EduVR: Towards an Evaluation Platform for User Interactions in Personalized Virtual Reality Learning Environments

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ABSTRACT

Integrating novel technologies in education, namely technology-enhanced learning (TEL), is broadly discussed in educational and technology development areas. It is understood that educators can improve their comprehension of each student's learning processes using gathered data and provide more personalized content using technology. This work proposes a novel solution to automating getting data from interactions executed in Virtual Reality. This system offers a user-friendly interface allowing educators to create and share multimedia content in the game, collect data to provide insights about the users' behavior based on his interactions with the system, and provide an analytic tool for feedback and future analysis. The system's design discusses the main lessons learned by analyzing the theoretical concepts, functional and non-functional requirements, and the architecture proposal.

CCS CONCEPTS

• **Human-centered computing → Interactive systems and tools**.

KEYWORDS

virtual reality, technology-enhanced learning, learning analytics, immersive learning

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1 INTRODUCTION

The technology used in teaching and learning has given rise to the technology-enhanced learning (TEL) concept [11]. However, a technology discussion without a user-centric approach provides an incomplete process view. According to Laurillard [14], TEL is crucial to personalize the teaching and learning processes, improving their quality and effectiveness.

TEL-based systems require continuous feedback from users. Teachers need feedback to continuously improve their activities, while students need feedback to monitor their progress. This feedback is a critical aspect of the effectiveness of technology in education. Actually, most Educational Systems created in Virtual Reality base their foundations on creating an environment where the student can be evaluated in gamified ways, disregarding their interactions when grading.

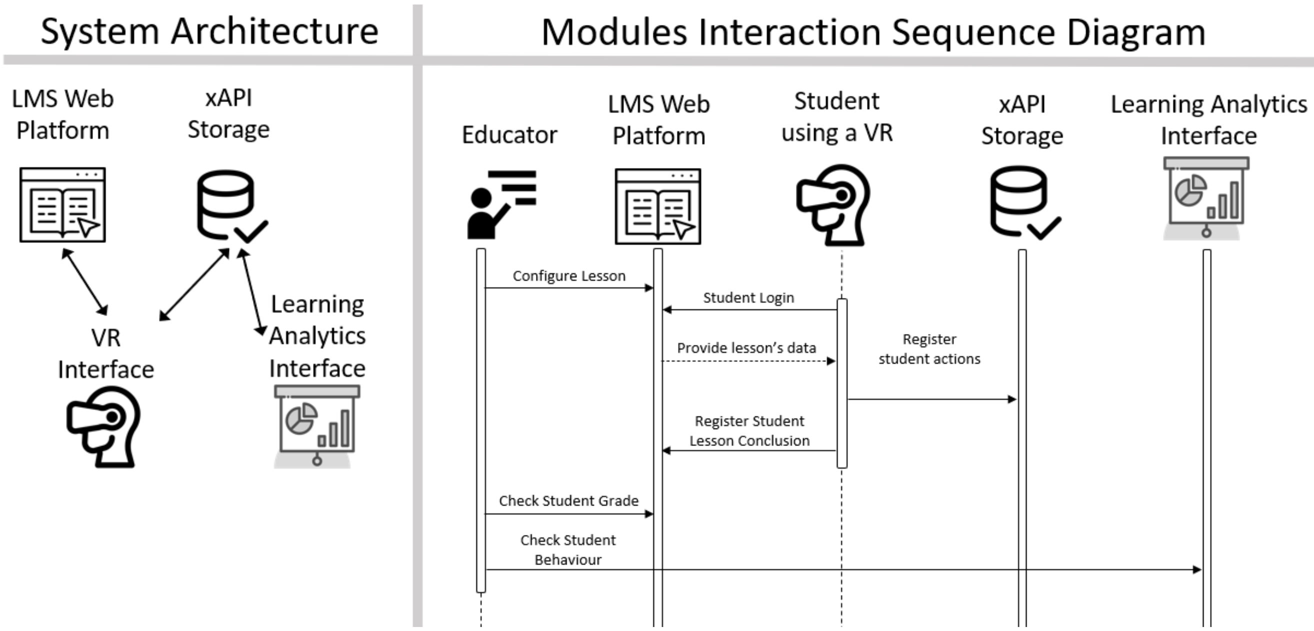

Figure 1: System Architecture and Modules Integration Flow

While existing systems lack the capability to gather feedback from users' interactions, a novel architecture is being proposed to estimate and analyze these interactions within a personalized learning system developed in virtual reality. Drawing upon theoretical concepts from Learning Analytics, Human-Computer Interface, and Education, an interactive ecosystem is envisioned, seamlessly integrating personalized learning and learning analysis. This proposed architecture empowers educators to tailor the teaching environment according to individual needs and receive precise, concise evaluations of their students' performance, irrespective of their prior computing knowledge. Consequently, the primary objective of this project is to introduce a new architecture for evaluating user interactions in a personalized learning environment, leveraging the potential of virtual reality technology.

