Game

This game consists of a 3x4 grid (12 squares), where the child tries to identify and match the letter with the name of the icon that contains that letter before time runs out (Figure

2). If the child fails to identify and match the letter with the picture, they lose a round of the game. The game aims to create neural bridges and networks to decode written text, making it easier to recognize and recall letters from memory by remembering the names of objects whenever necessary. It also facilitates the mastery of the linguistic code by using icons that align with mental processes, making the recognition, differentiation, and decoding of written text more automatic through repeated attempts. This helps players become more fluent in reading the alphabet.

The game leverages neuroscience principles by engaging the child's brain with concrete objects before moving to abstract concepts. This involves transitioning from abstract letters to images of familiar objects stored in memory, which the child can see and interact with by pressing the corresponding button. The brain stores information in the form of images associated with emotional reactions, and enjoyable games provide this experience.

Both this game and the second one captivate the learner's attention, especially since they are played as a mobile application. As is well known, digital games generally attract children's attention and motivate them to continue playing. The more they win, the more motivated they become, increasing their appetite for playing and, consequently, learning more.

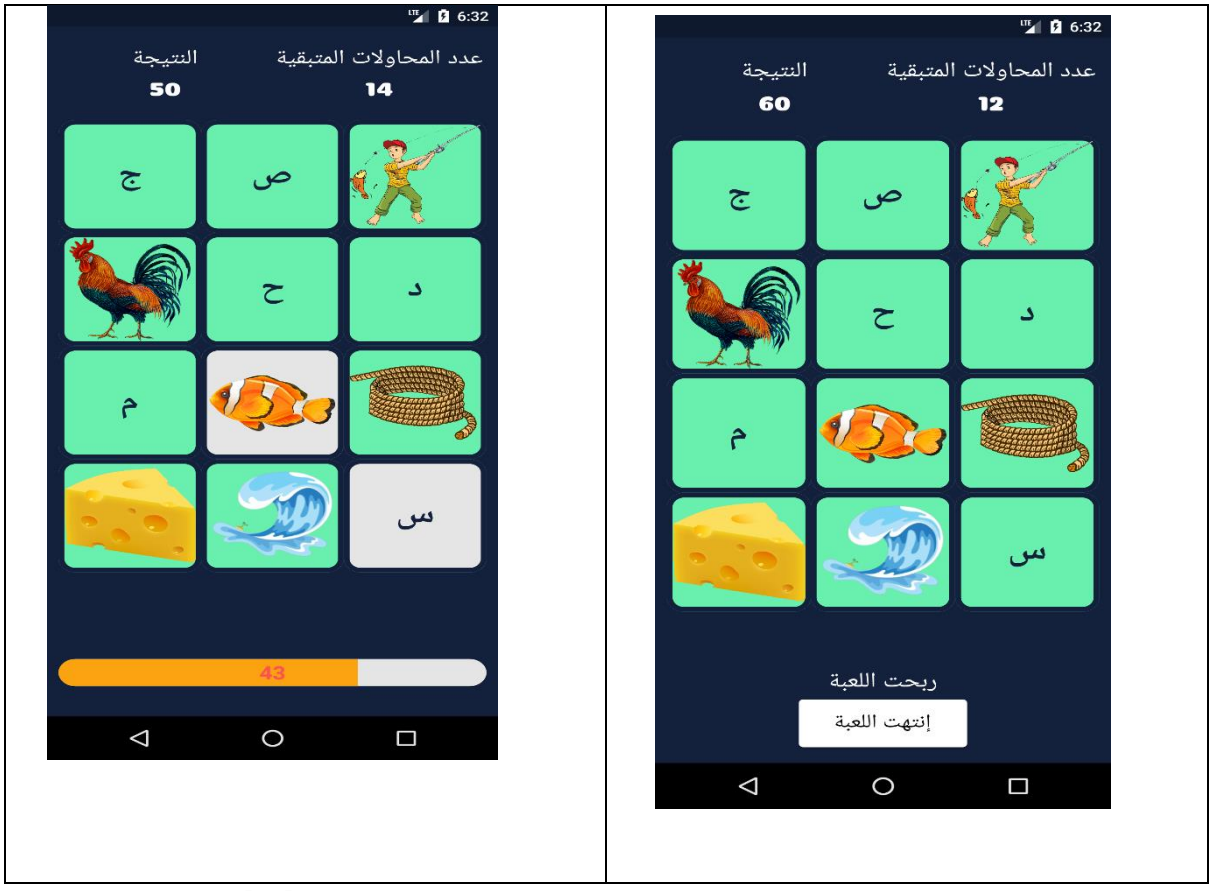


Figure 2. **The letter/ image game**

4.3.The Similar Letters Game

Inspired by the famous X/O game, it consists of a 3x3 grid (9 squares) and is played between the child and the device (Figure 3). Each player aims to fill three consecutive squares with the same letter, while emphasizing the sound of the letter. Neuroscience emphasizes the importance of phonemic awareness in developing reading skills. The objectives of this game include:

- Addressing the difficulties with similar letters that most children, whether they are struggling or not, face in mastering the linguistic code.
- Highlighting the importance of repetition in activating and renewing neural networks, making them stronger. This ensures that letters are memorized and recalled as needed by the learner, making the reading of letters—whether in isolation, syllables, or words—an easy and automatic process.

