LetterHeroes: Designing Support Systems for Improving Literacy Levels in Romanian Children with Dyslexia

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ABSTRACT
Dyslexia, also called specific reading disability, is a neurodevelopmental disorder that characterizes moderate and imprecise word identification and recognition, impairments in decoding, word reading accuracy and fluency, and spelling. In Romania, awareness and recognition of dyslexia as a distinct learning difficulty is relatively recent and effective digital support tools in Romanian are lacking. Dyslexic children need adapted support in letter recognition, syllable identification and pronunciation to develop their reading ability. We describe a user-centered design process in developing an application that supports early literacy development (letter recognition/identification, phoneme identification, syllables, spelling and reading) for the Romanian language. We describe the scientific foundation for our approach, the design process and the results of qualitative evaluation with field experts.

Author Keywords
Dyslexia; assistive technology; User Centered Design.

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H.5.m. Information interfaces and presentation (e.g., USI): Miscellaneous.

General Terms
Human Factors; Design; Measurement.

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INTRODUCTION

Dyslexia, also known as a specific reading disability, is a neurodevelopmental disorder characterized by challenges in word identification, decoding, reading accuracy, fluency and spelling [3, 12]. Individuals with dyslexia struggle with reading despite having age-appropriate language comprehension skills [3] and often possess normal intelligence and sensory abilities, yet exhibit significant reading deficits.

This condition is the most prevalent neurobehavioral disorder in children and young adults, impacting an estimated 5% to 20% of the population [4, 6, 9]. Diagnosis often occurs late, typically after a child has repeatedly failed to learn to read in elementary school. Such delays not only put children at an academic disadvantage but can also contribute to anxiety and depression [16]. Identifying this specific learning disability requires highly particular diagnostic criteria [3]. If not adequately addressed, dyslexia can have significant long-term effects on functional reading and writing abilities, which are crucial for full societal participation. The inability to read accurately and fluently can lead to negative consequences like poor educational outcomes, limited occupational choices, lower employment rates, reduced self-esteem and poorer mental and physical health. Therefore, early identification of dyslexia is vital for maximizing a child's educational potential, but ongoing progress monitoring and access to appropriate intervention programs are also essential, as reading difficulties may persist or emerge later in a child's schooling [3].

Dyslexia presents in various subcategories, each linked to specific symptoms: phonological dyslexia - affects the ability to break words into individual sounds (phonemic awareness); surface dyslexia - causes difficulty recognizing familiar words and matching printed words to their sounds; rapid naming deficit dyslexia - involves trouble quickly naming letters, colors and numbers; double deficit dyslexia - combines issues from two reading areas, such as rapid naming and phonological awareness; visual dyslexia: leads to difficulty remembering recently read text and challenges with spelling and letter formation; deep dyslexia: Impacts the ability to sound out nonsense words and often involves semantic errors (e.g., substituting "avenue" for "road" - replacing the actual written word with another that has a similar meaning but is not the correct word**,** because of difficulties with phonological decoding) [10, 25].

DYSLEXIA IN ROMANIA

In Romania, the Education Law was supplemented with a provision targeting people with learning disabilities in 2016. Before that, the dyslexic children were not recognized as a distinct disability, but most of the time they were considered lazy and unmotivated.

The main challenge is the absence of systematic screening at the beginning of first grade for all children (an important period as the main objective of the child activity is learning, learning to read and write), hence the difficulties of each one cannot be identified by the specialists. Children are tested by a speech therapist, but not specifically for dyslexia. That is the main reason that a lot of children with dyslexia are not identified and there are many situations in which parents realize too late the difficulties their children are facing. According to data from the Romanian Association for Dyslexic Children, specialists evaluate on average 650 children in schools and 75 children in private offices each year. Of these, approximately one in six are diagnosed with dyslexia (http://dislexic.ro/).

The general ranges of dyslexic people expand from less than 5 percent to 20% [20, 21]. Statistics show that 15% of people have dyslexia, meaning over 30 million adults in the United States, about 6 million in the United Kingdom and 3 million in Canada [27].

The percentage of dyslexic children in European countries may vary from 6 to 10%. Romania is probably between the percentages of European statistics. In almost every class, there is at least one dyslexic [18]. Dyslexia is not yet a recognized learning disorder by teachers, hence not approached accordingly in the learning environment. That is the main reason that a lot of children with dyslexia are not identified and there are many situations in which parents realize too late the difficulties their children are facing [11].

