Improving Reading Literacy with an Immersive Learning App

Célio Gonçalo Marques[1] (0000-0002-1503-0363), Ana Amélia Carvalho[2] (0000-0002-0621-9447), Ana Paula Ferreira[3] (0000-0002-0411-8917), António Manso[4] (0000-0003-2504-0642), Felisbela Morgado[5] (0000-0002-7676-6446)

[1]Instituto Politécnico de Tomar, Tomar, Portugal
`celiomarques@ipt.pt`

[2]Universidade de Coimbra, Coimbra, Portugal
`anaameliac@fpce.uc.pt`

[3]Agrupamento de Escolas Artur Gonçalves, Torres Novas, Portugal
`anaferreira@esagtn.com`

[4]Instituto Politécnico de Tomar, Tomar, Portugal
`manso@ipt.pt`

[5]Agrupamento de Escolas Artur Gonçalves, Torres Novas, Portugal
`felisbelamorgado@esagtn.com`

Abstract. The acquisition of reading skills is of high importance for a student's scholar success. However, we are facing a complex process and a significant number of 2nd year students still have specific learning difficulties. To answer this problem, Instituto Politécnico de Tomar (Tomar, Portugal) in a partnership with Agrupamento de Escolas Artur Gonçalves (Torres Novas, Portugal) developed the information system *Letrinhas*. This system includes an App for mobile devices, a digital repository of educational contents and an information management system. The interactivity and the real-time feedback offered by the mobile app led to an unmatched learning environment that presents excellent learning results. *Letrinhas'* architecture allows its adaption to the individual profile of each user and its sociocultural context. This puts the student at the center of the teaching and learning process. Teachers tested *Letrinhas* and its learning results were assessed. The evaluation's success led to *Letrinhas* being used for teaching foreign languages and extended to other schools.

Keywords: App, Immersive Learning Environment (ILE), Letrinhas, Mobile Devices, Reading.

1   Introduction

Reading is fundamental for the individual development for it allows access to the environment and consequently promotes its personal, social and professional (re)building. Mastering reading skills outstands the individual in this global and competitive world where only the competent readers dominate the mechanisms that allow them to critically access knowledge as a way to actively participate in the society.

However, learning how to read is a complex process and not all students reach the desired proficiency level. For this, it is fundamental to invest in the development of projects that give an early answer to the detected difficulties, for prevention is key to the growth of well-succeeded readers.

The Basic Education Portuguese Program has the following objectives for the 1st cycle:

- […] Use the language fluently, mobilizing several verbal and nonverbal resources, and timely using technological resources.
- […] Acquire, interiorize and automatize the processes that allow the decoding of written text, aiming for a fluent individual reading.
- […] Develop and cement the written texts' reading ability for different genres and with different themes and communication intention [1].

The number of students flagged with learning to read difficulties has substantially increased with a special incidence on the scholar population of the 1st and 2nd cycles [2]. This is the reason why several authors [3] [4] defend that research in the scope of reading must focus on three aspects: early identification, prevention and reeducation. However, teaching and learning how to read implies the use of diversified strategies from the educators but also the students' motivation and reading habit. As Sim-Sim [5] refers, the learning how to read process is complex and requires students' motivation, effort and practice.

The need to identify ways of promoting reading skills acquisition and helping teachers meet their curricular goals established by the Ministry of Education is the origin of this research work, inserted on the "Ginásio de Leituras" project. This is a project by Agrupamento de Escolas Artur Gonçalves that involves the design, implementation and evaluation of a program to promote oral reading fluency, a key indicator of reading proficiency. Based on this problematic the research question formulated was: *how to promote reading learning with the use of information technologies in a more attractive, personalized and immersive way?*

Facing the inexistence of tools, in the Portuguese panorama, that could enable students' evaluation and the reading fluency improvement, the already mentioned Agrupamento and Instituto Politécnico de Tomar began the development of an information system - *Letrinhas*.

This system explores information and communication technologies' potential, notably mobile devices, respecting students' learning rhythm and allowing them to learn anytime and anywhere through interactive contents that lead to a more immersive learning.