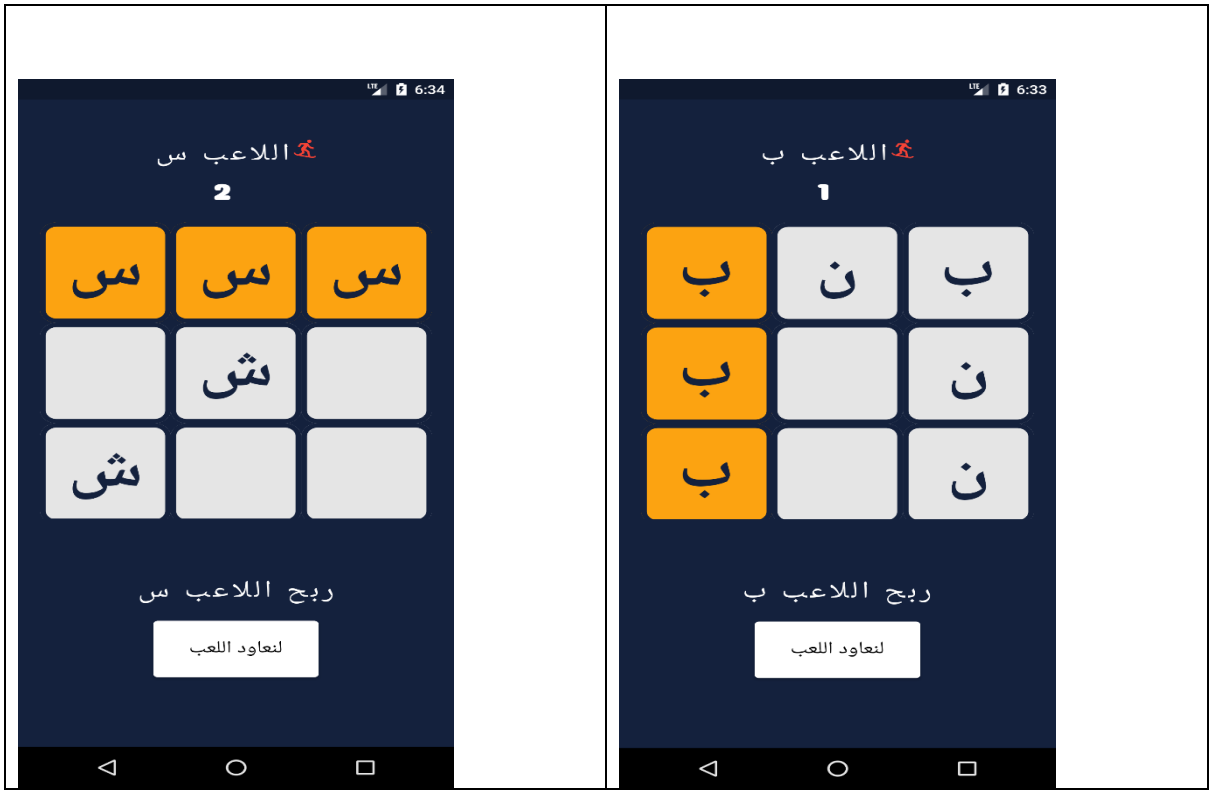


Figure 3: The similar letter game

4.4. The Word / Image Game

This game features a 3x4 grid (12 squares), where the child needs to match words with the corresponding icons before the timer runs out (see figure 4). If the child cannot successfully match the word to the image, they lose that round. The primary goal is to create neural pathways and bridges that aid in decoding written text, enhancing the ability to recognize and recall words from memory by associating them with familiar objects. It also aims to make the acquisition of linguistic skills smoother by utilizing icons that correspond with cognitive processes. This repeated matching exercise helps the child become more proficient and fluent in reading words.

The game employs principles of neuroscience, recognizing that a child's brain interacts with concrete objects before transitioning to abstract concepts. This involves moving from abstract words to images of familiar objects stored in memory, which the child can see and interact with by pressing the corresponding button.

The game helps integrate words into the child's mental structure, expanding their mental vocabulary so that their reading process could develops, they won't need to segment and spell out each word every time. This allows for recognizing the text as a whole (utilizing both hemispheres of the brain), making reading more fluent, faster, continuous, and better understood by reducing memory load.