The research in [18] identifies a lack of background and experiences of schools, teachers and parents, to reduce the gap in knowledge, skills and attitudes of professionals working with dyslexic students, to develop support mechanisms, techniques, or motivations. The recommendations draw from the research include training sessions for teachers (knowledge, skills, attitudes, building the gap between existing and required competencies), organizing therapeutic services for dyslexic students aiming specific difficulties due to learning disorders (speech and language therapy, psychomotricity etc., to develop resources centers within schools for dyslexic students) and a network of support teachers adapting the learning according to the needs of students, offering training and support services for parents.

ROLE OF TECHNOLOGY IN SUPPORTING READERS/READING FOR DYSLEXIC CHILDREN

Technology offers powerful tools for all learners, and it can be especially supportive for those with dyslexia. Assistive software can provide age-appropriate scaffolding that fosters independence, confidence and self-esteem [11, 16]. Such tools allow dyslexic learners to demonstrate their abilities without being constrained by difficulties in decoding or spelling [9, 12].

A wide range of hardware and software solutions have been designed to support everyday skills such as accurate reading, comprehension, spelling, writing and organization. Examples include text-to-speech, speech-to-text and adaptive reading platforms [2, 13]. These technologies enhance accessibility and promote autonomy by compensating for literacy-related challenges.

Recent studies emphasize that the most effective approaches are multisensory, structured and individualized [7, 17, 19]. However, applying such methods consistently in classrooms remains challenging. Educators face large class sizes, limited resources and insufficient training in dyslexia-specific techniques [18], while psychologists underline the difficulty of sustaining motivation among dyslexic learners over extended periods [6]. This gap creates a demand for software-based systems that can reinforce literacy development through interactive, adaptive and evidence-based methodologies [2, 8, 22].

Applications for Dyslexia

Children with dyslexia may benefit from assistive technologies such as text-to-speech software, phonics-based educational games and adaptive learning applications, which provide multisensory support and improve engagement [2, 7, 13, 17]. Apps created specifically for teachers and parents to use with their dyslexic kids can help them overcome their learning difficulties. The key features of dyslexia-friendly apps are: multisensory approach (sight, sound, touch) to reinforce learning; phonics-based - many apps focus on teaching phonics, the connection between letters and sounds, which is crucial for reading development, visual aids - clear fonts, color-coding and visual cues can reduce visual confusion; auditory support - text-to-speech (TTS) features allow children to hear words read aloud, which can improve comprehension; gamification - turning learning into games keeps children engaged and motivated and personalization - allow customization to suit individual learning needs.

Educational researchers and software engineers have begun to bridge the gap between scientific understanding and classroom practice, leveraging digital tools to assist with early diagnosis and personalized intervention. For instance, the iLearnRW project [22] proposed a gamified, adaptive learning platform for children, grounded in evidence-based strategies and tailored to the user's individual difficulties. Similarly, apps like DysWebxia [13] and IREAD [2] integrate text simplification, speech technologies and visual customization to enhance reading comprehension and learner autonomy. The advent of artificial intelligence has further expanded the landscape. Recent literature reviews [1] and novel applications such as Alexza [15] or the puzzle-based screening tool from [14] demonstrate how deep learning and machine learning can aid in the early detection of dyslexia based on behavioral data, handwriting patterns, or gameplay telemetry.

Mobile and web-based applications now serve as flexible, scalable and inclusive platforms for learners with dyslexia. Projects like Helpdys [8] focus on underserved or rural populations, showing that digital interventions can bridge educational equity gaps. Moreover, user-centered and participatory design methodologies - such as those employed

in the Design Thinking-based development by Yedra and Aguilar [26] highlight the importance of aligning technical solutions with the lived experiences of learners and educators. Taken together, these developments represent a shift from one-size-fits-all interventions toward highly personalized, data-driven support systems. While promising, these solutions also face challenges related to scalability, language specificity and integration into formal educational frameworks. Nonetheless, they mark a crucial step in the evolution of dyslexia support from theory to practical, engaging and effective tools accessible to children, parents and educators alike We could not find any application developed for Romanian children that targets dyslexic children to improve their literacy level. Our goal is to develop support applications for reading and phoneme understanding for Romanian children using a user-centered approach. We address the following aspects that are poorly developed in dyslexic children: learning to recognize, read and write letters, recognizing phonemes, spelling words and filling in missing words in statements.

