LibroTech: a virtual gamified library learning environment*

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Abstract

Context: Reading is an essential pillar that significantly affects the learning of schoolchildren. However, more and more young people are turning away from reading, as it increasingly seems tedious and boring to them. In addition, school libraries are often underused by most students due to a lack of awareness about the resources they offer, whether physical or digital. Objective: This article presents a prototype of a Virtual Gamified Library Learning Environment (VGLLE) integrated into VLE. For this, it seeks to develop a library management environment that implements gamification strategies. Pursuing the promotion of reading with motivating strategies for students and that allow an effective and informative management of resources. Method: Design and implementation of a prototype of a gamified virtual library environment, and subsequent realization of a preliminary evaluation of learning, satisfaction and usability. Conclusions: A priori, the implemented functionalities obtained learnability: 91.67%, usability: 85.5%, satisfaction: 86.67%, which poses a promising scenario for future studies that observe the promotion of reading.

Keywords

Technology-Enhanced Learning, Virtual Library, Gamification, Virtual Learning Environments, Serious Games

1. Introduction

Education is a fundamental pillar in the development of countries, as it promotes individual growth and, consequently, increases employment opportunities while contributing to economic and social progress [1]. Furthermore, education strengthens essential skills such as decision-making, problem solving, and critical thinking [2].

Within educational systems, it is possible to differentiate between urban and rural education. Although both contexts in Spain are governed by the same regulatory framework [3], there are significant differences in the organization and distribution of educational centers.

In this regard, it is worth noting that this research is conducted in the province of Albacete, within the autonomous community of Castilla-La Mancha, where primary education is also regulated by [4], which establishes the organization and curriculum for this educational stage. This decree adapts national regulations to the specific characteristics of the educational environment in Castilla-La Mancha, incorporating methodological approaches focused on the development of students' competencies, attention to diversity, and educational inclusion, in line with the principles of equity and quality set forth in the LOMLOE.

In urban areas, educational institutions are usually concentrated in a single geographical location within one building, whereas in rural areas, educational centers are organized into structures that may

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include several sites separated by several kilometers. An example of this model is the *Colegio Rural Agrupado (CRA) Sierra de Alcaraz*, where several communities share administrative and pedagogical resources to guarantee access to education in low-population-density environments.

This study focuses on the educational context of rural areas, as various studies have highlighted the existence of specific challenges in these settings, particularly regarding the development of students' verbal and numerical reasoning [5]. The limited access to specialized teaching resources and the reduced exposure to advanced educational stimuli may contribute to these difficulties.

A key strategy for addressing this issue is the promotion of reading, as it has been shown not only to improve verbal comprehension but also to facilitate the learning of mathematical concepts [6, 7, 8]. The relationship between reading and cognitive development is particularly relevant in rural environments, where students may face greater challenges in accessing diversified educational materials.

Given that today's schoolchildren are digital natives, it is essential to address these challenges by integrating digital technologies for learning, known as Technology-Enhanced Learning (TEL) [9]. These tools have proven to be effective in improving educational processes by providing access to interactive materials, personalizing teaching, and fostering learning autonomy.

However, these schoolchildren have reduced their reading consumption [10], making it necessary to incorporate strategies that enhance motivation [11]. Such strategies could include game-based approaches, such as the use of rewards, transforming reading activities into serious games [11, 12].

The main objective of this work is the design and implementation of a Virtual Gamified Learning Library Enviroment (VGLLE), specifically intended for primary school students of the *CRA Sierra de Alcaraz*. This virtual library aims to provide a management tool and access to both physical and digital educational resources that facilitate learning and promote reading, overcoming barriers to accessing physical materials in rural areas.

This article is structured as follows: Section 2 - Gamified Virtualization of Libraries: This section presents the state of the art regarding the virtualization of libraries, briefly addressing the use of gamification and highlighting the functionalities that primary school students seek in such environments. Additionally, related work in rural contexts is presented. Section 3 - Architecture and Technology Design: This section presents the proposed software architecture for the creation of the virtual library, as well as the technology stack used for development. Section 4 - Description of LibroTech - Virtual Gamified Learning Library Environment (VGLLE): This section describes the functionality flows carried out by a teacher and a student, from the moment a book is published in the library to the moment the student completes the reading activity. Section 5 - Usability Evaluation of LibroTech: This section presents the usability and satisfaction evaluation carried out with a population of 9 individuals, aimed at the early identification of user experience issues. Section 6 - Discussion: This section presents the discussion on the results. Finally, section 7 describes the conclusions of the study and future work, addressing future improvements that could be beneficial to incorporate into virtual libraries and the VGLLE.

2. Background and related work

Reading is a fundamental pillar in the cognitive and educational development of primary school students. It plays a key role in the development of the so-called *Soft Skills*, skills related to cognitive processes [13]. Reading can therefore help develop skills such as *critical thinking*[14, 15], *working memory* and *problem solving capacity* [16].

The importance of reading during early childhood has been widely studied, highlighting the role of systematic instruction in fostering literacy abilities. Research suggests that early reading experiences significantly impact cognitive growth, with individual differences in reading abilities becoming more pronounced over time due to factors such as the home environment and exposure to literacy activities [16]. Furthermore, longitudinal studies indicate that early phonological awareness and short-term verbal memory are strong predictors of later reading success [17]. Moreover, the relationship between executive functions and reading comprehension has been explored, showing a bidirectional influence in

which cognitive control mechanisms, such as working memory and inhibition, play a crucial role in understanding texts, while reading itself contributes to the enhancement of these cognitive functions [18]. This connection underscores the importance of integrating cognitive training within reading instruction programs to optimize literacy development.

School libraries are a fundamental component for the improvement of schoolchildren's reading [15]. However, in many educational centers, school libraries continue to operate under a traditional model focused on the passive storage of books, without clear strategies to boost or promote their use[19, 20]. This situation means that much of their collections remain underutilized, as students sometimes do not know about the available resources or do not find an attractive environment that stimulates their autonomous and regular use [21, 15].

The digitization of school libraries is essential to modernize education and improve access to learning resources [22]. Hasibuan et al. analyze strategies to develop digital collections in school libraries, emphasizing the importance of collaboration and continuous evaluation in this process [23]. Similarly, Konlan et al. explore how technological integration in the management of school libraries influences student learning and library services, highlighting the need for specific investments in digital infrastructure and professional development programs [24]. In addition, the work of Mahendra et al. underlines the role of school libraries in promoting students' interest in reading and initial literacy skills, highlighting the importance of virtual libraries in this context [15].

Likewise, the growing need to motivate young students to engage with reading has led to the adoption of innovative techniques such as gamification [25]. However, there is no universally accepted definition of gamification. Several scholars have offered influential interpretations:

- Deterding et al. conceptualize gamification as the application of game design principles within contexts that are not inherently game-related [26].
- Werbach frames gamification as an approach that aims to introduce playful dynamics into otherwise conventional activities [27].
- Zichermann views it as a strategy that utilizes both the cognitive processes and mechanics of games to engage users and address real-world problems [28].
- Bozkurt and Gartner converge on a definition where gamification is seen as a digital engagement tool that leverages game mechanics and experience design to stimulate user motivation and goal achievement [29, 30].

Collectively, these perspectives emphasize gamification's role in enhancing user interaction and commitment through elements inspired by games.

