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ARELE-bot: Inclusive Learning of Spanish as a Foreign Language Through a Mobile App Integrating Augmented Reality and ChatGPT

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ABSTRACT

Formal learning of Foreign Languages (FL) is often perceived as a challenging process, especially for students with Specific Learning Disorders (SLDs), notably those with developmental dyslexia. In educational settings, traditional teaching methods and materials often fail to adequately meet the unique needs of these students. Elements such as the pace of classes, the student-teacher ratio, and evaluation criteria can exacerbate their difficulties, making the educational experience challenging and frustrating. This study introduces ARELE-bot, a novel mobile application that integrates Augmented Reality (AR) and ChatGPT, with the intent of operating within an inclusive approach in the field of linguistic education. The article details the development and key features of ARELE-bot, emphasizing how its functionalities have been designed to meet the specific needs of students with dyslexia and, more generally, SLDs. ARELE-bot positions itself as a complementary educational resource, aiming to provide an accessible, and personalized learning experience in a non-judgmental context. Its purpose is to enhance the learning processes of Spanish as a Foreign Language (SFL) and, at the same time, to increase students' positive attitudes towards SFL.

Index Terms: Augmented Reality—ChatGPT—Spanish as a Foreign Language—Dyslexia—Inclusivity

1 INTRODUCTION

Learning a Foreign Language (FL) involves complex processes that encompass linguistic, cognitive, and cultural aspects. In formal education, this task can be daunting and sometimes frustrating, especially for students with Specific Learning Disorders (SLDs), such as dyslexia[1], which is the most widespread and impactful in this diagnostic category for language learning. The growing interest in dyslexia and SLDs from various scientific and research fields, along with legislative measures for educational equity, has not entirely resolved the challenges faced by students with these disorders. Traditional educational environments often struggle to effectively engage students with SLDs. In a conventional formal learning setting, factors such as the pace of classes, student-teacher ratio, and evaluation criteria can exacerbate their difficulties, making the educational experience more challenging [17]. This situation highlights the need for more accessible and inclusive teaching methods and materials. The integration of Artificial Intelligence (AI) and Augmented Reality (AR) in language education introduces innovative methods but also poses challenges in maintaining the crucial balance between technology and the human elements of language learning.

In response to these challenges, the introduction of ARELE-bot[2] may mark an advancement in modern language education. This mobile application integrates AI, including ChatGPT, and AR technologies. Its primary goal is to provide an accessible, personalized, and non-judgmental learning experience. ARELE-bot aims to complement traditional teaching methods and support language teachers, rather than replace them. It offers a unique environment that can reduce linguistic anxiety, stimulate motivation, and improve overall linguistic performance, ultimately leading to enhanced proficiency in Spanish as a Foreign Language (SFL).

During the design and development of this app, particular focus is given to its effectiveness for students with dyslexia, by utilizing their unique cognitive skills, termed the 'holodysnomic brain.' This term, originating from 'Holo-' for global and '-dysnomia' for a deviation from usual cognitive processes, highlights the dyslexic strength in global and holistic information processing. These individuals demonstrate a remarkable ability to merge data from varied sources, and their robust holistic visual processing and visual memory offer significant advantages in specific tasks [7]. This leads to a distinctive approach to thought that positively deviates from the conventional norms, offering unique advantages in language learning contexts which ARELE-bot is designed to harness, providing specialized assistance for their specific areas of difficulty.

In the following sections, this paper will investigate the specific challenges dyslexic students face in foreign Language learning, utilizing current research and their distinct cognitive strengths characterized by a holistic and global information processing approach. Additionally, it will explain how AI and AR integration can enhance language learning and improve accessibility, while also considering the potential difficulties in applying these technologies in language education. Subsequently, we delve into the design and features of ARELE-bot, detailing how it addresses these specific challenges through its deliberate use of AI and AR technologies. Finally, we conclude that the app holds significant potential to enhance educational inclusivity and effectiveness for students facing these challenges.

2 RELATED WORK

This Section offers an overview of relevant research focusing on SLDs and dyslexia in Foreign Language Learning (Section 2.1) and on AI and AR's roles in language education (Section 2.2). It also explores some of the critical challenges of the application of AI and AR technologies in language education (Section 2.3).

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[1] In this contribution, the term dyslexia will refer exclusively to developmental dyslexia.

[2] The app takes its name from the combination of two acronyms: AR (Augmented Reality) and ELE *(Español como Lengua Extranjera)* - Chatbot.