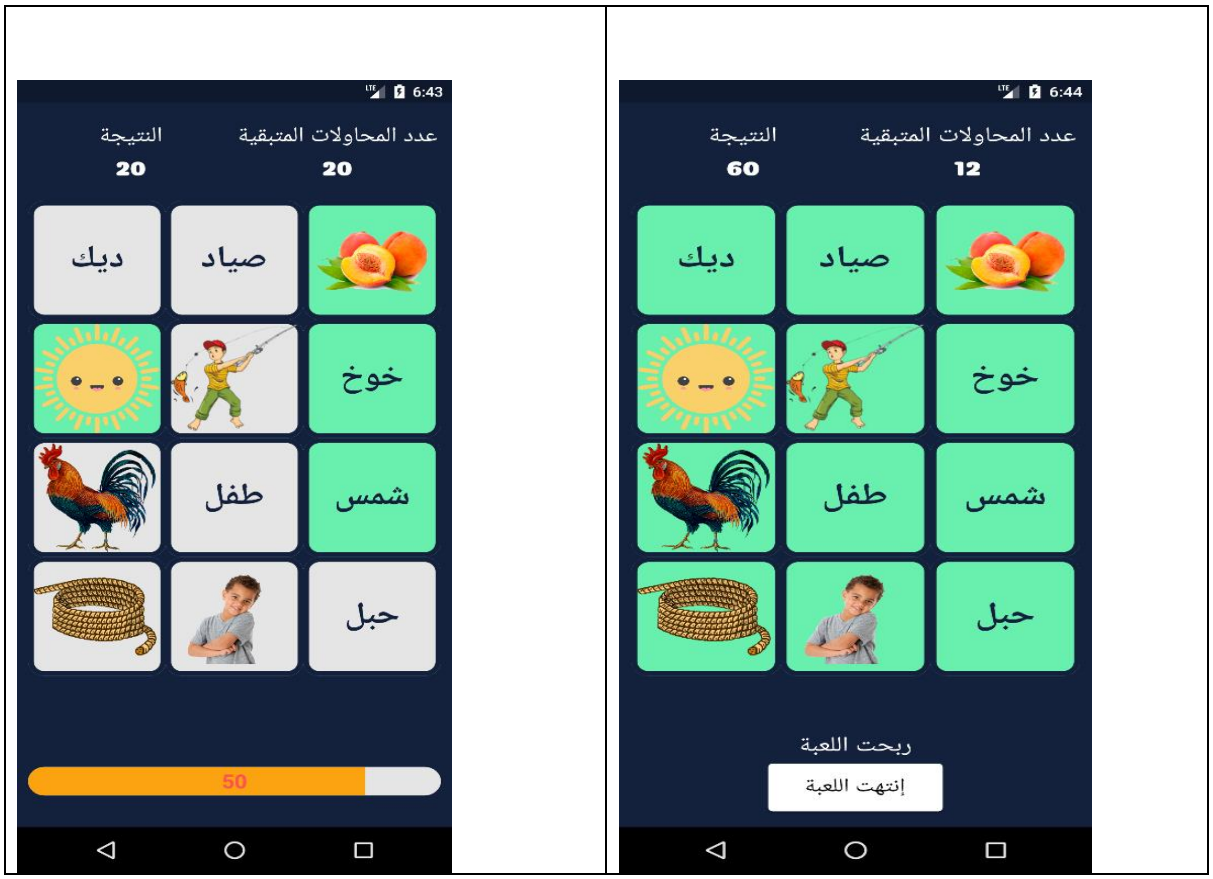


Figure 4. The word /image game

4.5.The Synonym Game

This vocabulary development game features a 3x4 grid (12 squares) where the child tries to match a word with its synonym before the timer runs out (figure 5). If the child fails to make the correct match, they lose a round. The game aims to enrich the learner's vocabulary, as studies suggest that reading instruction is crucial for expanding vocabulary. It improves the child’s ability to read sight words more fluently, enhancing their reading speed, comprehension, and interpretation of meanings, while reducing memory overload.

Figure 5. The synonym game

4.6.The Antonyms Game

This game consists of a 3x4 grid (12 squares) where the child tries to match each word with its antonym before time runs out (figure 6). If they fail to make the correct match, they lose a round. The game aims to enhance the learner's vocabulary, as studies suggest that reading instruction is closely linked to vocabulary development. Additionally, it helps the child develop personal understanding strategies by focusing on word pairs and their opposites, thus deepening their grasp of language.

Figure 6. The Antonym game

4.7.Procedures

Participants were grouped based on their pretest results, and the learning activities were customized for each group. The instruction included pair work and group activities, all supervised by the researchers. The main goals were to explain the game's objectives, teach the rules, and encourage peer challenges to improve response speed and accuracy. The program spanned seven weeks, with sessions held every two weeks, each lasting two hours, totaling 28 hours of instruction. The use of digital tablets was integral to the program, as they provided both convenience and engaging features that enhanced the learning experience. Their interactive capabilities facilitated more dynamic and immersive gameplay, which helped maintain student interest and support more effective learning outcomes.

5. RESULTS AND DISCUSSION

5.1.The impact of araread on enhancing participants' reading abilities

5.1.1. Comparison of Pretest and Posttest Results