For the purposes of this study, we define *Gamification* as *the use of motivational and game-based strategies in non-game contexts to encourage individuals to achieve their goals and objectives* [31].

The application of gamification strategies in educational and professional contexts often takes the form of what is known as *serious games*.

Serious games (SG), therefore, are digital games used in various fields [32], and in particular, they are not employed solely for entertainment purposes [33]. In the educational domain, these games are designed to assist students in the development of skills, facilitating the acquisition of meaningful learning [34]. Consequently, they could be considered part of the concept of *Technology-Enhanced Learning* (TEL), as they utilize SG and digital technologies for educational purposes [32].

A relevant example of this application can be found in the work of Jiménez-Honrado et al., who developed a modular digital system composed of educational minigames specifically designed to enhance the social integration of children with Autism Spectrum Disorder (ASD). Their study illustrates how serious games can be adapted to promote emotional regulation, communication, and collaborative skills in children with special educational needs, further validating their role within the TEL framework [35].

Therefore, the term *Technology-Enhanced Learning* (TEL) is used to refer to the set of tools and digital platforms used to improve and support learning processes[36]. These technologies provide an interactive and accessible environment that facilitates teaching, autonomous learning and personalization of education, optimizing the educational experience in various contexts [37, 38].

TEL has evolved by providing greater interactivity through the creation of virtual worlds, which are known as *Virtual Learning Environments* (VLE). A VLE is a virtual environment that allows the exploration and review of complex phenomena, where traditional or less interactive methodologies do not manage to reach [39]. This causes, therefore, the extension of learning from physical space to virtual space [40], and when this term is used together with gamification, it is known as *Pervasive Games* [41].

We propose as *Virtual Gamified Library Learning Environments* (VGLLE) as referring to systems of gamified virtual school libraries, whose main objective is the optimization of the resources available in the libraries, facilitating access to these resources to the whole society, with a particular emphasis on students. Through gamification, it seeks to promote intrinsic motivation in users by creating an environment that supports autonomy and continuous engagement in learning.

According to Self-Determination Theory (SDT) [42, 43], intrinsic motivation is driven by the satisfaction of three basic psychological needs: autonomy, competence, and relatedness [44, 45]. A well-designed gamified virtual environment can fulfill these needs by offering students choices in their reading paths (autonomy), clear and achievable goals with feedback (competence), and opportunities for interaction or recognition within a learning community (relatedness). These factors contribute to sustained engagement and deeper learning [46, 47].

Although various researchers have extensively explored the central themes of gamification and digitization of libraries, as mentioned above, we have not found sufficient evidence to address the origin of gamification specifically applied to platforms designed for libraries.

LibroTech represents the convergence of three research areas: gamification, virtual learning environments (VLEs), and digital libraries. While existing works typically apply general gamification or focus on digitizing content, LibroTech integrates pedagogical workflows, interactive reading exercises, and user monitoring into a persistent gamified environment. This novel combination addresses both engagement and access issues in rural school libraries, offering a differentiated and context-aware solution not previously covered in the literature.

Based on the above, we propose the following usability hypothesis:

> *The implementation of the GamiCRA gamification model in a virtual library learning environment (VGLLE) significantly enhances students' perceived usability, particularly in terms of ease of access, efficiency, and satisfaction when interacting with the resources of a distributed rural school library.*

To test this hypothesis, we will use GamiCRA, the gamification model developed within the framework of the InteCRA project [31], together with a prototype of a virtual library environment embedded within MundoCRA [48].

3. Overview of LibroTech: a virtual library environment

The functionalities described below are integrated into the interactive system developed, and correspond to the specific usage flows of the teacher and student profiles. These flows not only structure the interaction experience according to each role, but also enable differentiated, accessible, and continuous management of the mediated reading process. This functional proposal is implemented in MundoCRA, a virtual learning environment for primary education that, as noted by Sebastián-Rivera et al. [48], combines a gamified architecture with modules for pedagogical management and formative evaluation adapted to the needs of the school context. Within this framework, the actions of teachers and students are articulated as interactive journeys within a shared graphic environment, enhancing both engagement and effective supervision of the educational activity.

3.1. Workflow of teachers

From a user-centered design perspective, a set of specific functionalities oriented to the role of coordinator ("Professor" in the implementation) has been developed within the interactive environment.

These functionalities are designed to facilitate effective management of classroom dynamics, allowing a flexible, personalized and real-time intervention in students' experiences.

The teacher's interaction with the system typically begins by accessing the "Consult Books" option. From this section, teachers can explore the repository of available works (see Figure 1), review their contents, and manage associated metadata such as title, description, subject or educational level. Similarly, teachers can preview the activities related to each book, enabling them to select the most appropriate materials in an informed manner according to the didactic objectives and students' characteristics.

Once a book is configured, the teacher can add a "Programmed Reading". This option allows the orchestration of structured reading dynamics, assigning fragments to different students. The interface facilitates synchronization between reading and evaluation, enabling directly linking of text fragments with interactive tasks. This integration is realized in the "Reading Activities" module, from which different types of tasks can be launched - "Fill in the blanks", "Tests", "Graspme", "Writing" [48]- associated with specific scheduled readings.

Finally, the "Reading Statistics" module provides (see Figure 2) a visual panel with all relevant information about the available books and the metadata completed by the teacher - name of the book, description, subject, course-. For each book, the panel also displays the reading status and the evaluation of each student to whom it has been assigned. This visualization enables the coordinator to identify levels of participation, evaluate progress and make informed pedagogical decisions. Its design adheres to principles of clarity and accessibility, facilitating a rapid interpretation of data.