2.1 SLDs, Dyslexia and Foreign Language Learning

SLDs pose a considerable challenge in the educational context. International estimates suggest that their global prevalence ranges from 3% to 15%, influenced by varying definitions and diagnostic criteria used across countries [5, 12, 30, 60]. Based on neurobiological and evolutionary foundations, SLDs specifically affect the learning of essential academic skills such as reading, writing, and mathematics, while not altering general intellectual functions. They often co-occur with issues in self-regulation, social perception, and interaction but are not directly caused by external factors like cultural or educational influences [11]. SLDs are characterized by significant comorbidity and can coexist with other disorders, such as Attention Deficit Hyperactivity Disorder (ADHD) and emotional conditions like anxiety, low self-esteem, and depression [2, 33, 57]. This added complexity leads to further challenges in students' educational journeys, often resulting in academic failures and impacting personal and social development [40, 42]. Among SLDs, dyslexia is the most widespread disorder, affecting about 80% of individuals with an SLD and significantly influencing the development of linguistic skills [46, 47]. Dyslexia is a neurobiological disorder, characterized by genetic, morphological, and neurofunctional anomalies [14, 16, 19, 25, 26, 45, 54], manifesting in difficulties in decoding and recognizing words.

Given these difficulties, students with SLDs, particularly those with dyslexia, face challenges in several areas of Foreign Language learning, as noted in Melero (2020). In reading and text comprehension, they struggle with text decoding and phonological processing, which requires extensive cognitive effort and affects their ability to understand texts deeply. Listening skills are hindered by problems in auditory processing and phonological memory, making it difficult to grasp spoken language, especially in foreign contexts. Writing is also a challenge due to lexical, morphosyntactic, and syntactic retrieval issues, impacting the quality of their written work and their ability to organize text effectively. Additionally, speaking and oral interactions are affected by difficulties in lexical retrieval and phonological processing, leading to reduced fluency and accuracy in their spoken language [34]. Additionally, memory retention, particularly for sequential or detailed information, can be a significant hurdle for them, as well as difficulties in organization [28, 35, 36, 48, 49]. These cognitive difficulties are further compounded by challenges in maintaining attention and motivation in conventional learning environments, making traditional language education methods less effective for them. These cognitive challenges are often accompanied by behavioral and emotional difficulties, including frustration, stress, and a decline in motivation, negatively impacting self-esteem and leading to avoidance behaviors. Anxiety related to linguistic performance can create mental blocks, hindering language performance [39].

On the other hand, individuals with dyslexia exhibit a unique cognitive profile, often characterized by a holistic and global approach to information processing, as described in the 'holodysnomic brain' concept. Their strengths lie in their ability to integrate information from multiple sources, a skill that lends itself well to creative and artistic endeavors, as well as divergent thinking. This cognitive style also includes robust holistic visual processing and strong visual memory skills, providing them with distinct advantages in certain tasks [7]. However, these strengths are counterbalanced by challenges in traditional language learning areas.

Well-designed educational tools should therefore leverage these cognitive advantages while providing support in areas of weakness. By highlighting and utilizing their strengths in holistic and visual processing, and simultaneously addressing challenges in phonological and auditory processing, memory, and organizational skills, along with adaptive assessment, the design of these systems can offer a more effective and personalized learning experience for individuals with dyslexia.

2.2 Enhancing Language Learning: Integrating AI and AR Tools

AI-driven tools in language education, including AI-powered automatic speech recognition (ASR), AI-powered chatbots such as ChatGPT, and advancements in AI in Language Testing have transformed the methodology of language learning and education in language acquisition technologies [53]. In the context of language learning, ASR emerges as a vital tool for pronunciation training and oral skill development. It enables the applications to accurately transcribe and assess spoken language inputs from learners, providing immediate feedback on their speech accuracy and fluency [58]. Particularly noteworthy is the role of AI-powered chatbots like ChatGPT in this technological ensemble. ChatGPT, as an advanced chatbot, offers interactive and conversational practice by simulating real-life dialogues in the target language. This feature is crucial in not just enhancing language proficiency, but in providing a responsive and engaging learning environment. Users can practice and refine their language skills in a dynamic setting, closely mimicking real-world interactions. This hands-on approach facilitates a deeper understanding and retention of language, making ChatGPT an invaluable tool in language learning applications [44]. Progress in language evaluation through AI, including ChatGPT, utilizing sophisticated algorithms, offers personalized and adaptive testing experiences, comprehensively measuring language proficiency [32, 59].