In this paper, Section 2 discusses theoretical references that guide this work and related works and how they connect to the proposed environment. Section 3 discusses the stakeholders and the functional and non-functional system requirements. It also presented the system proposal in Section 3. Section 4 displays a study case developed as a proof-of-concept for this application. Finally, the lessons learned are discussed through the design process in Section 5, concluding with final remarks in Section 6.

2 THEORETICAL REFERENCES

This section assesses the main concepts within the context of Active Learning and its assessment. It begins by discussing the relationship between active methods and personalized learning. The technology's integration is discussed into the education system and concluded with the importance of analyzing learning technologies and their own challenges.

2.1 Active Learning

To comprehend the learning process is a complex task, encompassing various approaches. In traditional teaching, for instance, the learning process revolves solely around the teacher, as noted by Saljo [20].

In this model, the teacher is responsible for conveying all knowledge while students passively receive it within the classroom limits. The knowledge transmission of it is one-side oriented, with students depicted as passive roles. Nevertheless, with the information globalization arrival, students now have access to alternative means of acquiring knowledge, which were previously restricted. Consequently, teachers' roles needed to be refined. As students can actively pursue knowledge, teachers must find new ways to teach, assuming guidance in students' pursuit of knowledge. This student-centered teaching approach has given rise to tools development that enables and directs students' exploration [5]. This methodology is known as Active Learning.

Recognizing students learning differently, this methodology enables teachers to focus on each student's individuality. Personalized learning involves adapting methods and instructional systems to meet the unique objectives of each student [18]. It entails evaluating the student's difficulties and abilities, providing appropriate activities to fast-track learning, and benefiting from the student's strengths while addressing weaknesses.

Armbruster, Patel, Johnson, and Weiss [1] describe how implementing a student-centered pedagogy in a biology course enhances academic performance. They emphasize crucial elements such as presenting course content in a new way, incorporating interactive learning activities and problem-solving tasks, and fostering an environment centered around student learning.

Research evaluating student-centered pedagogical approaches indicates that students exhibit improved performance when exposed to active learning methodologies compared to those who were not. Evaluations of students in Science, Engineering, and Mathematics courses show that the implementation of Active Methodologies was sufficient to raise the grades from the top 50% to 68% of the class and decrease errors in evaluations from 33.8% to 21.8% [7].

2.2 Enhancing Learning with Technology

Technology has emerged as a valuable asset in reshaping traditional teaching methods. It empowers teachers by offering support in developing innovative educational tools that personalize knowledge for students and transcend the confines of the conventional classroom. Simultaneously, it aids students in comprehending and retaining concepts more effectively, granting them greater access to readily available, up-to-date content.

Technological device dissemination, such as computers, mobile phones, 3D immersion equipment, and video games, has significantly expanded educators' range of teaching and learning solutions. Here are some unique approaches by Pathania, Mantri, Kaur, Singh, and Sharma [19]:

- E-learning: This online, self-learning platform allows students to access educational materials from anywhere and receive constant updates. It promotes flexibility and convenience in the learning process.
- Massive Open Online Courses (MOOCs): These open-source platforms are valuable for students and teachers, offering opportunities for professional development. While they provide publicly accessible information, the feedback and interaction with instructors may be limited.
- Serious Games: These highly engaging tools captivate users' attention, bringing a sense of enjoyment and transforming study into a pleasurable experience. However, teacher personalization can be challenging since the games are not readily adaptable.
- Augmented Reality (AR): AR visualizes virtual elements within a physical domain, enabling students to interact with and observe the world through an AR device.
- Virtual Reality (VR): This immersive technology transports students to a new 3D world to experience heightened immersion and engagement. It can sharpen users' attention, promote the same sensations of pleasure experienced in games, and offer regulated choices for users.

Each of these possibilities has its compensations and shortcomings. In general, those activities can better promote personalization and student immersion and generate better cognitive responses [2, 8].

2.3 Learning Analysis

A challenge when using technology as a means of teaching and learning is to gauge the acquired knowledge.

Educators' role naturally transformed within new teaching methods emergence. The teacher is responsible for understanding students' learning profiles using personalized learning technologies. Through this step, they generate personal learning paths that dialogue with each individual's objectives and goals [18].

In addition, the teacher must create the proposed activities and define the scope of learning topics. This feature enhances support for student development on the personalized learning path. The parallel use of personalized learning also makes the teacher responsible for setting the criteria to proceed students to the next step in their learning path.

In immersive learning, teachers play a crucial role in designing and facilitating immersive experiences and activities for students, tailoring the content to suit their developmental needs. Just like traditional classrooms, teachers also require feedback on the activities progress they develop. This feedback allows reassessment and future improvement of the educational tools.