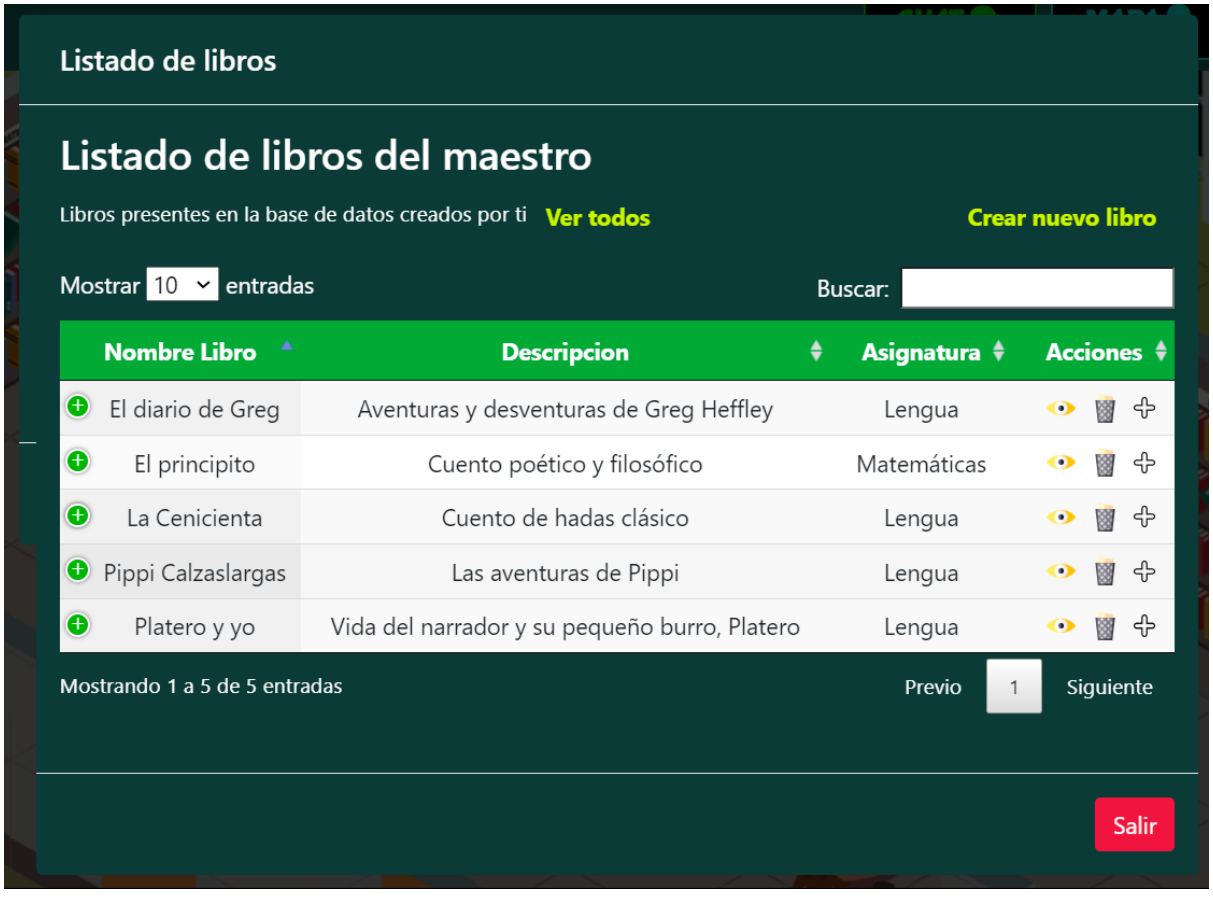

Figure 1: Book list interface used by teachers to manage and assign readings

3.2. Workflow of students

The system has been designed to offer students a guided, interactive, and participatory reading experience. The functionalities intended for this profile complement those of the teacher's role, aiming to

Figure 2: Reading statistics panel showing student performance indicators

promote immersion in readings and programmed activities.

The experience begins with the student's participation in a "Programmed Reading". This functionality, previously configured by the teacher, structures the readings that the student must complete before proceeding to the associated activities.

Upon completing the reading, the student can rate the experience, providing simple yet meaningful feedback on the book. This assessment is recorded along with the student's reading progress, allowing the system to consolidate an individual participation profile that the teacher can consult through the statistics panel.

As student progresses, the student unlocks the "Reading Activities" associated with the fragments read. These tasks, created by the teacher, are presented as interactive challenges that require the various types of responses mentioned above. The interface is designed to integrated these activities seamlessly into the session, reinforcing the content and encouraging active student engagement (see Figure 3).

4. Architecture and technology design

This section contains a general description of the architecture of the virtual library (LibroTech), including the key components and the technological infrastructure used. Likewise, the tools used for the development of LibroTech (and throughout the project) are detailed, particularly the technologies used for the graphic integration of the virtual environment MundoCRA [48].

4.1. Overview of the system architecture and software technologies used

In the context of the research and development InteCRA project, a Virtual Learning Environment called MundoRA was developed, available for web browsers, desktop applications, and mobile devices.

This application has a client-server architecture and is developed in JavaScript using NodeJS. The database is implemented with MongoDB. The application follows a Software as a Service (SaaS) delivery model, with the client and server decoupled. It is therefore a service-based application, and the architecture of the system can be seen in Figure 4.

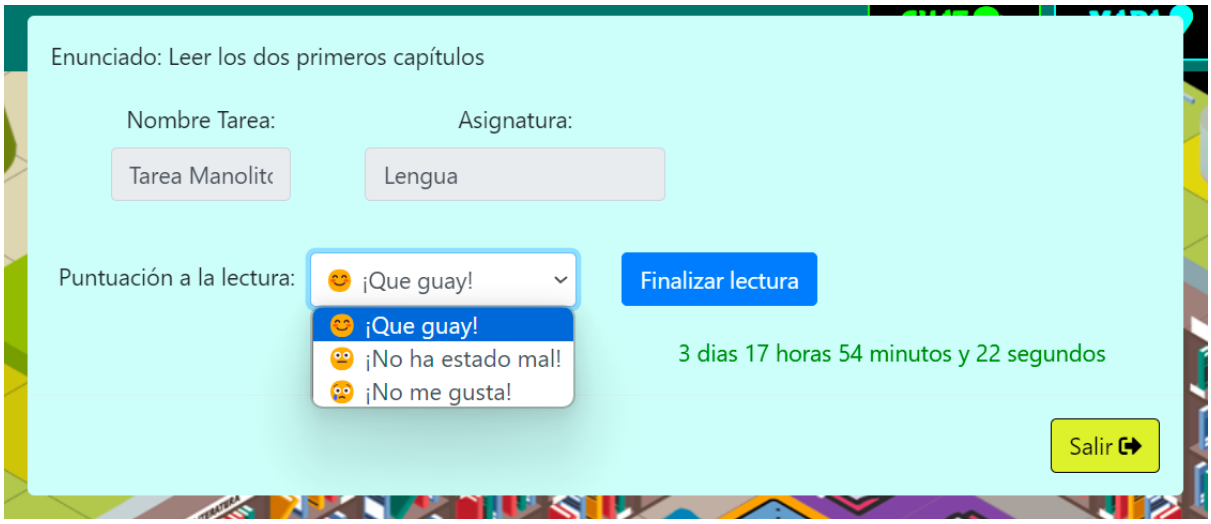

Figure 3: Workflow of Student

Figure 5 presents the class diagram (CD) designed for the *MundoCRA* exercise system, which is used to create reading activities. This diagram is aligned with the architecture defined for the *Virtual Library*, as illustrated in Figure 7.

The *ExerciseModel* model facilitates the construction of exercises in educational environments, allowing the implementation of different types of activities. Among them are simple exercises, such as tasks, and more complex, such as a *Gaspme* that consists of a collection of interactive tests, similar to platforms such as Kahoot.

The CD on *GamificationModel* is also presented, where teachers can assign prizes, or even knowledge Figure 6, this model is known as *GamiCRA* [31].

The two models ExerciseModel and GamificationModel (GamiCRA), serve as the foundations for the design of the gamified school virtual library in Figure 7. In addition to standard library management functions, the system allows the capture of statistics and the association of gamified activities.

4.2. Technology stack

In the following, we present the fundamental technologies used in the development of BiblioTech. They are these:

Node.js: Node.js is used as an execution environment for the server, allowing the execution of JavaScript code on the server side and facilitating the management of dependencies through npm.

HTML: HTML has been fundamental for the creation of the structure and presentation of web pages, providing the basis on which the user interface of the game is built.

JavaScript: JavaScript, as a client-side programming language, has been essential for real-time interactivity and dynamic content manipulation in the browser, improving the user experience.

jQuery: We have integrated jQuery to simplify the manipulation of the DOM (Document Object Model) and to facilitate the implementation of interactive functions, thus optimizing the development of the user interface.