Augmented Reality, on the other hand, adds an immersive dimension to language learning. By overlaying digital information onto the physical environment, AR applications can create context-rich, interactive scenarios that facilitate language comprehension and retention [8, 50–52]. AR's potential is exemplified by its ability to simulate real-life situations where language skills are applied, thereby bridging the gap between theoretical knowledge and practical application. For instance, Ibrahim et al. [29] and Weerasinghe et al. [55] introduce novel systems for immersive language learning through dynamic labeling of real-world objects. They compare this AR-based approach to traditional learning, finding that AR is more effective and enjoyable, with significant improvements in immediate and delayed recall tests. Additionally, an AR system designed for learning Japanese compound verbs, which utilizes image schema and animations, demonstrated notable improvements in post-test performance and retention [18]. In addition, AR can create virtual environments where learners can engage in simulated dialogues with native speakers or AI-driven characters, thereby improving their conversational fluency and comprehension. Such environments can mimic everyday situations like shopping, dining, or traveling, providing learners with practical language usage experiences [13]. Moreover, AR's interactive nature encourages active participation, which is essential for language retention and mastery [41].

2.3 The Role of AI and AR in Enhancing Accessibility and Inclusivity

The integration of AI and AR in language learning applications also significantly contributes to making language learning more accessible and inclusive for a broader spectrum of learners. For instance, ASR applications are not only beneficial for pronunciation training but also serve as an essential tool for learners with writing or typing difficulties, enabling them to interact with the application through speech [20]. AI-driven chatbots can adjust their interaction style and content complexity based on the learner's profile, ensuring that the educational material is accessible and comprehensible to all users. Furthermore, advancements in AI in Language Testing incorporate adaptive algorithms that can modify the testing format to suit the needs of learners with disabilities, ensuring fair and equitable assessment conditions [27]. AR can provide visual and auditory cues in language learning scenarios, which are particularly beneficial for learners with SLDs or attention deficits [3]. By creating an engaging and multisensory learning environment, AR helps in maintaining

focus and motivation among these learners [56]. Additionally, AR's ability to create simulated real-world environments is invaluable for learners with mobility limitations, allowing them to experience diverse linguistic and cultural contexts without physical travel [4].

2.4 Critical Challenges of Application of AI and AR Technologies in Language Education

The integration of AI and AR technologies in language education, while offering numerous benefits, also brings critical challenges. The shift towards technology-mediated language instruction, such as AI-driven tools, can lead to a diminished presence of direct human interaction, which is vital for developing communication skills and cultural competencies in language learners. Kozar [31] emphasizes that the absence of face-to-face interaction can impact the development of pragmatic language skills, which are best nurtured through real-life conversational experiences. AI-driven chatbots, such as ChatGPT, offer interactive language practice but may lack the depth and flexibility of human tutors. They are often critiqued for their inability to fully understand and respond to the nuances of human emotion and cultural contexts, which are crucial in language learning, potentially leading to misunderstandings or limited conversational scope [15]. On the other hand, AR brings an immersive dimension to language learning, yet it is not without its drawbacks. Bower et al. [10] point out that while AR can create engaging, context-rich learning experiences, it may also lead to cognitive overload, as learners have to process both the real world and the overlaid digital information simultaneously. Additionally, Godwin-Jones [21] argues that the effectiveness of AR in language education is contingent on the quality and relevance of the augmented content, which can be challenging to align with specific learning objectives and cultural nuances. These criticisms underscore the need for careful integration of AI-driven tools and AR in language learning environments, ensuring that these technologies complement rather than replace the essential human elements of language acquisition.

3 METHODOLOGY

This section details key features of ARELE-bot, with particular emphasis on how its functionalities have been carefully designed to specifically meet the needs of students with dyslexia.

3.1 Design Strategies Tailored for the Requirements of Individuals with Dyslexia

Our literature review highlights the unique challenges that individuals with dyslexia face in language learning, such as difficulties in phonological processing, auditory processing, memory, organizational abilities, and maintaining attention and motivation. On the other hand, their strengths include the effective integration of diverse information sources and strong visual processing skills. Furthermore, it also underscores the advantages of integrating AI-driven tools and AR thoughtfully in language learning contexts, ensuring that these technologies enhance rather than supplant the crucial human aspects of language learning. Considering these elements, this section outlines the specific design strategies of ARELE-bot, tailored to meet the educational needs of students who present this learning disorder.

ARELE-bot has been meticulously developed with a user-centric focus, incorporating interfaces and modules specifically targeted to enhance the learning experience for learners facing such challenges. Capitalizing on their skills in visual processing and memory, the app highlights the significance of visual learning strategies, enabled through AR technology. AR components in ARELE-bot generate immersive, contextual-rich settings by superimposing digital data onto the real world, enhancing both motivation and attention.