The pretest was administered to all 36 participants to assess their initial reading skills before using the digital learning application. The mean score of the pretest was 1.92, indicating the baseline reading proficiency of the participants (Table 5). This data will serve as a reference point for evaluating the effectiveness of the application in improving reading skills. It is important to note that participants were assessed on a scale from 0 to 10.

Table 5 Descriptive Statistics about the pretest

	N	Minimum	Maximum	Mean	Std. Deviation
pretest	36	0	6	1,92	1,556
Valid N (listwise)	36				

After using AraRead for seven weeks, the posttest was administered to the same 36 participants to evaluate any improvements in their reading skills. The mean score of the posttest was 3.26, reflecting a notable increase from the pretest mean score of 1.92 (table 6). This significant improvement suggests that the digital learning application had a positive impact on the participants' reading abilities.

Table 6 Descriptive Statistics about the post test

	N	Minimum	Maximum	Mean	Std. Deviation
posttest	36	1	7	3,25	1,461
Valid N (listwise)	36				

5.1.2. Data Characteristics and Application of Nonparametric Tests

In analyzing the data from our pre-test and post-test variables, we conducted a normality test to determine if the data followed a normal distribution (Tables 7and 8). The test

yielded a p-value of 0.002. This result is significantly lower than the commonly used significance level of 0.05. Consequently, we reject the null hypothesis that our data is normally distributed. This finding suggests that the distribution of our pre-test and post-test scores deviates from a normal distribution, which may have implications for the types of statistical analyses we can appropriately apply. For instance, parametric tests that assume normality may not be suitable, and we hence considered non-parametric alternatives to accurately analyze our data.

When comparing pre-test and post-test scores of the same sample using non-parametric tests, the Wilcoxon Signed-Rank Test is the appropriate alternative to the paired t-test. This test does not assume normality and is used to compare two related samples to assess whether their population mean ranks differ. This test was used in our study to compare the performance of students before and after using the digital application.