4.3. Graphic integration of the MundoCRA virtual learning environment

As already mentioned, the proposed solution is based on web technology, which has allowed the virtual world to be represented specifically through the use of the PixiJS and TravisoJS libraries. These technologies have influenced the choice of graphic tools, which led to opting for Tiled and Texture Packer for the design and management of the sprites, which are integrated into the MundoCRA environment [49].

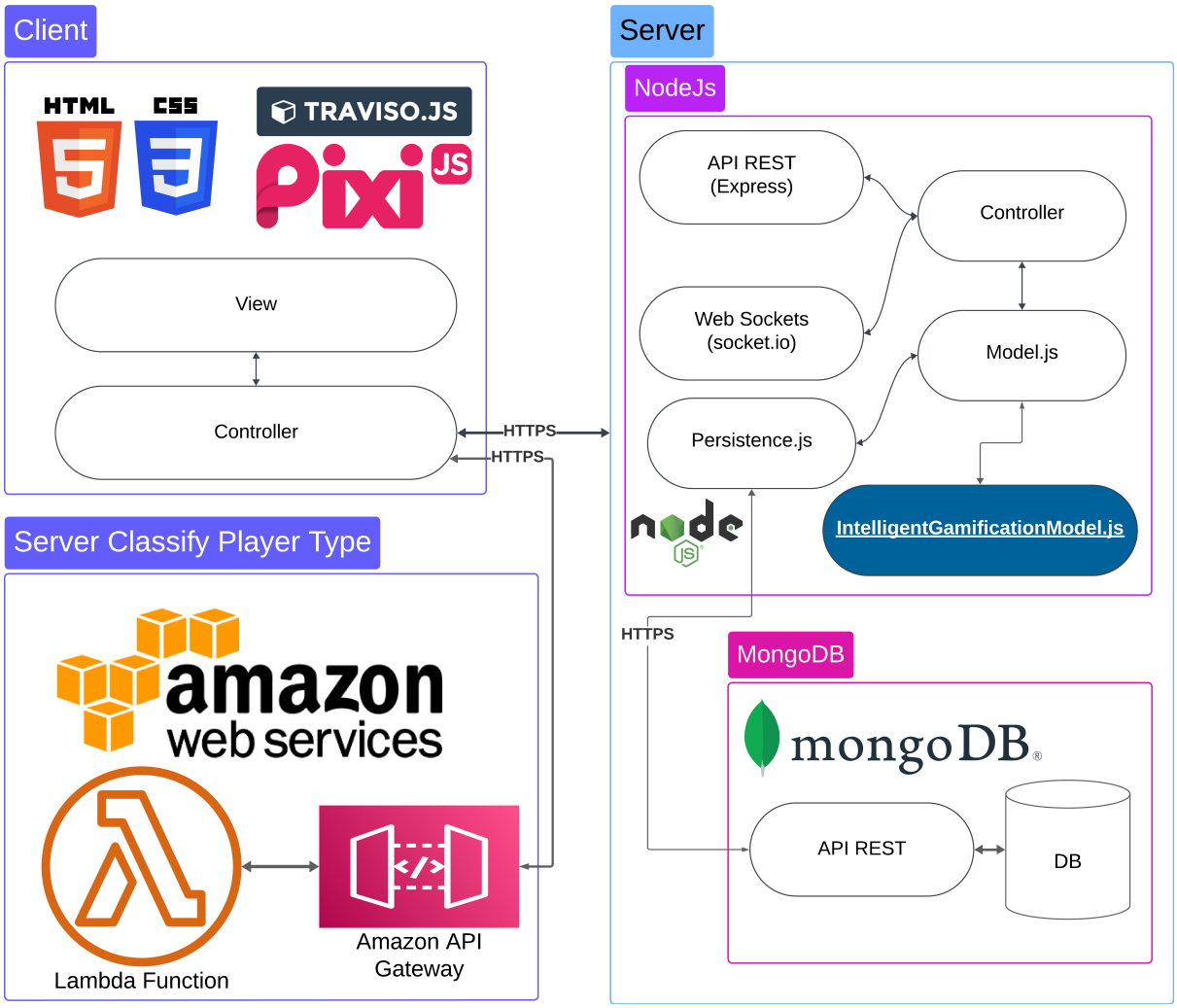

Figure 4: Client-server architecture of the MundoCRA platform, highlighting the use of Node.js, MongoDB, AWS Lambda, and the integration of the intelligent gamification model.

The Tiled tool has been used in a process aimed at creating graphic resources that allow you to build the MundoCRA virtual environment. In a first phase, different ”Tile Sets” were developed which allow you to visually compose the world. These sets work as a kind of ”color palette” that facilitates the definition of the graphic elements of the virtual map. An example of this can be seen in the lower right corner of Figure 8, under the label ”Tilesets”. With this set, the floors and objects visible in the central part of the same figure were generated.

Next, two ”Pattern Layers” were created: the first intended for the composition and visualization of the floors, and the second focused on the placement and representation of the objects with which players can interact, either through collisions or through activations (see layers ”Objetos” and ”Suelos” in Figure 9).

Tiled facilitates the transformation of these created resources (floors and objects) into files (of type .PNG and JSON) containing the necessary information for the presentation and management of the virtual world in the provided cross-platform distribution.

The TexturePacker tool has been used to create animations associated with avatars and their movements within MundoCRA. This tool has been essential for packaging all the sprites corresponding to the different movements of the avatars, as well as the graphical elements related to the tiles of activities within the virtual environment. Using TexturePacker (see packaging of tile and object types with TexturePacker in Figure 10), PNG and JSON files were generated, containing the graphical and structural information of the movement sequences. These files, along with PixiJS and TravisoJS, enable