In this paper we describe part of the research done in the domain of reading promotion and present the system Letrinhas. Its use in classroom context is described and its evaluation results are presented. At the end, we list some conclusions and describe future work.

2 New Pedagogical Approaches to Promote Reading Literacy

Lately we have been watching the emergence of several tools and pedagogical strategies based on information and communication technologies for reading promotion. Amongst those tools is GraphoGame, developed by the University of Jyväskylä in collaboration with the Niilo Mäki Institute [6]. Although this tool was created for children with dyslexia it can be used with any child that presents difficulties in learning to read. It is an educational game that makes learning to read easier and more fun, and according to some studies, it makes students "significantly better readers on most measures than the children […] receiving only traditional remedial teaching" (p. 52) [6].

Mystakidis, Lambropoulos, Fardoun and Alghazzawi [7] "used 3D VIEs as a digital medium to narrate a transmedia story, visit various virtual environments and immerse learners into different times and civilizations" (p. 1) with the objective to "motivate and promote the early literacy and extracurricular reading" (p. 1). The success of this project led to its expansion to other schools.

Lan, Sung and Chang [8] developed a learning system grounded on mobile devices to learn English as a second language and the studies show that this tool "seemed to reduce anxiety in elementary EFL learners, promote motivation to learn, and enhance oral reading confidence" (p. 142).

Gupta [9] presents a teaching strategy that "uses Karaoke as a tool to build and enhance reading behaviors such as fluency and motivation as a twofold purpose for struggling readers" (p. 80). According to this author, "the joint delivery of music and text provides an exciting, immersive experience for the child" (p. 84) with excellent learning results. Duolingo (https://www.duolingo.com) is another popular language teaching tool that can be used for free on a personal computer or on mobile devices. It uses gamification strategies and the mnemonic method of repetition.

The success of these tools is due to its potential to make learning a more immersive activity. Nowadays, "technology enables us to recreate reality in a virtual space and provide a degree of authenticity that allows almost complete immersion of learners in given scenarios" [10]. It is central to captivate and involve students. For this to happen, immersive approaches are an important help.

Witmer and Singer [11] define immersion as "a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" (p. 227). According to Slater and Wilbur [12] immersion is "the extent to which a display system can deliver an inclusive, extensive, surrounding and vivid illusion of virtual environment to a participant" (p. 603). For Bystrom, Barfield and Hendrix [13] immersion is more related to multimodal sensorial stimuli facilitated by technology.

Adams [14] states that immersion can be tactic, strategic or narrative. For this author, tactical immersion "is immersion in the moment-by-moment act of playing the game, and is typically found in fast action games", strategic immersion "is a cerebral kind of involvement with the game. It's about seeking a path to victory, or at least to optimize a situation" and narrative immersion "is much the same as it is in books or movies. A player gets immersed in a narrative when he or she starts to care about the characters and wants to know how the story is going to end".

For Pagano [15] "the future of technology-enabled learning is immersive. Immersive in the sense that I am "in" the learning experience and I am practicing doing the things that I need to do better" (p. 3). This idea is reinforced by the degree of attention that has been given to this concept where can be enhanced the iLRN workshops [16]. The author adds that "the future of technology-enabled learning is mobile, augmented, visual, location based, kinetic, and story-line driven" (p. 3) [15]. Within the listed characteristics, mobile is one of the clearest. The evolution and vulgarization of mobile devices created enormous educational challenges and opportunities, allowing for new immersive learning environments (ILEs).

Computers are being replaced by mobile devices, which are gaining processing and storage capacity that allied to portability and multimedia capacity, make them excellent work tools and unlock great opportunities for teaching and learning [17]. An inquiry led by Pearson in basic and high schools across the USA, shows that 81% of the students agrees that the use of mobile devices, specifically tablets, allows them to learn "in a way that's best for them", and 79% refer that these help them "to do better in class" (p. 11) [18].

Although some mobile devices' apps promoting immersive reading are appearing, none of the ones that were tested allows the user to choose texts according to each students` necessities, to accompany the students' learning process, or the evaluation of reading fluency in respect to the Portuguese Curricular Goals for the 1st cycle [2].