Further enhancing its approach, ARELE-bot offers a customizable learning experience, enabling users to tailor language proficiency levels [3] and interaction pace. This adaptable approach aligns with user preferences, easing cognitive load and stress, particularly benefiting dyslexic students by allowing them to learn at their own pace, enhancing confidence and motivation.

Interactive and multisensory learning is another key element of ARELE-bot's design. By combining visual and auditory elements, the app creates a rich, immersive learning experience. Interactive, conversation-based learning is facilitated through dialogues with a teacher's avatar in an AR environment, making language practice realistic, engaging, and relatable.

ARELE-bot also includes features that aid in organization, planning, and sequencing with an emphasis on visual modes of interaction. Users can create and edit their visual dictionaries and visual semantic networks, helping them visually organize vocabulary and concepts for enhanced understanding and recall.

The design of ARELE-bot also focuses on reducing cognitive load, presenting information in small segments with simple instructions and an intuitive, uncluttered user interface. This ensures a seamless and enjoyable learning experience without overwhelming the user with complex navigation or information.

Finally, ARELE-bot features an adaptive assessment system that personalizes language learning exams according to the proficiency level selected by the user, ensuring a customized educational experience. The app includes positive reinforcement, and continuous, constructive feedback as part of an extensive language learning assessment, designed to keep learners engaged and motivated. The app's assessments are designed to be stress-free and encouraging, focusing on understanding and progress, thus contributing positively to the overall learning experience.

3.2 Feature Description

The application starts with a registration and sign-in process. Upon entry, users are greeted by name and prompted to select their language proficiency level. This level of personalization is dynamic, allowing users to adjust their language level as they progress, thereby ensuring the learning experience evolves with them.

Continuing this, the application offers four main features: conversation with the virtual teacher's avatar, discovering word meanings, exploring dictionaries, and examining language skills. These will be detailed in the subsequent sections:

3.2.1 Conversation with the virtual teacher's avatar

In the ARELE-bot language learning application, the user has the option to have a conversation with the virtual teacher's avatar, experienced through an AR interface that incorporates the use of OpenAI's chat feature. The user should scan the ground, to find a suitable place for the placement of the avatar. This action leads to the unveiling of the conversation interface which allows users to actively engage in simulated real-life conversations by speaking to the virtual teacher via a microphone button. This feature is instrumental in honing verbal communication skills, as it mirrors actual conversational scenarios. Moreover, the inclusion of a stop button empowers users to pause the teacher's responses, granting users agency, thus allowing learners to customize the interaction according to their unique learning requirements and preferences (See figure 1a).

3.2.2 Discovering word meaninings

Another functionality of ARELE-bot includes an interactive feature for learning the meanings of words and lexical chunks. Users can capture images or vocalize words and chunks to enhance their contextual understanding, multisensory learning, and memory retention (See figures 1b, 1c). In image capture mode, objects are labeled and bordered for easy identification (See figure 1b). Users then select a

[3]The language proficiency levels in ARELE-bot are based on the scale of the Common European Framework of Reference for Languages (CEFR).

name from the detected objects list and access a detailed information page with various learning aids (See figure 1d). This page is also accessible for vocalized words, offering similar learning aids. It includes a suggested editable object name, a selection of images, and a sentence contextualizing the word's use. Users can listen to and adjust the pronunciation speed, practice speaking themselves, and receive feedback. The learning process concludes with saving the interaction in the cloud-based visual dictionary for future review, supporting long-term vocabulary retention.

