Towards a Competency-Based Method for Designing Virtual and Augmented Reality Environments that Support the Needs of Elementary School Classrooms

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Abstract. Currently, traditional teaching, mainly in public elementary schools remains unidirectional, with teachers transmitting knowledge and students limited to passive listening and acquiring information. This has led to the need for developing new strategies that adapt educational models and enhance student learning through the use of facilitating tools. This paper presents the design of a method that utilizes virtual reality (VR) and augmented reality (AR) technologies to strengthen classroom learning. The different phases of the proposed method are described, aiming to be used both in the classroom and at home, adapting to the constant changes in the current educational environment. The method proposal focuses on educational competencies within the classroom and leverages VR and AR technologies to provide new opportunities for improvement in elementary school students' learning. The goal is to offer an immersive, interactive, and personalized learning experience that can enhance students' motivation and engagement, as well as strengthen their understanding and retention of key educational concepts. Furthermore, with the use of VR and AR tools in the classroom, it will be possible to personalized learning to accommodate the individual needs of each student, promoting an inclusive and diversified approach where students can learn at their own pace and according to their preferred learning styles. As a result of this work, the stages of the proposed method are presented, oriented towards the educational competencies associated with learning that can be developed through the proposed VR and AR applications.

Keywords: learning· virtual and augmented reality· educational models· basic education

1 Introduction

Virtual reality (VR) and augmented reality (AR) are revolutionizing current education by offering immersive and interactive experiences that enhance students' learning process ([6]. These technologies have been adopted by educational institutions and are used as complementary tools in the classroom to enrich teaching and capture students' interest.

Currently, there are various methodologies and forms of learning that seek to ensure students acquire knowledge and develop skills effectively. Educators have found great support in VR and AR, as these technologies enable meaningful learning and deliver expected knowledge in a more impactful manner [20].

The incorporation of technology in the educational field implies the need to adapt existing methodologies and leverage available technological resources in the classroom. VR and AR offer the possibility to restructure teaching methods, providing students with an immersive experience that facilitates an easier, interactive, and enjoyable understanding of topics [17].

VR and AR in education are producing a significant change in how teaching and learning take place. Virtual and augmented environments, through didactic and interactive games, promote active student participation in their learning process [19]. These technologies have managed to break the unidirectional dynamics of traditional classes, where teachers simply explain and students listen. Now, students can interact with virtual objects, explore abstract concepts, and engage in practical activities in a safe and immersive manner [17, 22].

The use of VR and AR as learning-teaching support tools has the potential to improve educational quality. Educators can utilize these technologies to create more dynamic and stimulating learning environments where students feel motivated and actively participate [21]. Furthermore, these technological tools foster inclusion by providing accessible educational content for all students in the classroom [29].

Virtual and augmented reality are technological resources that are transforming education. Their implementation requires the adaptation of educational methodologies, the involvement of different educational stakeholders, and the creation of immersive and effective learning environments. These technologies provide new possibilities to enhance the teaching-learning process, capture students' interest, and empower their educational development.

2 Virtual Reality and Augmented Reality in Education

Currently, virtual reality (VR) and augmented reality (AR) are widely used in the field of education to provide students with immersive and meaningful experiences. There are various applications and technological tools, such as Oculus Quest, AuthorAR, and didactic guides applied to augmented reality, that allow students to immerse themselves in virtual environments, enhance language acquisition and communication, and facilitate the visualization of knowledge [2, 14, 12].

In addition, numerous educational proposals in VR and AR have been developed (See Figure 1) that can be used as support in the classroom. For example, Anatomyou offers a 360-degree view of the organs of the human body, VR Education & Learning 360 provides a library of educational applications and games in AR and VR, Math VR presents scenarios related to basic mathematics and geometry, and Solar System VR allows exploration of the solar system and obtaining information about the universe [5, 24, 23].