Various Big Data techniques have been employed to develop an educational system called Learning Analytics [3] to address this analysis challenge. Learning Analytics involves analyzing, measuring, collecting, and visualizing data related to the learning process, including information about students and the context in which one is engaged [13]. It encompasses user experiences, behaviors and assists in identifying and validating processes. Furthermore, it supports practices based on assessing progress, motivation, attitudes, and user satisfaction [16].

In their quest for dynamic data collection solutions for Learning, Analytics [4], Serrano-Laguna et al. [25] developed an API for serious games that allows educators to customize predefined actions. Their platform, known as xAPI Profile, provides a method to implement Learning Analytics within an application, enabling data collection from user interactions. Tuparov et al. [24] use this platform to integrate a framework that focuses on evaluation features. They evaluate how assessment activities, peer assessment, and self-assessment could be implemented on the Moodle platform using xAPI.

2.4 Interactions in VR

Imagining a platform where data is transformed into an experience makes VR a fantastic way to improve communication. When we consider the definition of interactivity [23] as "users participating in modifying the form and content of a mediated environment in real-time," it becomes clear that user interactions play a crucial role in developing Virtual Reality. The primary method of interaction in a VR system is translating users' positions and hand movements into a different environment [22]. Speech is also a common form of communication in this technology. However, the potential for engaging the user's senses goes beyond that.

In their review, Kitson et al. [12] catalog 12 different types of design elements used to measure interactions in a VR environment. Among them, breath awareness can make users more mindful of their bodies, biofeedback can aid in achieving concentration, and physiological measures such as temperature can provide insights into the user's health. In-game inputs can enhance social presence and emotional expressions. The more connected the user feels to the virtual environment, the more enriched their experience will be. While a headset is typically used to provide mechanics for user interaction [22], it is also possible to create environments with handheld displays or multi-display setups.

This project pioneers an innovative approach incorporating iterations with objects within a scene and user trajectory as novel metrics for assessing effort. These distinctive measures are subsequently linked to conventional performance evaluation mechanisms frequently utilized in educational settings.

2.5 Gamified Learning Environments

In the current "state-of-art," Gamified Learning Environments are feasible and present lots of advanced innovation. A common approach is to employ gamification elements in learning environments to create challenges and emotional triggers that motivate users. Badges and points are often used to quantify learning progress [6]. Incorporating these components makes a sense of progression, which helps motivate users to continue their learning journey. However, it is essential to consider how engagement is built, as students' motivations are not typically evaluated in this educational setting [6]. Many projects focus solely on creating evaluations for grading purposes, with less emphasis on understanding user interactions and motivations. Additionally, most projects adopt a unique scenario-based approach, which is just validated by their users and not easily reusable. There is a lack of information regarding how instructors and designers select and incorporate game elements in these projects [10].

To push the boundaries of the state-of-the-art, this project aims to establish an environment where the evaluation of progress is not solely based on grades but considers all interactions to create a comprehensive knowledge pathway. Additionally, by creating a versatile setting capable of accommodating multiple activities, we address the primary issue identified in the review conducted by [10] regarding gamification.

3 SYSTEM PROPOSAL

The systems' development used shared design techniques, in which all members contributed to full archive development. The stakeholders - Teachers, students, developers, and institutions - participate in the conception process beginning. Whereas teachers, e.g., act like co-designers in the conception process, the students generate data that create patterns for machine learning.

3.1 Stakeholders

Three different stakeholders for the system were identified. Each has its own needs and has been observed during the conceiving process.

(1) **Teachers:** The system needs to be accessible for the teachers to adapt it to the activities throughout the development platform. It needs to operate even without the development team's participation or even if they do not possess any programming knowledge.
(2) **Students:** The system has to be capable of providing adapted tools to the students. These tools [17] must promote students' motivations and reflect on the positive results in the learning process.
(3) **Institution:** The platform must generate results on the learning evaluation and be capable of self-adapting to the student's level to create a complete trajectory of knowledge development.

These evaluations aim to implement a robust learning analytic system that automatically captures user interactions within the learning environment. This system will provide valuable insights to the teachers and researchers operating the platform, enabling them to track activity development and gather data for comprehensive analysis.

Furthermore, our proposal seeks to identify individual "paths of knowledge." By understanding how learners behave during the learning process, we can create personalized suggestions for interactions that maximize each individual's learning potential. This approach aims to optimize and tailor the learning experience to each learner's needs and preferences.

We evaluate the EduVR requirements in the following sections based on the stakeholders' needs.

3.2 Non-Functional Requirements

The system will be integrated into a web platform, where teachers include and manage multimedia microservices such as uploading videos, photos, or texts for students. These microservices interface with the web platform and the game's tasks. The classroom system will be developed through VR adaptation games developed on Unity. All queries between both systems will be implemented using JSON (JavaScript Object Notation) [1], a lightweight data-interchange format.