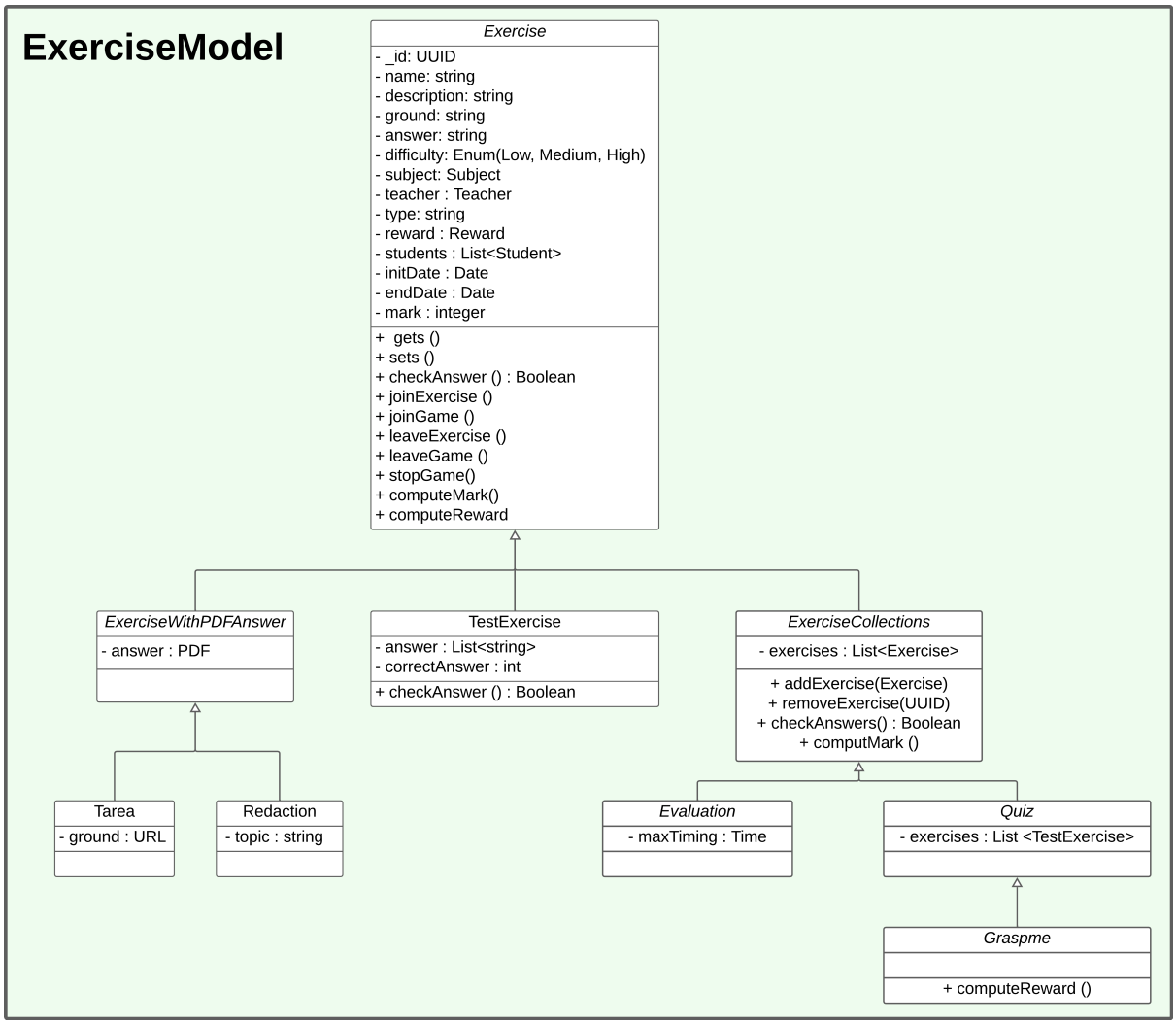

Figure 5: Class diagram of the exercise model, defining the hierarchical structure that organizes the different types of exercises supported by the platform.

the efficient integration and use of animations and graphical transitions in the "virtual world" environment. It is worth noting TexturePacker's ability to optimize the designed graphical resources by grouping them into a texture atlas, which reduces resource load. To further improve performance on web platforms, Squoosh is employed after composition in TexturePacker, reducing the size of PNG files by around 30%, at the cost of a 20% loss in quality, and converting them to WEBP format. Nonetheless, this reduction allows images to be served efficiently over HTTP.

5. Usability evaluation of LibroTech

Once a system has been developed, it is essential to carry out an evaluation with users to determine if the application is suitable and meets the requirements provided. For the evaluation of this system, the ISO 25062:025 [50] standard will be used. The test will focus on the two types of users who will use the implemented features: students and teachers. In addition, to evaluate the

User satisfaction, the SUS (System Usability Scale) [51] test will be carried out.

The ISO 25062:2025 standard is used to report the measures obtained in terms of effectiveness, efficiency and satisfaction in a context of specific use. This standard will guide the system evaluation process described in this work.

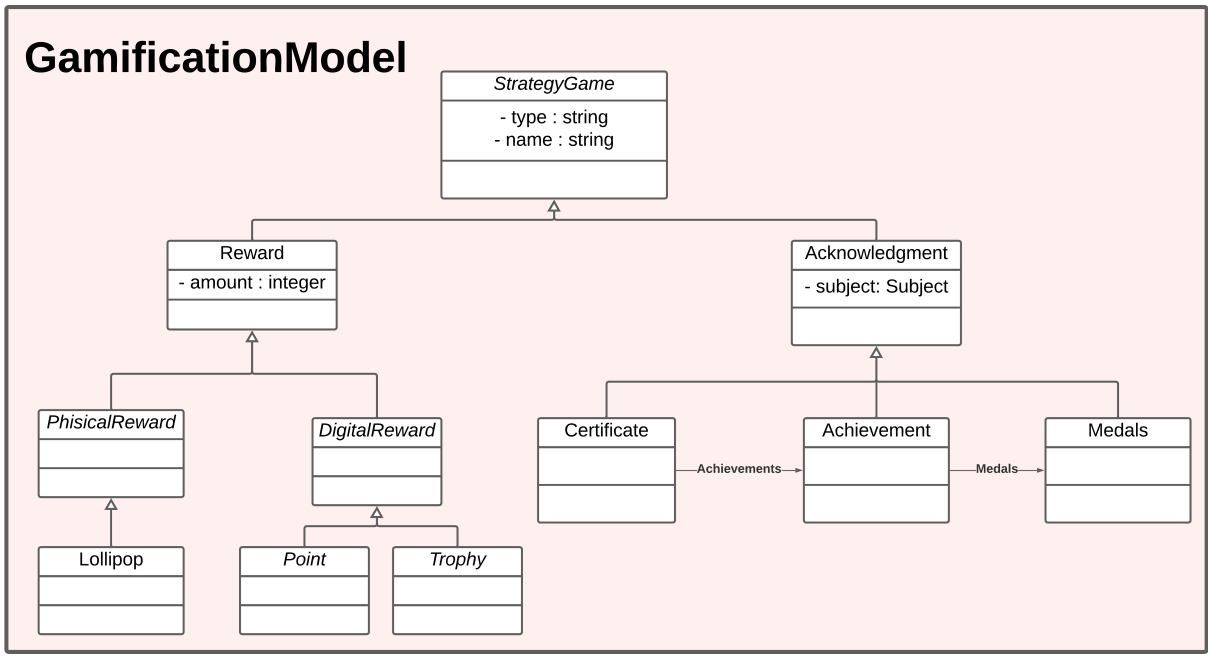

Figure 6: Structured definition of the GamiCRA model within the platform, where gamification strategies are hierarchically organized to foster user motivation and engagement.