Research Aims

Building on the existing landscape of dyslexia support applications, this study was conducted to explore how such tools could be adapted to the Romanian educational context, where no localized solutions currently exist. Our work was guided by three main aims: to identify the specific literacy challenges faced by Romanian children with dyslexia, to apply User-Centered Design (UCD) principles in developing an application that addresses these challenges through multisensory and gamified strategies and to evaluate the usability and perceived pedagogical value of the resulting prototype with domain experts.

CASE STUDY: LETTERHEROES

Methodology

To ensure the development of a usable product, we have used the principles of User Centered Design (UCD). The first step was the gathering of a multidisciplinary team to design and implement the application. The design and development team was composed of a student in Psychology and Educational Science, a parent of a dyslexic child from our university, a student from the Software Engineering master's program, a specialist in Dyslexia and an HCI expert.

First, we have organized multiple workshops to understand the challenges determined by dyslexia in the learning process. We have used the physical materials used nowadays in the teaching process: cards with letters, paper-based exercises and the primary reader. In this step, a set of constraints have been identified: the need for spoken instructions, the option to replay them, a big font size and the need to use vibrant colors. Moreover, the design team has studied state-of-the-art applications developed in English with the same goal and provided some alternative designs for the application. After obtaining feedback from experts in dyslexia, a prototype of the product has been developed and evaluated with them.

In parallel, the team analyzed state-of-the-art applications developed in English for similar purposes, which provided alternative design ideas and highlighted gaps relevant to Romanian learners. Based on these insights, early prototypes were created and refined iteratively. Feedback from dyslexia experts directly informed design choices - for example, adjusting font size for readability, incorporating audio instructions across all exercises and simplifying visual layouts to reduce cognitive load.

Design

The interface is embedded within a continuous narrative. As soon as the app launches, a story begins: Fifi the Fox has stolen the letters of the alphabet and Dudu the Bear asks the player for help to recover them (see Figure 1). Storytelling is deeply integrated into the UI itself - navigation between levels, transitions and game progression are all framed as episodes in Dudu's journey.

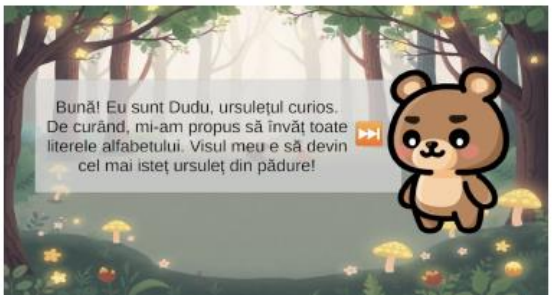

Figure 1. LetterHeroes – Main screen

The narrative interface includes 56 story levels, which serve as short, animated bridge scenes that advance the storyline and introduce new challenges. Between these story levels, players complete 214 interactive exercises that directly train literacy skills.

The application was developed in Unity, chosen for its flexibility in building interactive, animated educational games. It runs offline on Windows, macOS and Android devices and does not require any special hardware specifications. The game can simply be executed directly after installation.

Level Structure and Locking System

The main UI displays a map-like, scrollable level selection system. As previously mentioned, the app currently contains 214 interactive game levels, which include various types of phonetic and literacy-based games. We deliberately structured LetterHeroes to follow the Romanian abecedary sequence: starting with letters such as M, N, R, S, T rather than the conventional A, B, C - because this ordering is rooted in phonological and pedagogical principles tailored to Romanian learners. The abecedary is not merely an alphabetical primer; it orders letters by phonetic simplicity, sonority and the ability to form early decodable syllables (e.g., ma, me, na, ne). Studies on synthetic phonics show that introducing a small set of easily blended phonemes first

accelerates decoding skills [26]. The alphabetic principle - teaching systematic letter-sound correspondences - is particularly critical in transparent orthographies like Romanian for developing early literacy [23]. Moreover, research emphasizes that beginning reading programs are most effective when they start with phonically regular, high-utility graphemes, enabling learners to quickly read real words and boost confidence [5].