3   *Letrinhas*: Learning Environment to Promote Reading Literacy

The Information System *Letrinhas* is constituted by a digital content repository, an information management system (back office), and an App for mobile devices.

The information system architecture is based on JavaScript as a programming language. JavaScript is used through Node.js on the server and through the Cordova framework for the mobile component. Since the use of the App for mobile devices can occur in a place without Internet access, a CouchDB and PouchDB combination was chosen for a transparent synchronization. When the device has connectivity with a data network, it executes an automatic data synchronization procedure with the server (CouchDB) and saves the necessary elements for offline functioning in local databases (PouchDB). In the same way, it transfers from the mobile device to the server the tests and corrections made by students and teachers, respectively [2].

In the back office (https://letrinhas.ipt.pt) the system's administrator manages the schools, teachers and students' information. This is also the space for teachers to create

learning and evaluation elements, to make them available, make corrections and consult each student's learning results.

The students only interact with the App, the visible part of the system. The App was developed in a platform that makes it available for Android, iOS and Windows and several screen resolutions. This feature allows the App to be used not only on the mobile devices made available by the school but also on the students and parents' mobile devices for out of school periods.

As a way to answer the students and teachers' needs, the App has two types of elements: information and evaluation elements. The information elements allow the teacher to make available the educational contents about the curricular programs while the evaluation elements allow the teacher to assess the student learning on those same contents.

Every element was created with the intent to make use of the main features of mobile devices, namely multimedia and touch interaction to create more immersive learning environments. The information elements can be based on text or images. The first ones allow teachers to make available sound and visual information about words. This makes it possible to present additional information when the student touches a word. This information may be the classes any word belongs to (e.g. verb, name, adjective), its meaning (e.g. synonyms, translation) and it can even reproduce a sound that represents the reading in a different language than the one it is written. The information elements based on images, work in a similar manner to text but the touch identifies a region in the image.

To assess the knowledge acquired by the students, several assessment elements were developed. These elements can be divided in two: ones that demand the teacher intervention, and others which evaluation is done automatically, allowing students its use in a more broad and autonomous way.

3.1   Reading Tests

The reading tests were the first to be developed and the teacher intervention is necessary for its correction. The students' difficulties are identified and texts are chosen according to each student's individual needs. The student ears the text through the teacher's recorded voice on the mobile device, allowing access to a correct reading in terms of intonation, speed and prosody. This is the reading model the student will try to reproduce with his own voice. The student can hear the reading as many times as he thinks necessary and the text has a synchronization system that allows the student to associate the words being heard with the ones written. When taking the test, the student reads the text and the system records his voice that can later be heard. The student can repeat the test if he is not happy with the result. The fact that the student can hear his own voice allows him to identify difficulties and tries to correct them in an autonomous way (Fig. 1).
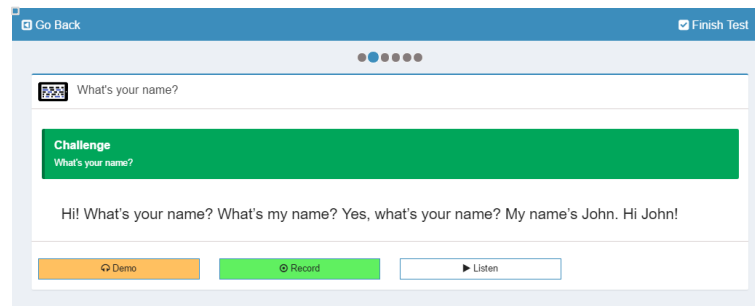
**Fig. 1.** Taking a reading test – voice recording

Evaluating the reading fluency is done through the correction of the test, by the teacher, that identifies the reading errors the student presented, namely accuracy errors (letter substitution; word substitution; additions; letter omission; syllable omission; word omission; inversions), and fluidity (hesitation; repetitions; spelling; word fragmentation; spontaneous rectification).