3.3 Functional Requirements

The classroom must be adaptable through changeable resources in the web platform, making every classroom unique for each teacher and promoting the reuse of the games. The interface must make the classroom programmable without programming. The system must return results through distracts [9], evaluate the students for the complete learning received, and discard possible problems due the fatigue, emotional issues, or learning disabilities.

3.4 Proposed Architecture

This section presents the application components, their technologies, and their roles. It is described used technologies manipulated to build each component. Teaser Figure 1 shows the system architecture. We provide web links for readers to access each module. A version that can perform in VR (compatible with HTC VIVE and Oculus Quest devices) and a non-VR model for experimental purposes were done. It is limited to running only on the Microsoft Windows operational system.

- **Learning Management System (LMS).** The LMS is a standard system used to connect educators and students. An LMS provides an interface for educators to manage the lesson content and for students to manage their advances. It can be used for remote or face-to-face lessons. Moodle [2] is an example of LMS used for many educational institutes for learning purposes. Learning Press [3] is also an open-source plugin based on Word Press [4] content management platform that contains several plugins. It also includes a course page with a structure for visualizing the offered courses. Although

[1]https://www.json.org/
[2]https://moodle.org/
[3]https://wordpress.org/plugins/learnpress/
[4]https://wordpress.org/

we are still not using this resource, we decided on Learning Press as an LMS for our proof of concept, given this project's purposes and next steps. Figure 2 shows our LMS web platform screen.

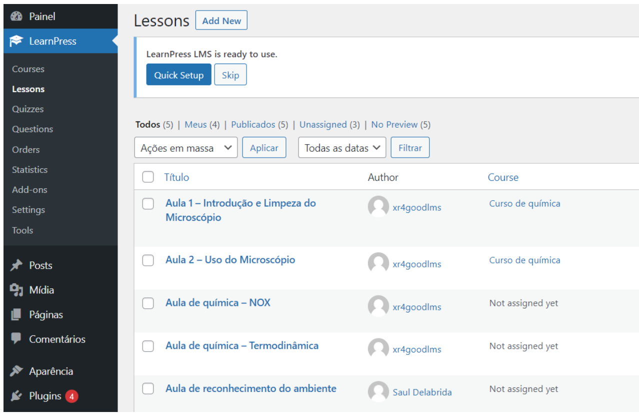

Figure 2: Developed LMS

The WordPress web platform and Learning Press plugin provide the interface. The paper team did some customization for communication among the LMS and VR system, but most of them are presented by an API accessed by an URL. The Learnpress panel provides an interface to create and manage courses, lessons, quizzes, and questions. All content prepared by an educator should be addressed through this interface. It is essential to state that the statistic modules are from the LearnPress system and do not correspond to our Learning Analytic interface.

- **VR Interface.** The VR interface is a developed 3D interface that provides users with an immersive experience to enjoy in practice. The current stage of technology still requires computer programming knowledge. It is perceived that most educators are not prepared for it. Thus, it is considered that the system should provide a 3D scenario, and the educators should add the lesson content through the 3D customized components ready to receive educators' data configured in the LMS interface. It was based on our 3D customized components on the most common multimedia components. It has been developed using the most common multimedia components used by educators. Next, it is described the implemented components.
Slider Component: The Slider Component shows the images loaded by the educator on the LMS system. It comprises a screen to show images and two buttons for the student to navigate among the images. Figure 3 shows an example of a slider component on the 3D scene
Video Component: The Video Component shows a video loaded by the educator on the LMS system. It comprises a screen showing the video and two buttons for the student to play/pause and repeat the content. Figure 4 shows an example of a video component on the 3D scene