The application features 13 distinct types of educational games, each carefully designed to activate and integrate multiple sensory channels - visual, auditory and kinesthetic. This multisensory approach is grounded in well-established pedagogical principles and is particularly beneficial for children with dyslexia, who often require diverse modalities of input to reinforce learning. The progression of the games is carefully scaffolded: exercises begin with very simple tasks, such as identifying isolated letters and gradually increase in complexity as the user demonstrates mastery. This adaptive design ensures that the cognitive load is appropriate at each stage of learning and supports long-term retention through incremental challenges.

Levels are sequentially unlocked, as seen in Figure 2, ensuring structured progression. Once a player completes a set of tasks associated with a specific consonant, they unlock a new set of levels where that consonant is combined with each of the five vowels, forming syllabic groups such as *MA, ME, MI, MO, MU.* These syllables are then practiced individually through various game types. Finally, each consonant sequence concludes with a recapitulation exercise that requires the learner to differentiate between the syllabic forms, thereby consolidating both phonological and orthographic knowledge.

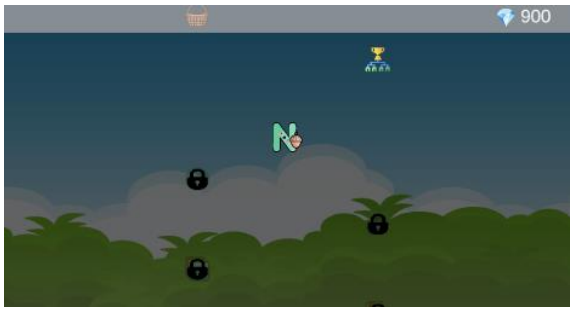

Figure 2. LetterHeroes – locked levels

Moreover, because some of the exercises involve verbal output - such as saying a letter or syllable aloud - the application is designed to be played in the presence of a parent, teacher, or speech therapist. This facilitates guided practice, ensures correct pronunciation and provides opportunities for immediate positive reinforcement and correction, making the learning experience both social and effective.

Letter Recognition Game

The letter recognition exercise is designed to develop and assess the player's ability to visually identify individual letters of the alphabet. In the example demonstrated, the user is prompted to identify and select the letter" N" from a set of distractor letters (see Figure 3).

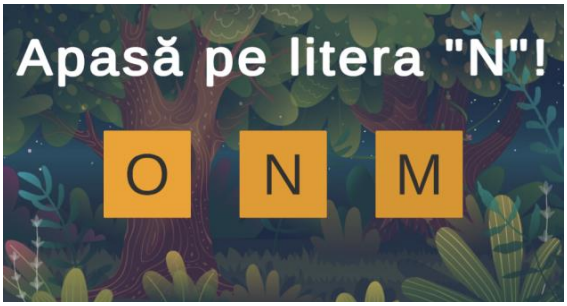

Figure 3. LetterHeroes – Letter recognition exercise

Letter Recognition Based on Sound

This exercise adds an auditory dimension to the letter recognition task by requiring the player to identify letters based on their associated phonemes. As shown in Figure 4, the user is instructed to press a bell icon to hear a sound, after which they must select the corresponding letter from a set of options. This activity supports the development of phoneme–grapheme correspondence, an essential skill in early reading acquisition and a known area of difficulty for children with dyslexia.

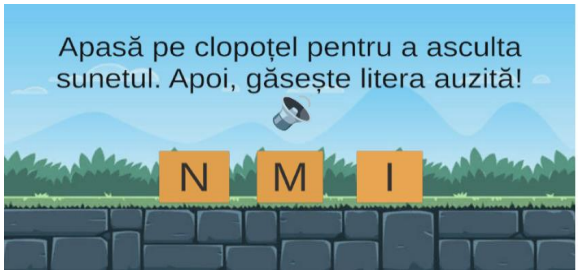

Figure 4: Letter Recognition Based on Sound Exercise

Matching Starting Sounds

This exercise targets phonological awareness, specifically the ability to identify the initial phoneme of a spoken word and match it with the corresponding image. As depicted in Figure 5, the user is presented with a set of six images, each accompanied by a sound icon. By clicking the icon, the player hears a word and must determine whether that word begins with the target letter. The task challenges the learner to listen attentively and isolate the initial sound of a word, reinforcing the association between spoken language and alphabetic characters. Correct selections are confirmed visually using green checkmarks, while incorrect answers prompt clear feedback and encouragement to retry. This game is a step forward in difficulty compared to isolated letter or sound identification tasks, as it requires the child to integrate auditory processing, semantic image recognition and phoneme discrimination.