As the student's reading is recorded, the teacher can hear it as many times as necessary. Every time the teacher detects an error, the reproduction can be stopped to select the category and type of error committed. The system also allows defining the reading speed, one of the criteria established by the Portuguese Curricular Goals for the Basic Education defined by the Ministry of Education.

The words where the student made a mistake and the type of error are signaled in the text, and at the end the system makes an evaluation of the test suggesting a grade to the teacher. This grade is saved and allows the teacher to register and follow the student's learning evolution.

Simultaneously, the system identifies the words where the student had more difficulties and makes available a type of test where those words can be trained singly.

There is also another type of test that enables the evaluation of other reading inherent skills. As an example, we have the identification of words within a text such as verbs, names or other word classes the teacher chooses (Fig. 2).
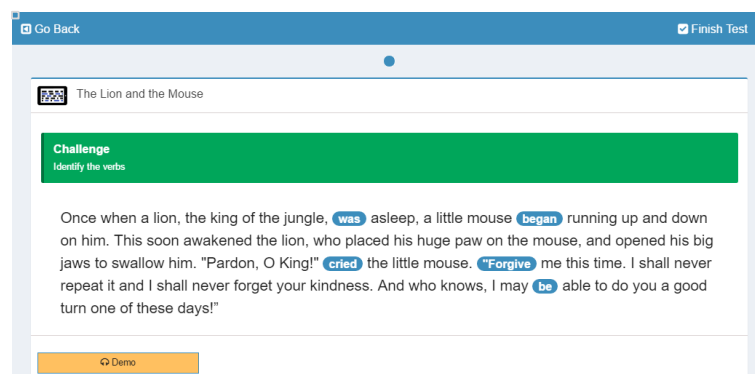
Fig. 2. Taking a reading test – Word identification in a text

3.2 Auto Corrigible Tests

This type of tests allows students to receive immediate feedback about their answers. Auto corrigible tests try to be attractive. Here are some examples:

- Filling the blanks from a list of words;
- Dragging words inside sets;
- Selecting the correct answer;
- Multimedia elements connection;
- Selecting areas in images;

Fig. 3 shows the example of filling the blanks. When the student selects a blank space a list of words appears with several choices.
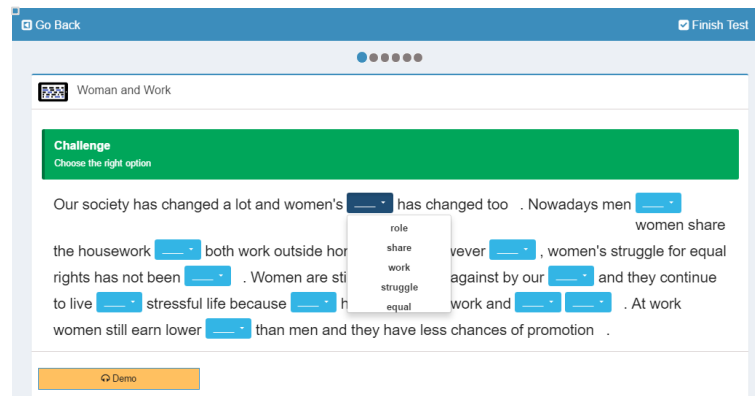
Fig. 3. Filling the blanks from a list of words

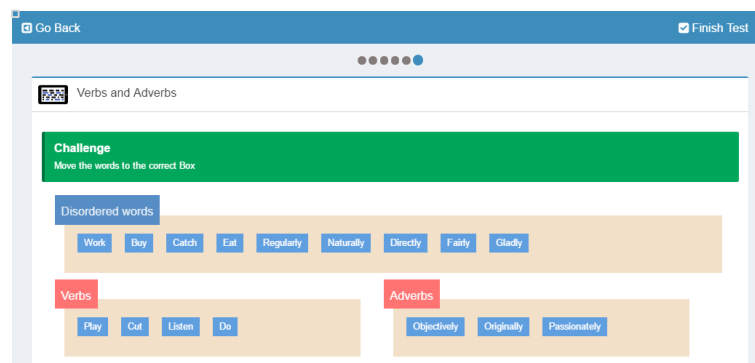Fig. 4 presents the example where the student must drag words to the correct set (verbs or adverbs).