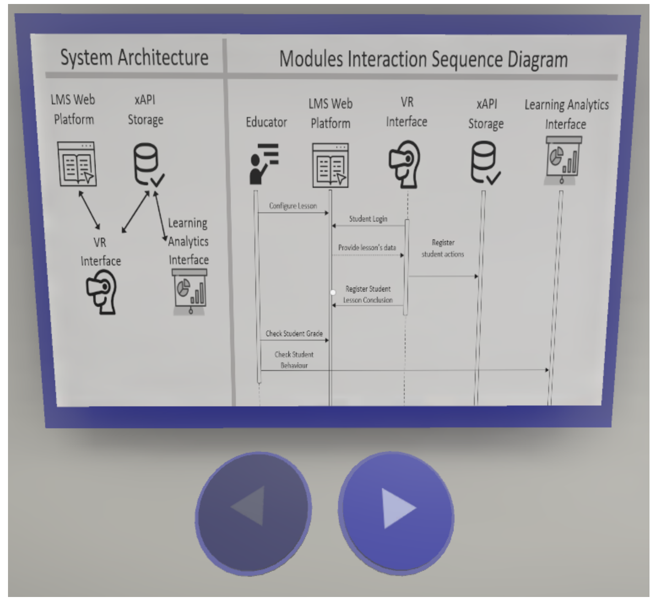

Figure 3: Slider Component

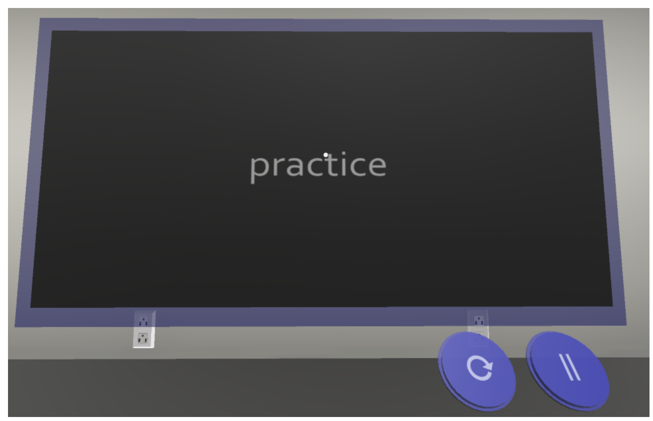

Figure 4: Video Component

Quiz Component: The Quiz Component shows the questions inserted by the educator on the LMS system and attached to a lesson. It comprises a screen showing the questions and possible answers and four buttons for the students to choose their responses. Figure 5 shows an example of a quiz component on the 3D scene
Lesson Instructions Component: The Instruction Component shows the lesson instructions inserted by the educator on the LMS. This version's shape is a whiteboard, and there is no interface for user interaction. Figure 6 shows an example of a Lesson Instruction component on the 3D scene
The team developed other components, such as an audio component. In this paper, the team restricts themselves to showing only the components available. Furthermore, all components with user interaction collect these data to perform the user behavior on the application. The following

Figure 5: Quiz Component

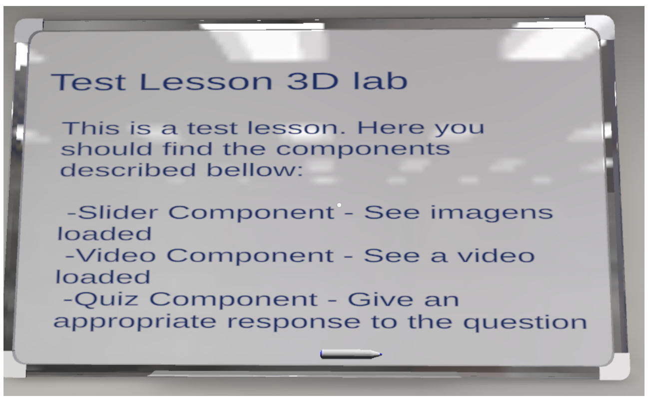

Figure 6: Lesson Instruction Component

section describes the xAPI interface used for this purpose. The team developed a system using Unity3D software.

- **xAPI Storage:** The Experience API (or xAPI) is part of the Training and Learning Architecture that an advanced distributed learning project developed. Originally named Tin Can API, the xAPI is an open-source specification for digital teaching applications. A specification collect data and information about these applications' learning and user experience, either online or locally [15]. An xAPI security group provides a set of guarantees for warranty and replacement over activities. The standard form of declarations is ⟨actor, verb, object⟩ [21]. For example: ⟨John read the document on food⟩. The data is companies using the JSON format. A *Learning Records Store* (LRS) was defined in the xAPI specification as a server responsible for receiving, storing, and providing access to Learning Records. An LRS store and retrieve xAPI assertions, store xAPI states, and save various other related metadata[5]. ScormCloud [6] receives claims registered by xAPI. Furthermore, it has a pre-configured interface for data visualization. Uses MySQL[7] as a database and checks before inserting if the data submitted matches the xAPI proposal. Figure 7 shows an example of the registered data captured from the user interaction with the components.

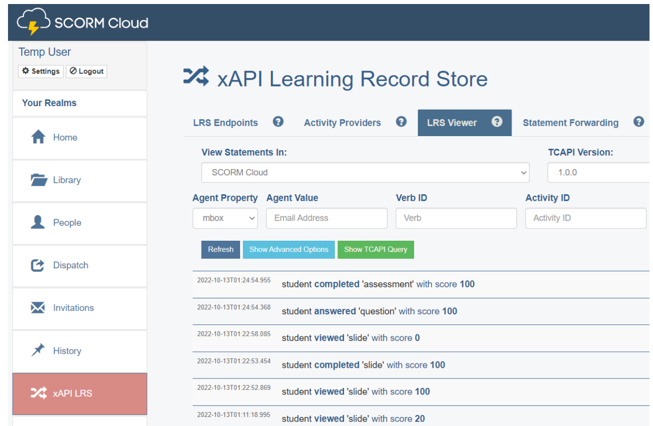

Figure 7: User behavior registered on ScormCloud xAPI interface

- **Learning Analytics Interface.** This interface is still being developed because the team needs more user data collected to create the interface. At this stage, the system requirements were defined and customized with the LMS system. To achieve these requirements, a synthetic database was generated respecting the structure of the xAPI as shown in Figure 7. Figure 8 shows a graph example generated by our synthetic dataset.
  The bars show students' time on each slide loaded on the slider component. The red line represents the average time other students spent using the system. This figure is a single representation of a visualization that helps the educator decide or have more knowledge about the student and their behavior. Much other visual information and techniques that can be used in future applications, such as data science methods, can be explored. Also, the user's spatial movement in the scenario can provide visual information about their movement during the lesson development through a heat map graph, for example.