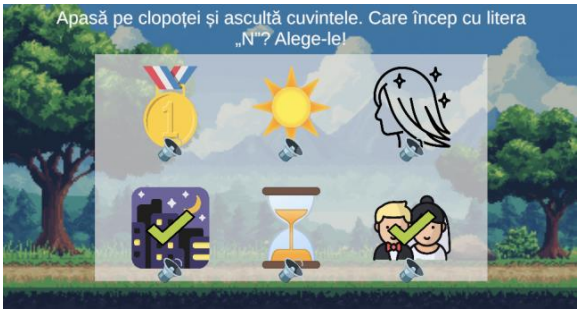

Figure 5. LetterHeroes – Matching sounds exercise

"Say Out Loud" Games

The "Say Out Loud" exercises are designed to develop oral fluency, phonemic awareness and reading confidence through verbal articulation. In these games, learners are encouraged to read either individual letters (as shown in Figure 6) or syllables out loud, following a clearly marked visual path that begins with a heart icon.

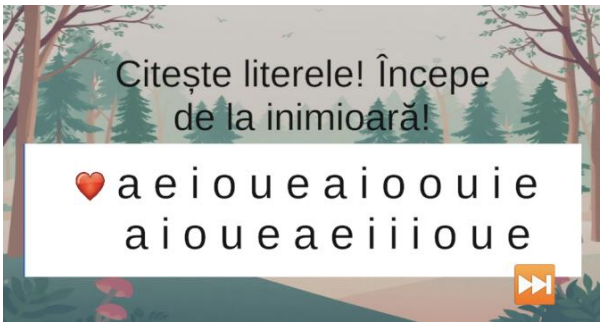

Figure 6. LetterHeroes – "Say Out Loud" game

Find Letters in Words

This exercise focuses on reinforcing letter identification within whole words, advancing the learner's ability to recognize target graphemes in context. As illustrated in Figure 7, the player hears a word pronounced by the character Dudu when clicking on a corresponding image. Once the word is spoken, the child is instructed to locate and tap on all instances of the target letter within the displayed word.

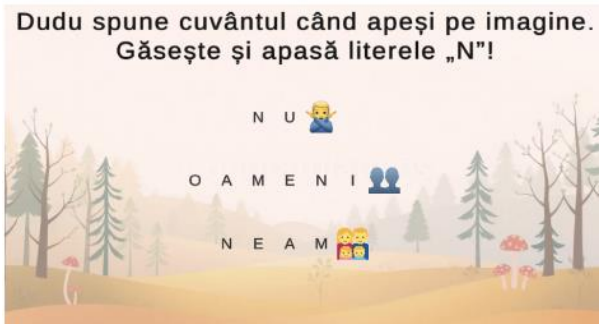

Figure 7. LetterHeroes – Find letters in words exercise

Letter Sorting into Baskets

The "Letter Sorting into Baskets" game is a drag-and-drop classification exercise designed to reinforce letter recognition and strengthen visual discrimination skills. In this activity, children are asked to sort letters into corresponding baskets labeled with their matching letter, as illustrated in Figure 8.

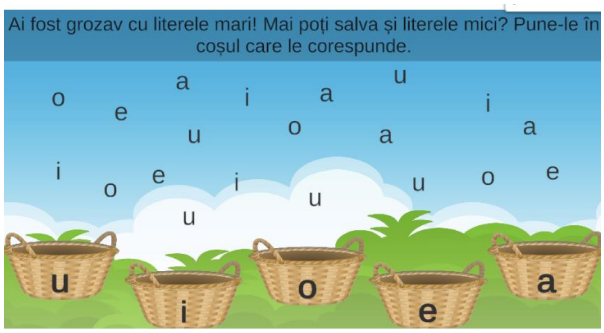

Figure 8. LetterHeroes – Letters sorting in baskets exercise

Syllable Spotting in Words

This exercise focuses on syllable recognition and phonological grouping by challenging learners to determine whether spoken names begin with a specific syllabic unit. As illustrated in Figure 9, the learner listens to a name pronounced by Dudu (e.g., MA-NU-EL, MA-RA), then chooses whether to confirm or reject the name based on whether it starts with the syllable" MA".