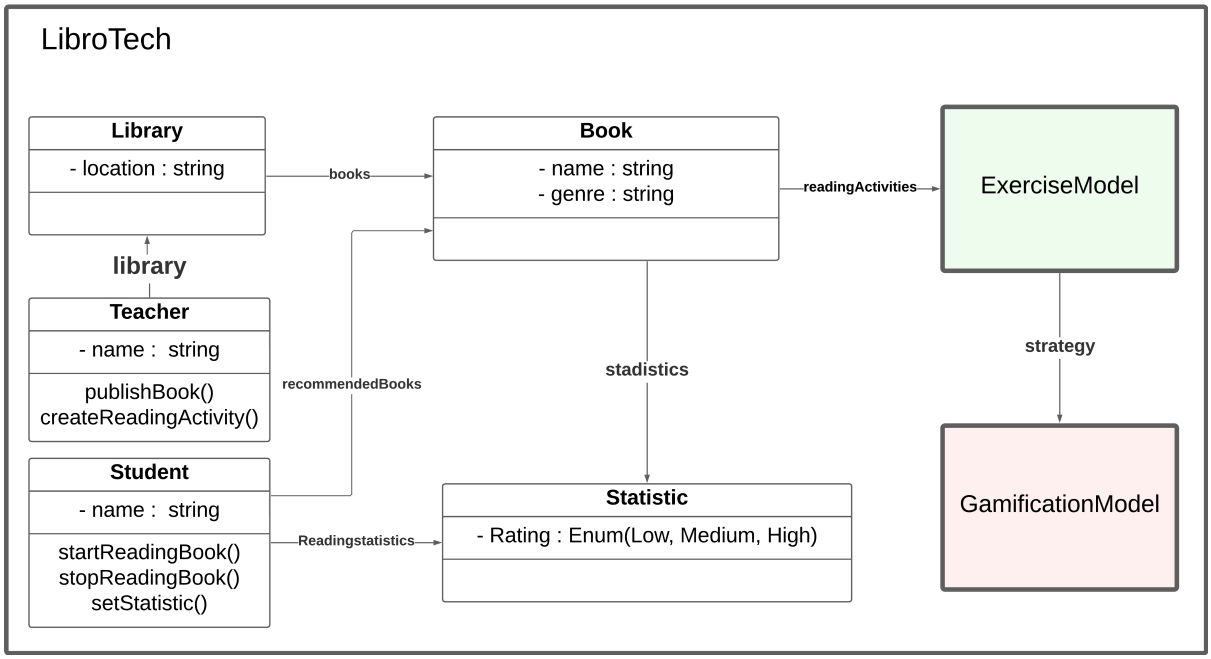

Figure 7: Class diagram of the LibroTech system, showing the core entities (Library, Book, Teacher, Student) and their relationships, including how the reading activity model and GamiCRA strategies are integrated.

5.1. Product description

The product evaluated is LibroTech, a subsystem embedded in MundoCRA that is a Technology-Enhanced Learning System. The entire system will not be evaluated, only the part developed in this work, which includes the new section of the virtual library. This product is designed for students and teachers and can be used both in web browsers and desktop applications.

Figure 8: Creation of the "virtual world" of MundoCRA with TILED (map)

5.1.1. Evaluation objectives

As described, there are two types of users, so the objectives of the test will be different for each of them. For students, it will be evaluated how scheduled readings and reading activities work. For teachers, the functions of book management, scheduled readings and reading activities will be analyzed.

However, the main objective of the evaluation is the same for both types of users: to evaluate the quality in use of the application.

To do this, we seek to verify three aspects:

- **Ease of use**: The user must be able to use the functions with little or no help, even if he has not used the system previously.
- **Functionality**: Users must find the new full functions and the system must react appropriately.
- **Utility**: Users should find the new features useful.

5.2. Method

This section will detail the method followed to carry out the evaluation. For this, it is necessary to know information about the participants, the context of use, the experimental design and the usability metrics used.

5.2.1. Participants

As previously mentioned, the evaluation will involve two types of users: teachers and students, comprising a total of three teachers and six students. According to a study [52] by Nielsen and Landauer, this sample size is sufficient to identify up to 80% of usability issues. However, including more participants in future iterations of this research would be beneficial to gain deeper insights.

First, the data corresponding to the teachers will be displayed in Table 1. All of them have previously used the system. The information collected includes their age, sex, level of knowledge in information technology (IT).

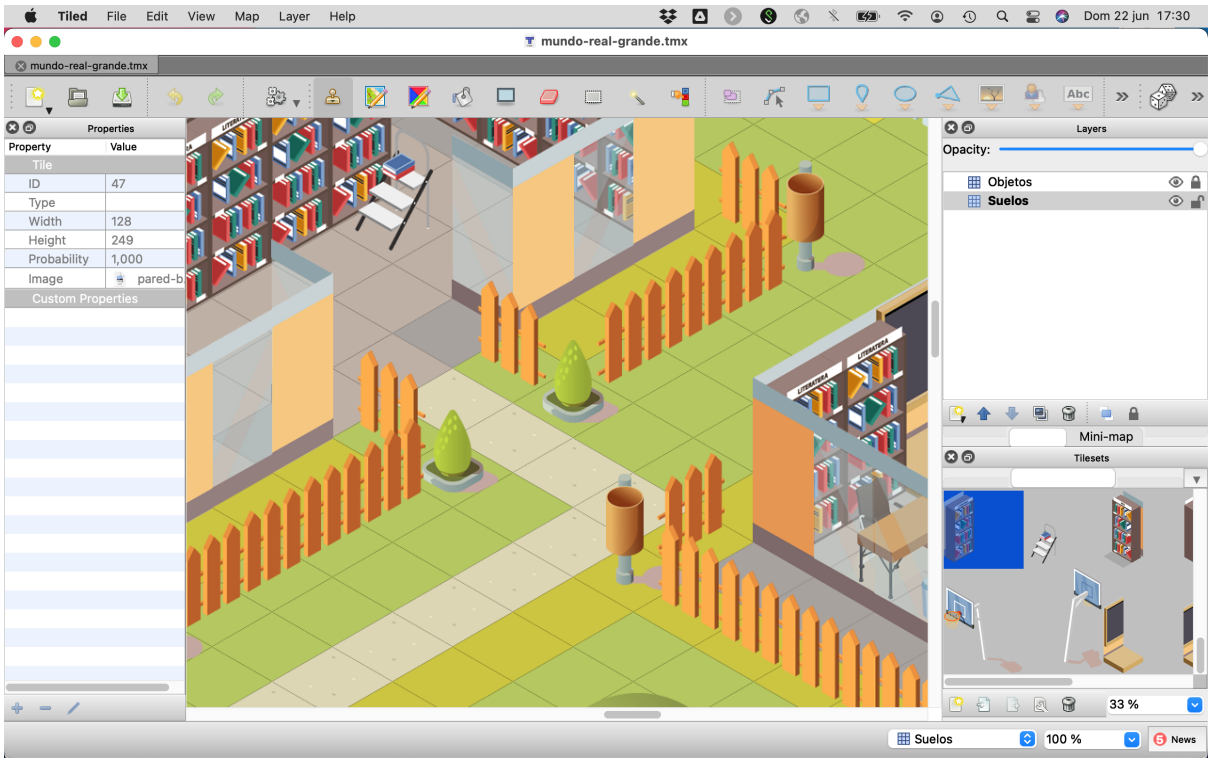

Figure 9: Creation of the "virtual world" of MundoCRA with TILED (layers)

Table 1
Teacher participants

Participante	Edad	Sexo	Nivel TI	Localidad
1	36	Hombre	3	Albacete
2	43	Mujer	3	Albacete
3	49	Mujer	3	Albacete

Next, the data referring to the students will be shown in Table 2. All students belong to primary education. The information collected includes your age, course, gender and whether they have used the system before or not.

Table 2
Student participants

Participant	Age	Course	Sex	Previous use
1	11	5º	Man	No
2	11	6º	Man	No
3	12	5º	Woman	No
4	12	6º	Man	No
5	11	6º	Woman	No
6	10	5º	Woman	No

This information will allow the system to be properly evaluated, taking into account the characteristics of the different types of users.