3.5 Modules Interaction

This section describes the system module interaction flow. Figure 1 shows a sequence diagram illustrating the flow. The diagram presents two actors: the educator, who can create content for learning, and the student, who can use the VR interface for learning purposes. The educator should access the LMS interface to create a course and its lessons according to the description provided in Section 3.4. A student using the system should log in and select the available lessons.

With the success of this process, the LMS system retrieves all metadata configured by the educator to the immersive interface.

[5]https://xapi.com/learning-record-store/ - Accessed on March 2021
[6]https://scorm.com/
[7]https://www.mysql.com/

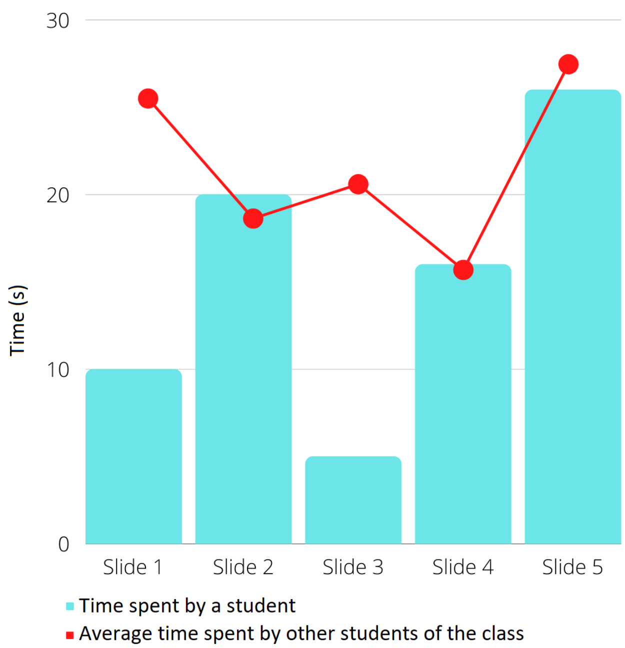

Figure 8: Example of a graph generated by our synthetic data set

When the student interacts with the components described in Section 3.4, their data are uploaded to the xAPI Interface, in this case, the ScormCloud platform. After finishing and lesson, the VR system should register this in the LMS interface. Depending on the interface, it can also be on the xAPI Interface—for instance, the Quiz component registry when the student completes the quiz. Once the students finish their lessons, the educator can check their grade and result on the LMS interface. The Learning Analytics Interface should provide a friendly interface for checking student behavior.

4 CASE-STUDY

To drive our development, the multi-disciplinary team, composed of academics from life and computational sciences, weaves a case for this system, defining requirements for a lesson in a lab and evaluating the results, endorsing the requirements' achievement. This section describes the study case and the development of our first proof of concept.

The first step in the project's development was to understand and identify the first set of needs of the users involved in the problem that must be solved. List of the needs:

- User should be able to select a class to take in the lab.
- Users must be able to interact with the lab using their hands.
- User must be able to move around the scene.
- There must be a way for the user to watch a video in two dimensions on a screen in the lab.
- There must be a way for the user to watch a 3D video on a screen in the lab.
- There must be a way for the user to view and scroll through items from a slide on a screen in the lab.
- There must be a way for the user to answer tests in the lab.
- User must be able to hold specific objects within the lab and move their angle or position freely.
- User usage information must be registered in some teaching data storage system, so responsible teachers can view them.
- The laboratory must model based on actual laboratories, creating the feeling of being there.
- Item and environment colors should be based on real labs but consider the color contrast required for good readability of items in a virtual reality environment.
- The game should run at a frame rate greater than 60 on computers with average hardware. This aspect ensures greater comfort and less chance of motion sickness or other joint complications when using virtual reality glasses.
- Hand interactions should be limited to pressing virtual buttons or, at most, one physical button, thus ensuring future compatibility with other low-cost hand-tracking methods.
- User must be able to move using an analog stick on the controller or via teleportation. Offering multiple options, users can select the one that best fits their use style and causes less initial discomfort.

After listing the requirements for carrying out this case, the next step in creating the laboratory was to look for references. Seeking to create a realistic environment, the dominant colors and construction characteristics, such as the material used and piping, electronic equipment, work benches, and exposed items, among others, were observed in the images found.