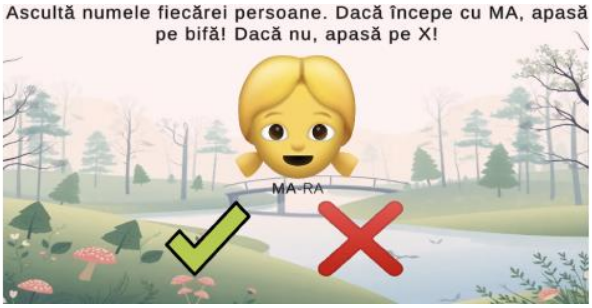

Figure 9. LetterHeroes – Syllable spotting in words exercise

Word Completion via Syllable Selection

This game supports syllabic decoding and semantic inference by encouraging learners to complete partially displayed words using the correct syllables. In the example shown in Figure 10, the child is presented with a playful riddle. The solution is hidden in a segmented word with a missing syllable and the player must choose the correct syllable from a list of distractors. This activity integrates both reading comprehension and phonological reasoning, as the learner must understand the question and identify the correct syllable based on its phonetic and semantic fit.

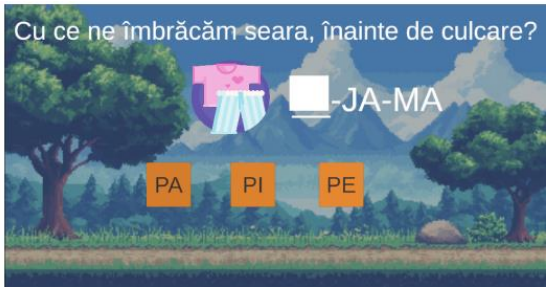

Figure 10. LetterHeroes – Word completion via syllable selection exercise

Prefix Recognition Based on Syllables

This exercise introduces learners to prefix-based word construction using familiar Romanian adjectives derived from syllabic components. As seen in Figure 11, the child interacts with characters who each describe a personality trait and the player must choose the correct first syllable to complete the word displayed beneath the character. This task develops morphological awareness, helping children identify meaningful components that change or define word meaning. The audio-visual interaction - where each emoji character exposes its descriptor - makes the task socially engaging and semantically grounded. Feedback is immediate: correct answers are confirmed visually and through onscreen messages, placing the syllable in the missing frame and marking the correctly selected prefix with green.

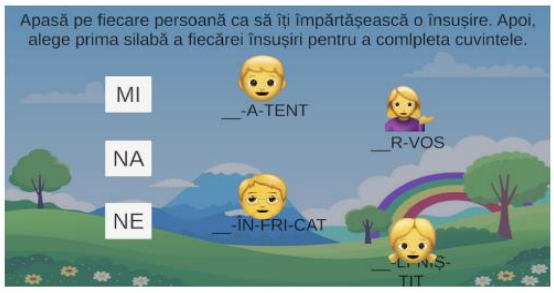

Figure 11. LetterHeroes – Prefix recognition exercise

Ethics Considerations

All participants were adult professionals and provided informed consent before the study. As no minors or vulnerable populations were directly involved, formal ethics board approval was not required. Feedback was collected anonymously and reported in aggregate to protect participants' privacy.

Results/Evaluation

To assess the functionality, educational relevance and usability of the LetterHeroes application, we conducted a small-scale qualitative evaluation**.** The study involved three professionals with direct experience in child psychology and dyslexia intervention, chosen to provide expert perspectives. Their diverse backgrounds allowed for a multidimensional understanding of the app's design, pedagogical validity and child-friendliness.

The evaluation consisted of two phases. First, each participant attended a 30-minute live demonstration of the application, where the researcher presented the main functionalities and exercises. In this phase, evaluators were encouraged to ask questions and provide immediate impressions. Second, participants received access to a standalone version of the application, which they could explore independently on their own devices.

Feedback was gathered through open-ended discussions during the demo session and through follow-up written notes submitted by the participants. The data were analyzed qualitatively and grouped retrospectively into three categories: what went well, what could be improved and actionable suggestions.

The evaluation was exploratory in nature and relied solely on expert opinions. As such, it reflects perceived usability and pedagogical soundness but does not constitute evidence that the application improves literacy outcomes for children with dyslexia.