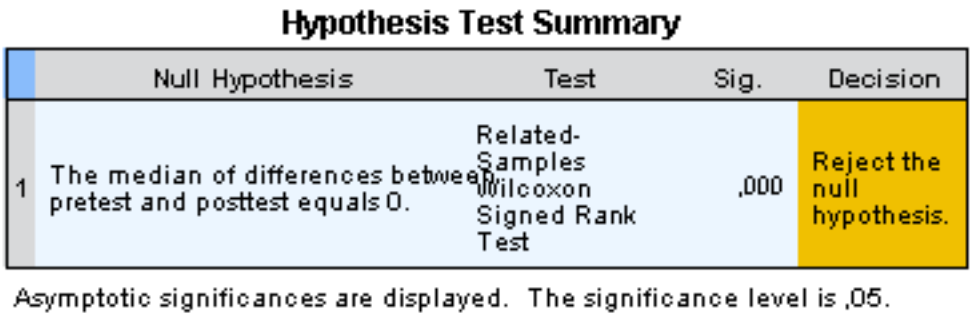
Table7. Normality test of the pretest scores

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
pretest	,201	36	,001	,894	36	,002
a. Lilliefors Significance Correction						

Table 8. Normality test of the posttest Scores

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
posttest	,179	36	,005	,893	36	,002
a. Lilliefors Significance Correction						

In our research, we aimed to determine whether there was a significant difference between pre-test and post-test scores following an educational intervention using a digital application. The null hypothesis (H_0) posited that there would be no difference between the pre-test and post-test scores, suggesting any observed differences were attributable to random chance. In contrast, the alternative hypothesis (H_1) asserted that a significant difference exists between the pre-test and post-test scores, indicating that the observed differences were not due to random chance. The results of our study, which led to the rejection of the null hypothesis, imply that the digital application intervention effectively enhanced students' reading skills.



Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between pretest and posttest equals 0.	Related-Samples Wilcoxon Signed Rank Test	,000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Figure 7. Testing the research hypothesis

Table 9 below provides further details on the shift in participant performance following the use of the application. It illustrates how participants progressed across the levels of proficiency, beginning with the ability to read letters, advancing to reading words, then paragraphs.

Table 9. Improvement in participant proficiency

ID	Test	Beginner	Can read letters	Can read words	Can read a paragraph	Can read a story	Can read and understand a story
1	**PRE-TEST**			X			
	POST- TEST				X		
2	**PRE-TEST**		X				
	POST- TEST			X			
3	**PRE-TEST**		X				
	POST- TEST			X			
4	**PRE-TEST**	X					
	POST- TEST		X				
5	**PRE-TEST**	X					
	POST- TEST		X				
6	**PRE-TEST**			X			
	POST- TEST			X			
7	**PRE-TEST**	X					
	POST- TEST		X				
8	**PRE-TEST**	X					
	POST- TEST		X				
9	**PRE-TEST**	X					
	POST- TEST		X				
10	**PRE-TEST**	X					
	POST- TEST		X				
11	**PRE-TEST**	X					
	POST- TEST		X				
12	**PRE-TEST**	X					
	POST- TEST		X				
13	**PRE-TEST**		X				
	POST- TEST			X			

14	**PRE-TEST**	X					
	POST- TEST		X				
15	**PRE-TEST**		X				
	POST- TEST			X			
16	**PRE-TEST**		X				
	POST- TEST		X				
17	**PRE-TEST**	X					
	POST- TEST		X				
18	**PRE-TEST**	x					
	POST- TEST	x					
19	**PRE-TEST**	X					
	POST- TEST		X				
20	**PRE-TEST**	X					
	POST- TEST		X				
21	**PRE-TEST**		X				
	POST- TEST			X			
22	**PRE-TEST**			X			
	POST- TEST				X		
23	**PRE-TEST**			X			
	POST- TEST				X		
24	**PRE-TEST**		X				
	POST- TEST			X			
25	**PRE-TEST**	X					
	POST- TEST	X					
26	**PRE-TEST**		X				
	POST- TEST		X				
27	**PRE-TEST**	x					
	POST- TEST	x					
28	**PRE-TEST**		X				
	POST- TEST			X			
29	**PRE-TEST**	X					
	POST- TEST		X				
30	**PRE-TEST**			X			
	POST- TEST			X			
31	**PRE-TEST**	X					
	POST- TEST			X			
32	**PRE-TEST**	x					
	POST- TEST	x					
33	**PRE-TEST**	X					
	POST- TEST		X				
34	**PRE-TEST**				X		
	POST- TEST				X		
35	**PRE-TEST**		X				
	POST- TEST			X			
36	**PRE-TEST**			X			
	POST- TEST				X		