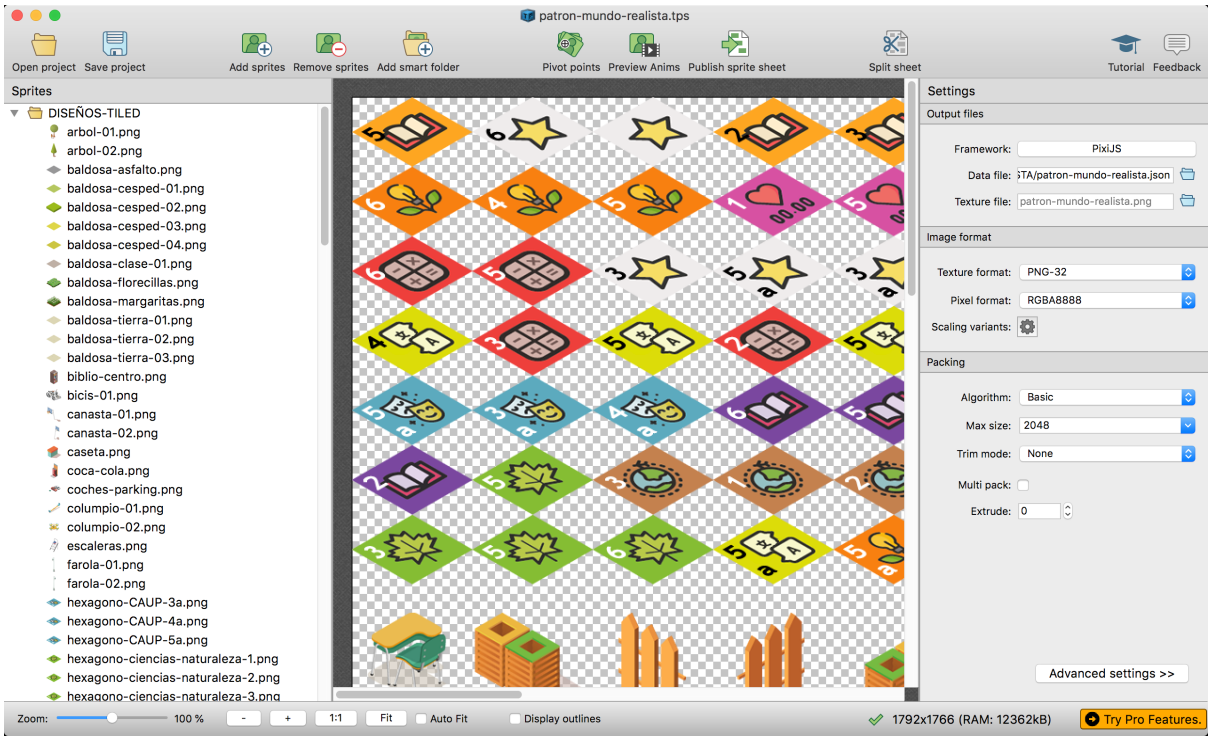

Figure 10: Packaging of tile and object types with TexturePacker

5.2.2. Context of product use

Tasks

Tasks Description

The tasks vary according to the type of user, with specific tasks for teachers and different ones for students.

The teachers will be in charge of testing the correct functioning of the library part in the world. Your task will be as follows:

Teacher task: Create a book, a scheduled reading and a reading activity.

a) Enter the application.
b) Enter the world.
c) Access the library section.
d) Create a new book.
e) Create a new scheduled reading for the book.
f) Create a new reading activity for scheduled reading.

As for the students, they will have a single task just like the teachers to prove that the part of starting a reading, finishing it and performing the reading activity works correctly. Your task will be the following:

Student task: Perform the scheduled reading and the reading activity.

a) Enter the application.
b) Enter the world.
c) Place yourself on the scheduled reading.
d) Start reading.
e) Value the reading.
f) Finish the reading.
g) Perform the reading activity.

Justification of the choice of each task

For teachers, it is crucial to verify their ability to create and manage books, scheduled readings and reading activities. In addition, your understanding and management of the virtual library within the world will be evaluated. This task ensures that teachers can use all the essential functionalities of the virtual library.

For students, it is essential to observe their ability to start, evaluate, and finish a scheduled reading, and then complete the corresponding reading activity. This task allows you to check if students can navigate and use the implemented functions without difficulties.

Information of the tasks provided to participants

For the students, the tasks were explained orally due to their simplicity, which did not require written instructions. Participants received verbal guidance on the actions they had to take, ensuring that they clearly understood each step of the process.

For teachers, in addition to the oral explanation, they received detailed information present in the System Evaluation and SUS Questionnaires. This made it easier for them to complete the tasks by having a written reference that they could consult at any time during the evaluation.

Compliance criteria

The task was considered successfully completed if the user was able to perform all actions from start to finish without significant external help.

Test facilities

The evaluation was carried out in the facilities of a primary school with the participation of six students and three teachers.

Computer environment of the participants

The evaluation was carried out using a single laptop with Windows 11. The desktop application was used instead of the browser version to ensure a uniform and controlled test environment.

Test manager tools

To record the time, the timer of an Oppo A74 Smartphone was used. In addition, Microsoft Excel was used to collect user data and their responses to the SUS questionnaire. This allowed accurate tracking of the time spent on each task and a structured compilation of participants' comments and evaluations.

5.2.3. Experimental design

For each participant, the time taken, the number of errors and the number of necessary attendances were recorded. With the number of attendances, it was possible to calculate the completion rate without attendance and with attendance. At the end, a SUS questionnaire was provided for participants to complete.

The students were called one by one. Upon arrival, the instructions were explained to them orally. A specific user was used for all students to ensure that each one had a scheduled reading task and assigned activities.

Students were instructed to perform the first activity, which consisted of entering the world and completing the scheduled reading. Once they finished the reading, they were told to stand on the reading activity and to do it.

Finally, they had to complete their personal data and answer the SUS questionnaire- For better understanding of the participants, this is adapted using emojis. At the end, they were asked to call another student from their class who had not yet taken the assessment.

Regarding the teachers, they were asked to create a book, a scheduled reading for that book and a reading activity for the said scheduled reading. Once they finished, they completed their personal data, and The SUS questionnaire also present in the SUS System and Questionnaire Evaluation.

The time of all users was recorded, as well as the necessary assistance and errors made.

5.2.4. Usability metrics

Effectiveness:

- Attendance completion rate: It is the percentage of tasks completed by the user without receiving help from the evaluator.
- Attended completion rate: It is the percentage of tasks completed by the user with the help of the evaluator.
- Errors: It is the count of errors the user makes when trying to perform a task.
- Assistance: It is the number of times the user requested the help from the evaluator.

Efficiency:

- Time to complete a task: It is the duration, measured in minutes and seconds, that the user uses to complete a task.

Satisfaction:

To measure user satisfaction when using the system, the SUS (System Usability Scale) [51] test was applied. This questionnaire contains ten items and produces a unique score. A five-point Likert scale is used in which the user indicates his level of agreement or disagreement. Users are also asked to respond quickly, and if they are not sure of an answer, they should select the midpoint of the scale.

For evaluation, two versions of the SUS questionnaire were used: a classic version and one adapted for children. Both questionnaires are available in the SUS System Assessment and Questionnaires.

The SUS score ranges from 0 to 100. The contribution of items 1, 3, 5, 7 and 9 is calculated by subtracting 1 from the position in the scale. For items 2, 4, 6, 8 and 10, the position is subtracted on the scale of 5. Then, all the contributions are added and multiplied by 2.5.