Fig. 4. Dragging words inside sets

Fig. 5 shows the example where the student must identify which answer is correct. The question body can be an image, a text or a sound and the answers can be text or image.
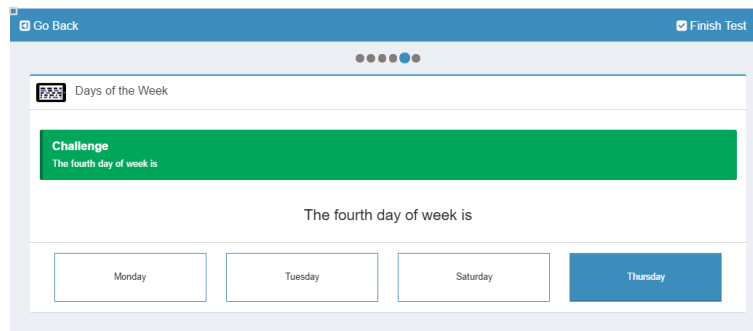

Fig. 5. Selecting the correct answer

The system also allows the connection of multimedia elements and the selection of areas within an image.

These elements can be used in different educational contexts allowing the adoption of contents to the individual needs of students and their sociocultural reality, providing a more attractive and immersive learning.

4   Teaching, Learning and Assessing with *Letrinhas*

During the school year of 2014/2015 *Letrinhas*' usability was evaluated by specialists and future users. The heuristic evaluation involved three specialists and the users' test was done with the 2nd degree class, three tutors and the class's teacher from Agrupamento de Escolas Artur Gonçalves.

For the heuristic evaluation a grill based on the heuristics defined by Nielsen [19] was used. The three specialists had experience in the design and evaluation of educational software, and had had no contact with the information system. Each specialist indicated the heuristics that were not being respected, describing the problem and presenting solutions. The suggested corrections were made before the users' tests.

The users' tests took place during a two-hour session in which 10 students with ages from 6 to 7 years old used *Letrinhas* individually under the supervision of three tutors. The tutors were teachers from the school and the children's teacher. The class's teacher selected students with reading difficulties.

The entire process was evaluated by the specialists to identify the difficulties students had while using *Letrinhas* as well as some errors that were detected and later corrected.

In March, during the evaluation year, *Letrinhas* was presented to every 2nd year teacher of the school where the test was done, and also to two special needs teachers, making a total of twelve teachers. All teachers were invited to use *Letrinhas* and to

suggest changes and/or improvements. Their contribute was very important for the latest version of the system.

Letrinhas use in a real environment began in the school year of 2015/2016 with a pilot class from the 2nd year at one of the schools from Agrupamento de Escolas Artur Gonçalves. 12 students took part in this pilot study – 5 males and 7 females, belonging two to the 2nd year classes (once again, these were students flagged as having reading difficulties). With the pilot study it was intended to: characterize the work methodologies implemented by the teachers while using *Letrinhas* with students, and in the phases of creating tests as well as evaluating those tests; acknowledge the users' satisfaction degree – students and teachers – while using *Letrinhas*; and understand the impact it had on the improvement of the students' reading skills [17].

For this assessment, interviews and informal conversations were held, session observation and document analysis (teachers reports, class councils records and student evaluation documents). A pretest at the beginning of the school year and a posttest at the end of the school year were also conducted.

The obtained results revealed an improvement of the students reading skills. All the students overcame their reading difficulties such as stated by the teachers in their reports. It can also be verified that *Letrinhas* enabled the overcoming of reading difficulties in a shorter amount of time when comparing with data from previous years. It was also noticeable the high degree of satisfaction from those involved in this process while using *Letrinhas*. Students were always motivated and excited at the work sessions with it, taking every task with effort and autonomy (this is favored by the system characteristics because of the interactivity it permits). Teachers considered the tool as fundamental for their students' success. Their satisfaction is also related to the possibility of creating differentiated activities regarding each students difficulties as well as the ease of tests evaluation associated with the statistic information created by the system, which helps the evaluation task.