With a list of items, objects already modeled for free use were searched on the internet. Some of these objects are representations of chemical experiments. Others represent storage flasks and a microscope. In addition to the items directly related to the Biological Sciences area, others, such as books and the fire extinguisher, were also selected to compose the laboratory scenario.

Objects not found on the internet were modeled using Blender[8], free and open-source software for 3D modeling and animation. Some of these objects are the laboratory bench and an air conditioner.

The number of polygons in the objects was counted and normalized to improve the performance of the lower power system, as illustrated in Figure 9, ensuring that items found for free on the internet did not have a high number of polygons, which could weigh and compromise the user experience depending on the hardware used.

Optimization is one of the significant factors to consider when designing virtual reality. Many polygons place a massive load on graphics cards, causing performance to drop. To avoid possible discomfort that the user may experience, ensuring that the software runs at a high frame rate is essential.

The models were imported into *Unity*, where the lab was built correctly. The characteristics extracted from the reference images, such as colors and dimensions, were considered, creating a three-dimensional environment to portray the same experience in a real laboratory. Figure 10 is the polygonal model with the applied textures without any light and shading treatment.

[8]https://www.blender.org/

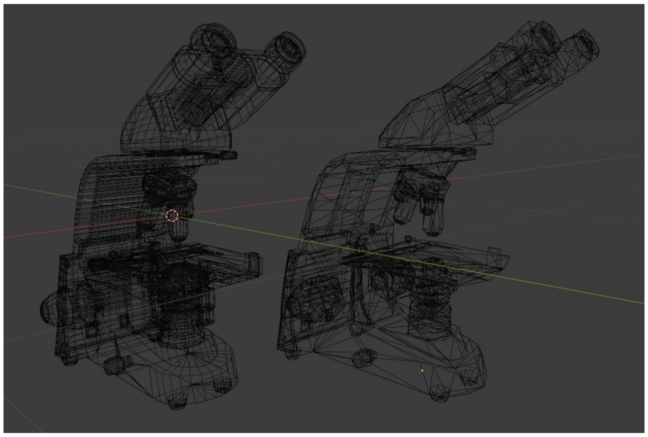

Figure 9: Left microscopy with the original mesh. Right microscopy with mesh reduced.

Figure 10: Final Lab before light and shadows treatment

The last step is the lighting part with the lab fully modeled and built within *Unity*. For virtual reality, real-time lighting is highly costly. Pre-calculated lighting was used and burned fixedly in the image, aiming at performance, especially on weaker hardware. The lights do not affect the real-time environment in which the player is. However, this technique helps to give realism to the environment, which until then seemed two-dimensional due to the lack of lighting.

The scene outside the laboratory was changed to have different levels of detail according to the distance of each element about the player seeking to optimize the game further using a technique called LOD, *level of detail*. Distant elements have a lower level of detail, while closer components have a higher level of detail. In addition to the LOD, an *occlusion culling* technique has also been applied, causing objects not in the player's field of view not to be rendered by the camera. Figure 11 shows the result.

With the conclusion of the environment, now is time to include the components described in Section 3.4. The components contain the scripts to access our developed LMS API and show the data configured by the educators. For this work, it was included a Slider Component (Figure 3), a Video Component (Figure 4), a Quiz Component (Figure 5), and a Whiteboard (Figure 6).

Figure 11: Final Lab after light and shadows treatment

Finally, the VR interface was included to complete the scenario. It was chosen Steam VR[9] plugin to provide interaction with users. It is compatible with the Oculus Quest and HTC VIVE, where users can interact with virtual hands. Both devices were available for the development of this project. Although the system captures the user's moves through the gadgets interfaces, they can also use the teleport feature to move in the scene.

The team successfully integrated all the modules in this case study to enhance the learning experience. The teacher effectively incorporated data into the Virtual Reality (VR) platform by leveraging the Learning Management System (LMS) platform. This integration allowed for the customization of the environment created by the programming team. By incorporating videos, slides, and quizzes, students could actively engage with the VR environment while being assessed within the system. Notably, all student interactions were meticulously recorded in the database and can be conveniently accessed through the developed xAPI interface. Furthermore, the gathered data were carefully analyzed, resulting in the automated generation of graphs and tables that the teacher can utilize for activity development and planning. These valuable insights also facilitate researchers in their analysis of student behavior in the virtual reality setting, eliminating the need for constant monitoring of student activity.

5 LESSONS LEARNED

In this section, the lessons learned are discussed, and identified challenges from the development of this system.

- **How do captivate tutors to become part of the team:**The first challenge in creating a platform that changes the common way of teaching is to involve professors. Since integrating new systems into traditional education has been a natural challenge, making professors believe that it is possible to evolve their way of teaching is not simple. The first lesson learned is that all professors want to integrate technology but do not know how. Although, the experience of trying virtual reality changes how they imagine how to integrate.

[9]https://assetstore.unity.com/packages/tools/integration/steamvr-plugin-32647

The use of Rich Media is a powerful tool to transform their mind.