3.2.3 Exploring dictionaries

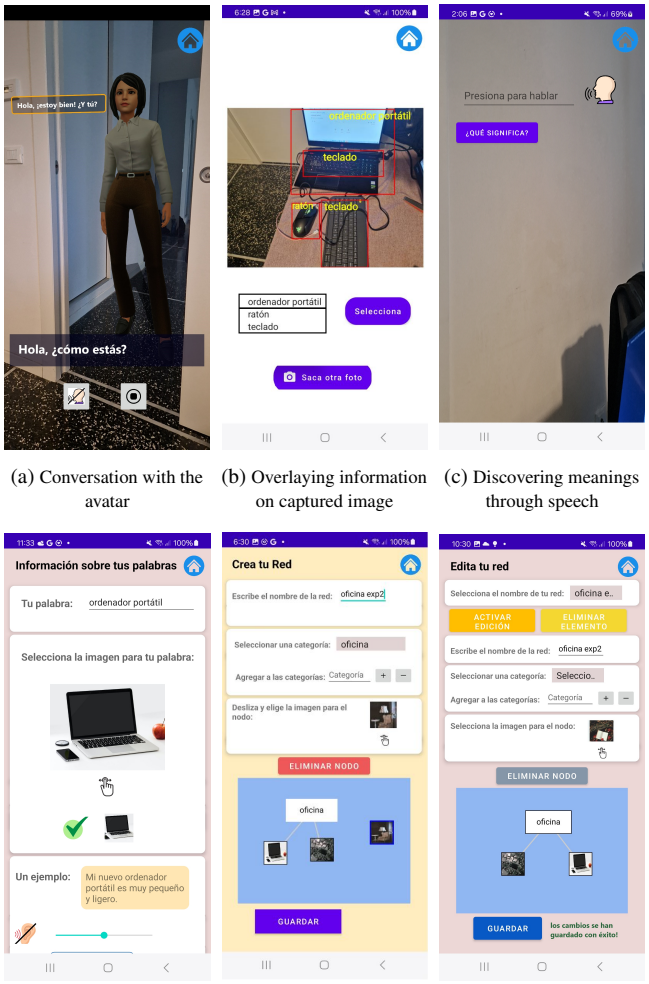
The ARELE-bot application enriches language learning with its advanced dictionary exploration and management features, crucial for building a strong vocabulary and semantic networks, thereby improving visual learning and organizational skills. Users can access and practice their stored vocabulary in the visual dictionary, enhancing retention and pronunciation accuracy. Additionally, the app enables the creation of visual semantic networks by selecting category names and adding visual nodes from saved objects, aiding in understanding language structure (See figure 1e). Users also have the option to edit these networks at a later stage by adding new categories or images and forming connections between them, allowing for a flexible and dynamic learning experience (See figure 1f).

3.2.4 Examining the language skills

In the design of ARELE-bot, a significant component is the examination module, which utilizes the Open AI API and is customized according to the user's chosen language proficiency level. This module offers a suite of exams, meticulously crafted to align with the user's language proficiency as defined by CEFR. Utilizing AI models from OpenAI, the exams are dynamically generated, ensuring a tailored personalized experience. Each exam segment - reading, vocabulary, listening, and grammar - is strategically designed to assess specific linguistic competencies. For instance, the reading exam presents a concise text of 100-150 words, followed by five multiple-choice questions, aimed at evaluating comprehension skills. Similarly, the vocabulary section challenges lexical knowledge through ten targeted questions. The listening and grammatical components, comprising five and ten questions respectively, are structured to test auditory processing and the understanding of various grammatical aspects. A notable element of these exams is the immediate, static feedback mechanism, which motivates users to persist in finding the correct answer. Moreover, the integration of time-tracking functionalities aids learners in developing effective time management skills, a crucial aspect often overlooked in language learning.

4 Implementation

In the creation of the ARELE-bot language learning application, specifically targeted for Android smartphones, Android Studio software [24] was employed as the development platform, utilizing Kotlin and Javascript as the main programming languages. A range of integrations were meticulously executed to enhance its functionality and user experience. The OpenAI API, particularly the GPT-3.5-turbo-instruct model [37], is a cornerstone of the app, enabling interactive conversations with the virtual avatar, language exams, and contextual examples for the words. Complementing this, TensorFlow Lite Vision API [22] is employed for object detection in captured photos. For backend operations, the app utilizes the Parse Platform SDK [38] and Back4App BaaS [6], ensuring efficient and secure data management, including user data and learning materials. AR elements are brought to life using the Sceneform library [43]. The Android Speech package is another key integration, facilitating speech-to-text and text-to-speech conversions for interactive language tasks and pronunciation practice [23]. The 3D avatar of the teacher is developed using the "Ready Player Me" [1] tool and animated with Blender Software [9]. Together, these elements



(a) Conversation with the avatar

(b) Overlaying information on captured image

(c) Discovering meanings through speech

(d) Information page, and building visual dictionary

(e) Creating semantic networks

(f) Editing semantic networks

Figure 1: A collection of interfaces

constitute the core of ARELE-bot, establishing it as a cutting-edge, accessible language learning solution.

5 Conclusion and Future Work

ARELE-bot is designed to address the cognitive, emotional, and behavioral needs of students with SLDs, particularly those with dyslexia, turning their challenges into strengths and creating an inclusive environment for language learning. It operates under a neurodiversity framework, emphasizing visual, multisensory, organizational, and communicative skills, along with adaptable real-time assessment, all within a supportive and non-judgmental space that reduces anxiety. Additionally, it is intended to augment traditional teaching methods and assist language teachers, not to supplant them. ARELE-bot has the potential to not only open new pathways for students and teachers in language education but also enrich teaching and learning through its engaging, immersive, and personalized approach.

Future improvements could involve expanding the range of languages for increased inclusivity and enhancing personalization features to more effectively cater to varied learning preferences and special needs of the target group.

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