Since the system allows for the evaluation and accompaniment in real time of the students' learning, it enables the teacher to define the methodology to use with each student considering their difficulties or knowledge acquired [20].

Throughout the school year, teachers' opinion was collected about *Letrinhas*. The 33 participants had the opportunity to use the mobile app and the backoffice system. At the end of the year they fulfilled an opinion questionnaire. A semantic differential scale was used with values ranging from 1 to 7 [21], where 1 is a positive appreciation and 7 a negative appreciation.

Table 1. Teachers' evaluation of *Letrinhas*

Evaluated aspects	Average
Question creation and editing (Simple - Complex)	2.5
Test creation and editing (Simple - Complex)	2.4
Test correction (Simple - Complex)	2.5
Back office color enjoyment (Pleasant - Irritant)	1.9
Back office icons' suggestiveness (Suggestible - Not Suggestible)	2.0
Back office structure (Simple - Complex)	2.2

Back office navigation (Simple - Complex)	2.0
Overall back office interface appearance (Pleasant - Irritant)	1.8
App color enjoyment (Pleasant - Irritant)	1.5
App icons' suggestiveness (Suggestible - Not Suggestible)	1.7
App Structure (Simple - Complex)	2.0
App navigation (Simple - Complex)	2.0
Overall App interface appearance (Pleasant - Irritant)	1.5

Participants considered it easy to create and edit questions and tests as well as correcting the latter. They liked the colors, icons, structure, navigation and overall appearance of the interface. The App got slightly better results than the back office. The majority of the respondents considered *Letrinhas* terrific describing it as fantastic, spectacular, excellent, interesting, very positive and good tool (Table 2).

Table 2. Teachers` opinion about *Letrinhas*

Category	f	%
Terrific	17	51.5%
Motivating/Stimulating/Appealing	7	21.2%
Of great use	3	9.1%
Functional	2	6.1%
Effective	2	6.1%
With great potential	1	3.0%
Eases the teachers' work	1	3.0%
Intuitive	1	3.0%
Should be available in every school	1	3.0%

Throughout the school year of 2016/2017 *Letrinhas* was integrated in the Promotion of Scholar Success Plan of Agrupamento de Escolas Artur Gonçalves. This project was financed by the Ministry of Education encompassing every student with learning difficulties attending the 2nd grade.

Letrinhas' versatility enables the design of new training paths that can be autonomously used by students in the classroom or at home.

5   Conclusions and Future Work

Acquiring reading skills is a decisive factor for learning success but despite the research in progress, specific programs, and the importance given to the Portuguese language, specifically to reading, we still find that the learning difficulties felt in reading lead 1st cycle students to failure, not only on their mother tongue but also on the rest [22].

Knowing that the reading difficulties continue to constitute one of the main obstacles to success and scholar performance, frequently originating difficulties in other learning areas, reflecting in the student's scholar progress [23], Instituto Politécnico de Tomar in partnership with Agrupamento de Escolas Artur Gonçalves presents *Letrinhas*, a tool

that may contribute to overcome this problem using Information and Communication Technologies.

The use of technology is not new. Several authors such as Ferreira e Horta [23] consider that the use of computers offers many advantages to practice and develop reading skills, helping students to overcome their reading difficulties. *Letrinhas* presents a set of singular characteristics allowing the creation of personalized learning environments considering that each student has different difficulties; enabling the use of texts suitable to the student sociocultural reality; providing interactive learning environments; and offering students' learning management and evaluation tools.

There are many immersive educational environments, however "most of the proposals ignore the differences between students - which can contribute to the students' dissatisfactions" (p.1) [24].

The system's adaptability, attractiveness and interactivity make students strongly involved with the contents. It allows students to become fully involved in an interactive digital environment. *Letrinhas* can be seen as an engaging and immersive learning environment, regarding the interaction with the contents [25] and the gamification strategies, to meet authentic learning [26]. The enthusiasm is so great that students ask if they can keep using the App even after they have learned how to read correctly.

Considering *Letrinhas* success promoting reading at Agrupamento de Escolas Artur Gonçalves, its use was extended to foreign languages and will be presented to other groups of schools.

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