- **How to create a friendly interface allowing educators to create their 3D lessons:** After starting the development, it was noticed that creating a simple assignment for a professor that get not used to programming can become a real problem. It introduced an interface that looks simple enough for the educator to make the process personalized. It was perceived it had to be simple. The interface must be close to what the user is already accustomed to. That is why the team established the development of Learning Press. Uploading multimedia or creating a quiz is a daily task for web educators.
- **How to incorporate changes from the interface in the proposal task:** After creating the interface, the main challenge was integrating multimedia. In a project in development, it is not difficult to change multimedia, but doing that after the program has already been built is quite a challenge. Creating components that receive their content at the building does not require reprogramming. So, it was perceived the simplest way to integrate changes is by incorporating changeable environmental components. Alongside this, the team prepared the ambiance to provide all the tools needed to archive the goals proposed for the tutors. In a laboratory, e.g., the students can be given a proposal to look at the microscopy. It was needed to have a component that shows the task and object microscopy. Otherwise, object microscopy does not need to be replaced if given a task to analyze a periodic table. The lecturer must only change the assignment and include a second object: the Periodic Table.
- **How to evaluate students based on their choices:** The first criterion when imagining how to evaluate students is the idea of right and wrong. The simple idea of using multiple options or evaluating based on some text is conventional. However, virtual reality should not have only one way to archive a goal. Various possibilities of choice are precisely the great trump of using VR. So, to look for alternatives, abandoning the idea of the duplicity of correctness and creating the idea of developing a way of knowing where the best way to do something is based on a profile, prebuild, based on the experience of students with the same profile that the user. The idea of using distractors came to synthetics the evaluation system.
- **How to release a friendly LMS interface for educators to connect different 3D interfaces:** The team developed a laboratory-focused 3D environment for cytology and integrated the proof of concept with an LMS interface. Customization development was required to complete this action. However, it must plan efficient interaction mechanisms when the number of three-dimensional environments offered to educators increases. The system must recognize which components are available for student data collection or even allow educators to choose these components. In this context, the challenge is to allow the customization of the spatial arrangement of the 3D elements of the application. At the same time, the class is being assembled in the context of the LMS.
- **Ethical Issues:** Although data collection can benefit the student, ethical and privacy aspects must be preserved. Recording a student's day-to-day activities must comply with local laws such as *General Data Protection Regulation* (GDPR) at the European level. An erroneous exposure of data can generate side effects such as demotivating. It is important to emphasize that behavioral data can shape social influences like social networks. These same data can be used as a basis for scientific research. Ethics and legislation must accompany the professionals' routine in all these scenarios.
- **Multiplayer Environment:** Users can experience games in *multiplayer* mode, more recently, connected to the Internet. This factor makes it possible for teachers to use custom computational interfaces *multiplayers* to allow collective use by students. This feature can be a viable alternative for collaborative learning. This challenge has technological and pedagogical demands. Finally, allowing a system like this on a large scale depends on some aspects related to the teacher's experience building their content in a gamified environment and a student's experience in the learning process with serious games. In this case, evaluating interactions from the Human-Computer Interface perspective is necessary for success.

6 CONCLUSIONS AND FINAL DISCUSSIONS

The development of this work started with concepts related to theoretical learning, seeking to provide new tools to educators and consolidate their role as planners and executors of interactive activities. The team assesses the progress of teaching and learning technologies to guide the development of the deployed system and looks for solutions to automate the knowledge assessment process.

Thus, a system was developed that proved helpful for teachers, accessible and easy to use, and for students who interact in a dynamic, well-structured environment capable of maximizing attention and fun. In this way, the team pursues to improve the learning experience. In addition, research and teaching institutions can benefit from the analyzes carried out by the proposed system.

The main aspects it was learned are related to attracting tutors to collaborate with the platform, creating friendly interfaces that allow the creation of lectures and experiments, integrating multimedia to customize the environment, evaluating students based on their choices, and to the launch of a user-friendly Learning Management System (LMS). Ethical issues and considerations related to multiplayer environments also arose.

The project involved a collaborative effort, incorporating adults, teachers, and young learners to create a more engaging and immersive academic experience. The focus is on developing user-friendly interfaces that cater to personalized teaching methods. Our ultimate goal is for this tool to become a valuable resource for researchers in the field of HCI-Education and Research. We aim to enhance the application's effectiveness in personalizing teaching approaches by conducting user studies with diverse objectives.

Through this work, we seek to engage the end-users, specifically students and teachers, actively. From a Human-Computer Interaction (HCI) perspective, this project opens up exciting new possibilities for conducting in-depth user studies, thereby enriching the educational experience.

For future work, it is planned to evaluate students' behavior in the presence of tutors in this type of environment. The team intends to test the practical use of this platform during a face-to-face course at the university. With this approach, it is expected to observe the effects of the learning platform on student performance.

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