5.2.The Effects of AraRead on Participants' Motivation

During the seven weeks of using AraRead, children were observed engaging enthusiastically with the application and tablet, approaching the games and challenges with joy and excitement. Many of them eagerly inquired about the next session. Some expressed their delight and amazement with the educational games, noting that this enjoyable learning method differed significantly from the traditional school approach. Both the children and their parents

requested to download the application on their phones. Another indicator of their motivated engagement was the low absence rate, which did not exceed 7 percent during the trial period, with no instances of dropout.

5.3.Discussions

The results support the research hypothesis that there are statistically significant differences in favor of the post-test, indicating a positive impact of the innovative application in addressing some language learning issues in children with dyslexia. These findings align with previous studies, such as those by Gooch et al. (2016) and Rodríguez-Ferrer et al. (2023), and numerous other studies, which suggest that employing purposeful and enjoyable play, particularly within the framework of modern educational neuroscience, can help mitigate the symptoms of dyslexia. This alignment reinforces the credibility of the research in relation to its objectives and methodology.

The set of games included in AraRead, addressing specific issues in learning Arabic and catering to the cognitive needs of this group, clearly demonstrate the positive relationship between interactive digital reading and phonological awareness, mental lexicon, comprehension, and metacognitive awareness. This is evident in the children's interaction with the sounds of letters, repeating and singing them, and noting the differences in sound and form. This process enhances their awareness of letters both visually and auditorily, thereby inhibiting incorrect responses.

It has become apparent through the use of AraRead that digitally supported phonological awareness holds a significant place in learning to read, especially in its interactive form that engages all senses (hearing, sight, and touch). The repetition of sounds strengthens synaptic connections, thus maintaining the letter's sound and shape in memory, which can be recalled when needed. This was programmed into the application by including a response speed component.

Notes from participant observations revealed that children tend to prefer learning through enjoyable interactive play, becoming more motivated. This finding is consistent with numerous studies, such as those by Khaleghi et al. (2022) and Rodríguez-Ferrer et al. (2023). The initial programming of this application successfully eliminated psycho-emotional differences related to age; the playful and challenging environment broke down psychological barriers among children, allowing learning needs to be addressed without age-related distractions. Consequently, during the intervention period, positive changes and improvements were observed in the acquisition of the Arabic language code. Most learners progressed from the beginner level to the letter level, or from the letter level to the word level.

5.4.Study Limitation and Direction for Future Research

One notable limitation of this research is the small sample size, consisting of only 36 participants, which may limit the generalizability of the findings. Additionally, the study utilized one tablet for every two students during the experiment. Ideally, each student should have had access to an individual tablet to ensure more consistent and personalized use of the application. Furthermore, the duration of app usage was relatively brief, which may not fully capture the long-term effects or benefits of the application on language learning. Addressing these limitations in future research by increasing the sample size, providing individual tablets, and extending the app usage period could enhance the reliability and applicability of the results.

We strongly encourage further research on this topic, given the pressing need to integrate smart digital applications into the Moroccan context, particularly for language acquisition and addressing challenges at the phonological, phonetic, morphological, syntactic, and semantic levels. This need is especially critical for both typically developing children and those with developmental learning disorders. The rapid technological advancements that learners are experiencing today underscore the urgency of this issue. Future research should explore the intersection of didactics and digital technology through the lens of educational neuroscience, paving the way for innovative approaches to enhancing language learning and addressing learning difficulties.

6. CONCLUSION

In conclusion, this research, which utilized a pre-test and post-test design to evaluate the effectiveness of a mobile application for children with dyslexia, yielded two significant findings. Firstly, the results corroborate existing literature on the utility of digital applications in supporting children with dyslexia, affirming their role in facilitating language acquisition. Secondly, the study demonstrated that these applications not only enhance learning outcomes but also significantly boost motivation and foster self-directed learning among the children. These findings underscore the value of integrating technology into educational practices and highlight the potential for mobile applications to positively impact both learning efficiency and student engagement. As such, this research contributes to a growing body of evidence supporting the use of digital tools in education and encourages further exploration into their application and effectiveness.