5.3. Results

5.3.1. Data analysis

Data score:

The behavior of the participants in groups was classified based on the number of errors, the number of attendances, the time taken to complete the evaluation, the completion rate with help and the completion rate without help.

Data reduction:

The users were grouped into two different categories: students and teachers.

Statistical analysis:

To obtain conclusions, the mean, minimum value, maximum value and standard deviation were calculated. The final score of the SUS questionnaire was also taken into account.

5.3.2. Presentation of the results of the teachers

Teacher's homework performance results

First, teachers were asked to perform tasks related to the creation and management of books, scheduled readings, and reading activities. The results can be seen in Table 3, the Table 4.

Table 3
Library management results

Participant	Attendance completion rate (%)	Attended completion rate (%)	Time (min)	Errors	Attendance
1	100	0	5.25	0	0
2	100	0	6.55	2	4
3	80	20	7.01	2	4

Satisfaction results:

Finally, teachers were asked to complete the SUS questionnaire. The results can be seen in Table 5. More results can be seen in the SUS System Evaluation and Questionnaires.

Table 4
Library management statistics

Statistical value	Attendance completion rate (%)	Attended completion rate (%)	Time (min)	Errors	Attendance
Mean	93	7	6.27	1.33	2.67
Maximum	100	20	7.01	2	4
Minimum	80	0	5.25	0	0
Standard deviation	12	12	1.00	1.00	2.00

Table 5
Results of SUS questionnaire (teachers)

Participant	SUS score	Usability	Learning
1	87.5	84.38	100.00
2	85.0	84.38	87.5
3	87.5	87.5	87.5
Mean	86.67	85.50	91.67

5.3.3. Presentation of student results

Student's homework performance results:

First, students were asked to perform reading-related tasks. The results can be seen in Table 6 and the statistics in Table 7.

Table 6
Student task results

Participant	Attendance completion rate (%)	Attended completion rate (%)	Time (min)	Errors	Attendance
1	100	0	1.03	0	0
2	100	0	1.05	1	1
3	60	40	2.41	3	3
4	100	0	2.39	0	3
5	80	20	3.05	0	4
6	100	0	0.50	2	2

Table 7
Student task statistics

Statistical value	Attendance completion rate (%)	Attended completion rate (%)	Time (min)	Errors	Attendance
Mean	90	10	1.75	1.00	1.83
Maximum	100	40	3.05	3.00	4.00
Minimum	60	0	0.50	0.00	0.00
Standard deviation	16.73	16.73	0.96	1.26	1.72

Satisfaction results:

Finally, students were asked to complete the SUS questionnaire prepared especially for them. The results can be seen in Table 8, along with the results of Learning and Usability calculated as indicated

by the study of Lewis and Sauro [53].

Table 8
Results of SUS questionnaire (students)

Participant	SUS score	Usability	Learning
1	82.5	84.38	75.00
2	90.0	90.63	87.5
3	85.0	81.25	100.00
4	80.0	75.00	100.00
5	85.0	81.25	100.00
6	70.0	75.00	50.00
Mean	84.5	82.5	92.5

More results can be seen in the SUS System Evaluation and Questionnaires.

6. Discussion

This section integrates the discussion derived from the analysis of the usability assessment, along with a general reflection on the contribution of the system and a description of the main lines of future work.

Once the evaluation is completed, it is necessary to analyze the data obtained and the observations recorded during the process.

6.1. Analysis of the results from teachers

Improvement Suggestions: Some teachers proposed modifying certain attributes in the creation of the books. For example, they suggested indicating the age range to which the books are directed, which can provide clarity. In addition, they recommended showing the name or some indicator in the table of reading activities to identify them more easily, as there may be more than one activity per scheduled reading in a course, making differentiation difficult.

Clarity in the Instructions: Although detailed instructions were available on the System Usability Scale (SUS) System Evaluation and Questionnaires, some teachers indicated that a quick guide within the application, with simple and visual steps, could improve ease of use.

These observations were reflected in the final score of the SUS questionnaire, highlighting that, although the system is functional, there are several areas that could be improved.

6.2. Analysis of student results

Response Time: On several occasions, the students took longer than expected to understand what to do after performing a scheduled reading. This suggests the need to provide more visual and audio indications.

These observations impacted the final score of the SUS questionnaire, indicating a significant margin to improve usability and user experience.

6.3. SUS score analysis

Finally, the SUS score is analyzed. By itself, the score does not have a specific meaning; it needs to be compared with other standards. Some specialists have proposed different scales to interpret the results.

- **Scores Above 68**: A SUS score above 68 is considered higher than average, therefore, acceptable. Both scores obtained (86.67 for teachers and 84.5 for students) exceed the threshold of 68, so the system can be considered acceptable.

- **Bangor et al. Scale**: According to the Bangor, Kortum, and Miller scale [54], a score from 0 to 59 is an "*F*," from 60 to 69 is a "*D*," from 70 to 79 is a "*C*," from 80 to 89 is a "B," and from 90 to 100 is an "A." Using this scale, students rated the system with a "B" (SUS score of 84.5), and teachers with a "B" (SUS score of 86.67).
- **Sauro and Lewis Curved Scale**: Lewis and Sauro created a curved scale based on the distribution obtained from 241 usability studies and surveys [53]. Ratings are awarded based on the percentiles obtained. Using this scale, students rated the system with a "*B*," and teachers with a "*B*."

It has been observed that technologies applied to libraries are primarily focused on resource management rather than their educational work and the promotion of reading. However, there is a more concerning issue in school libraries, where students may even be unaware of the resources available to them.

Therefore, LibroTech, in its first version, provides a tool to manage accessible resources for schoolchildren. Similarly, teachers can create functional reading activities that aim to motivate students to read.

The preliminary usability assessment primarily reveals whether users are satisfied with the functionalities. Evaluation has shown promising results in learnability (91.67%), usability (85.5%), and satisfaction (86.67%). Teachers mentioned that it would be interesting to create books during the process of creating an activity. Students, on the other hand, expressed the need for a system that allows them to read books beyond those recommended by teachers.

7. Conclusions and future work

LibroTech offers a novel contribution to the design of educational digital libraries by integrating gamified strategies (via GamiCRA) with teacher-driven reading activities. The system has proven to be usable and motivating in rural school contexts, as confirmed by a structured usability evaluation. These results validate its potential and lay the foundation for future iterations focused on personalization and creativity.

The students' opinions are revealing, as they allow us to consider the next steps in the research line. It appears necessary to develop a personalized recommendation system for each student, enabling them to choose possible readings for themselves.

Likewise, it would be interesting to expand the functionalities of the virtual library to include the creation of stories, which would allow convergence with the research line of story therapy. This could potentially increase the creativity of schoolchildren, one of the most important soft skills for the progress of knowledge societies and a priority for education [55].

All of this could be integrated into an intelligent agent within the system, similar to other gamified avatars. However, the specific functionalities of this agent have not yet been defined, although the mentioned features are the most promising for future work.

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Declaration on Generative AI

During the preparation of this work, the authors used GPT-4 in order to: Grammar and spelling check. Furthermore, authors use Consensus IA as a database, how it would be use ACM Digital Library for

search more relevant academics studies. After using these tools/services, the authors reviewed and edited the content as needed and takes full responsibility for the publication's content.

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