The first expert was a psychology student pursuing her bachelor's thesis on dyslexia, inspired by her personal experience raising a child with dyslexia. Her contribution was particularly valuable in identifying relatable content and motivational strategies that might resonate with Romanian children facing similar challenges.

The second evaluator was a pediatric psychologist resident working at a hospital in Gyula, Hungary, born in Romania. With a medical degree and clinical experience in child development, she offered professional insights into cognitive load, developmental appropriateness and the alignment of app mechanics with psychological research on learning disorders. The third participant was a graduate in psychology, currently working in a childcare home. Her practical background in working with children in institutional settings contributed to observations about user attention, engagement strategies and the emotional tone of the game-like interface. These three perspectives - parental, clinical and educational - ensured that usability testing addressed both technical and human-centered aspects, enriching the evaluation process. To carry out the evaluation, the application was presented to each participant through a live demonstration, during which initial impressions and feedback were collected. Following the demo sessions, each evaluator received access to a standalone version of the app, allowing them to explore it independently at their own pace. This combination of guided and self-directed testing helped capture both immediate reactions and more reflective insights, contributing to a well-rounded usability assessment.

The usability testing sessions generated a range of qualitative feedback, which has been grouped into three main categories, following a retrospective-style structure: what went well, what could be improved and actionable suggestions for revision.

What went well: Participants consistently appreciated the friendly tone of the application dialogues, particularly the conversational exchanges between Dudu and Fifi. The

auditory elements were also well-received: the background sounds and character voice cues were described as engaging and well-suited to the intended age group. Users noted the pedagogical thoroughness of the app, highlighting its frequent repetition of letters as beneficial for reinforcement and learning retention.

What could be improved: Some aspects of the visual design were flagged for revision. Dudu the bear was perceived as not sufficiently expressive or friendly; small changes, such as adding eyebrows or white highlights in the eyes were suggested to make the character more approachable. The font used in the application was considered too small and not sufficiently visible for young users, especially those with dyslexia. Interface elements such as text panels were described as too rigid or harsh due to their square shape and rounded edges were recommended for a softer aesthetic. Additionally, some exercises exclusively featured letter groups at the beginning of words, while it was pointed out that dyslexic children often only focus on word beginnings, making it pedagogically important to occasionally place target letter groups inside words as well.

Action items: The feedback pointed to several actionable revisions: modify Dudu's visual design to enhance friendliness (e.g., add eyebrows, eye highlights), increase font size across the interface and apply bold styling where feasible, redesign text panels to have rounded corners for a softer appearance, incorporate new exercise types where the target letter group is placed inside words, while maintaining the existing ones, ensure exercises only include letters and phonemes already introduced to the user, expand the narrative structure by adding Dudu-Fifi dialogues before and after each level to reinforce gamification principles, clarify instructional text to explicitly inform users of all interactive elements (e.g., clickable images for audio, drawable or clickable buttons).

CONCLUSION

LetterHeroes was designed to fill this niche. It incorporates a playful narrative, character-driven storytelling and progressively structured exercises tailored to early readers. The application was evaluated by three professionals with relevant experience in child psychology and dyslexia. Their insights were instrumental in identifying strengths and areas for improvement, ultimately guiding concrete enhancements to both content and user experience.

Compared to established applications such as GraphoGame, DysWebxia, or IREAD, LetterHeroes distinguishes itself by providing Romanian-language support and aligning with the abecedar sequence used in local early literacy education. While international tools demonstrate strong results in English, Spanish, or Finnish contexts [2, 7, 13, 22], they are not directly transferable to Romanian due to differences in orthography and pedagogy. Unlike Nessy, which assumes prior literacy, LetterHeroes starts from the earliest stages of letter and syllable recognition, making it suitable for beginning readers. At the same time, it shares with these applications a reliance on gamification and multisensory approaches, positioning it as both culturally specific and methodologically aligned with international best practices.

Future development of the application will focus on several key directions. First, the content will be expanded with new types of exercises to further reinforce literacy skills and reduce repetition. Collaboration with a visual designer is also envisioned to refine the graphical interface, making it even more appealing and user-friendly. From a technical perspective, the implementation of a proper login system and cloud-based hosting will support broader accessibility and individualized progress tracking. Moreover, the integration of basic AI components is planned to automatically evaluate user input, enabling dynamic feedback and adaptation. Additional features, such as real-time teacher dashboards or parental insights, are also under consideration.

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