Disclosure statement

The three authors report no potential conflict of interest.

Data availability statement

Data available as SPSS files and observation sheets if requested.

REFERENCES

Antoniou, F., & Souvignier, E. (2007). Strategy Instruction in Reading Comprehension: An Intervention Study for Students with Learning Disabilities. *Learning Disabilities: A Contemporary Journal*, *5*(1), 41-57.

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education*. 5th ed. RoutledgeFalmer

Cohen, L., Salondy, P., Pallier, C., & Dehaene, S. (2021). How does inattention affect written and spoken language processing?. *Cortex*, *138*, 212-227.

Corsini, R. J., & Ozaki, B. D. (1994). *Encyclopedia of psychology* (Vol. 1). New York: Wiley.

Creswell, J. W. & Creswell, J. D (2018). Research Design Qualitative, Quantitative, and Mixed Methods Approaches Fifth Edition. SAGE Publications, Inc.

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*.Fourth edition Pearson: University of Nebraska- Lincoln.

Erbeli, F., Rice, M., & Paracchini, S. (2021). Insights into dyslexia genetics research from the last two decades. *Brain Sciences*, *12*(1), 27.

Gooch, D., Vasalou, A., Benton, L., & Khaled, R. (2016, May). Using gamification to motivate students with dyslexia. In *Proceedings of the 2016 CHI Conference on human factors in Computing Systems* (pp. 969-980).

Higher Council for Education, Training and Scientific Research (CSEFRS) (2008). Annual Report

Jonker, J., & Pennink, B. (2010). *The essence of research methodology: A concise guide for master and PhD students in management science*. Springer Science & Business Media.

Khaleghi, A., Aghaei, Z., & Behnamghader, M. (2022). Developing two game-based interventions for dyslexia therapeutic interventions using gamification and serious games approaches entertainment computing journal. *Entertainment Computing*, *42*, 100482.

Kornhaber, M. L. (2002). Howard Gardner 1943–. In *fifty modern thinkers on education* (pp. 272-279). Routledge.

Miciak, J., & Fletcher, J. M. (2020). The critical role of instructional response for identifying dyslexia and other learning disabilities. *Journal of learning disabilities*, *53*(5), 343-353.

Moeschler, J. (2004). Intercultural pragmatics: a cognitive approach.

Mullis, I., Von Davier, M., Foy, P., Fishbein, B., Reynolds, K., & Wry, E. (2023). PIRLS 2021 International Results in Reading. TIMSS & PIRLS International Study Center. https://doi.org/10.6017/lse.tpisc.tr2103.kb5342

Nourbakhsh, S., Mansor, M., Baba, M., & Madon, Z. (2013). The effects of multisensory method and cognitive skills training on perceptual performance and reading ability among dyslexic students in Tehran-Iran. *International Journal of psychological studies*, *5*(2), 92-99.

Rodríguez-Ferrer, J. M., Manzano-León, A., Aguilar-Parra, J. M., & Cangas, A. (2023). Effectiveness of gamification and game-based learning in Spanish adolescents with dyslexia: A longitudinal quasi-experimental research. *Research in Developmental Disabilities*, *141*, 104603.

Snowling, M. J., Hulme, C., & Nation, K. (2020). Defining and understanding dyslexia: past, present and future. *Oxford review of education*, *46*(4), 501-513.

Thomas, M. S., Ansari, D., & Knowland, V. C. (2019). Annual research review: Educational neuroscience: Progress and prospects. *Journal of Child Psychology and Psychiatry*, *60*(4), 477-492.

About the Authors

Driss El Bouda ***is doctoral researcher at the department of Arabic studies, Ecole Normale Supérieure, Mohammed V University in Rabat.***

Aziz Ouladhadda*: Ecole Normale Supérieure, Mohammed V University in Rabat (Department of Foreign Languages and Cultures).*

Hassan Malek, Ph.D, ***is a Professor of Applied Linguistics at the Department of Arabic studies, Ecole Normale Supérieure, Mohammed V University in Rabat, Morocco.***