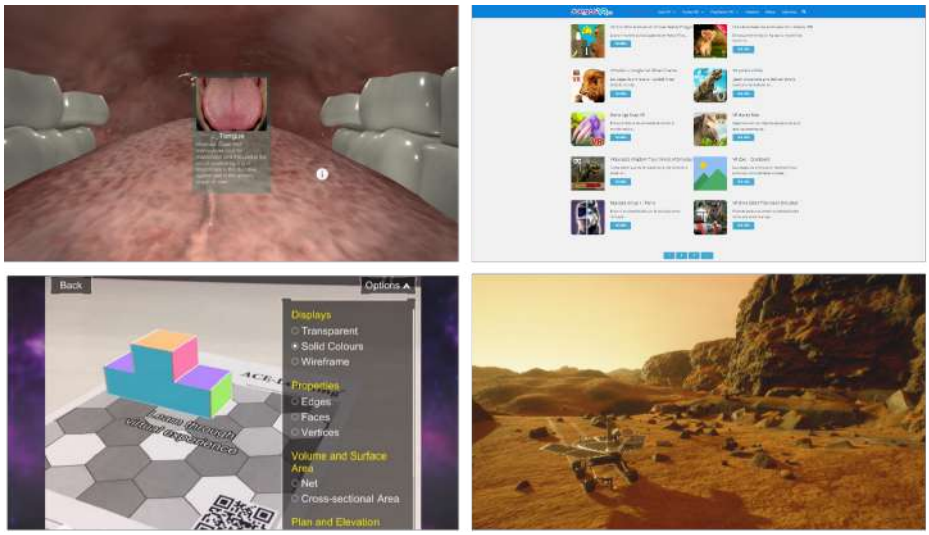

Fig. 1. Example of VR and AR Applications in the Educational Contex

The use of VR and AR in education offers multiple benefits for students. These technologies allow them to engage in immersive real-world experiences, facilitate understanding of complex concepts, maintain their attention and motivation, support the inclusion of students with learning difficulties or behavioral disorders, accelerate the learning process, promote communication in collaborative tasks, and enhance the assessment of skills and abilities [10].

Virtual and augmented reality have become valuable tools to enhance learning in the educational field. Through applications and technological tools, students can immerse themselves in virtual environments, explore concepts, and acquire knowledge in an immersive manner. These technologies offer numerous benefits, such as improving attention and information retention, including for students with difficulties, and fostering collaborative skills. It is important to continue exploring and developing new educational proposals in this field to fully harness the potential of VR and AR in education.

3 Related Work

The related work focuses on the pedagogical models used in the teaching-learning process in the classroom [25]. These models enable teachers to select, integrate, and organize the most appropriate methods, techniques, and materials to achieve educational objectives. Furthermore, they facilitate the evaluation of classroom work, allowing teachers to reflect on the quality of their practices.

Pedagogical models are based on educational theories and address key questions such as what to teach, to whom, how to teach it, when, and how to assess the results. These models structure the teaching and learning process, defining the objectives, content, methodologies, resources, and specific assessments to provide quality education to students [25].

The constructivist model has made significant contributions to education, particularly in psychological and didactic aspects, by enabling students to develop their learning and construct their knowledge [16]. In this approach, teaching focuses on the constructive mental activity of the student, which is not only activated when they manipulate, explore, discover, or invent, but also when they read or listen. The following Table 1 presents an analysis of the most well-known or commonly used pedagogical models in the educational context, detailing their characteristics and approaches.

It should be noted that pedagogical models are important in education as they provide guidelines for the educational process by defining purposes and objectives, reviewing the literature and among the wide variety of articles [8, 27, 26], in the Table 2 we chose some works that are related to these new technologies and share the same purpose of this article are the following as a brief summary.

Virtual and augmented reality in education is presented as motivating tools that foster students' interest in the classroom [4]. By creating interactive virtual objects, the assimilation of knowledge is facilitated, turning learning into a playful and stimulating experience. Additionally, these technologies promote the development of skills such as confidence, responsibility, communication, and the relationship between students and teachers. They also provide support in disciplinary learning and the development of cognitive skills such as critical thinking, collaboration, and analysis [3].

Virtual and augmented reality provide a learning experience that becomes a game, a challenge, an adventure, and a discovery, enabling the acquisition of skills, confidence, responsibility, communication, and relationships among students and with the teacher [4].

Furthermore, it is important to consider user-centered design (UCD) for the development of interactive systems in the educational context [1]. UCD is based on the consideration of human factors and ergonomic knowledge, which enhances the efficiency and effectiveness of interactive systems and reduces potential adverse effects on health and safety during their use [9].

Table 1. Analysis of educational models.

	Traditional training [13]	**Constructivist Model [18]**	**ADDIE Model [15]**
Learning method	Typical class session. One-way lectures. Repetitive support tools (books, blackboard, videos, etc.).	1. The learner follows his or her own learning process. 2. Learning builds new knowledge from the base of previous teachings. 3. Learning is active, they participate in activities instead of remaining passive observing what is explained to them.	E-learning learning experiences aimed at enhancing students' skills and knowledge.
Academic Program (Approach)	The priority is that the student is taught the subjects according to the curriculum.	1. The teacher is responsible for mastering the physical and mental activities so that the student thinks for himself, reflects and interprets reality. 2. Participation in activities.	1. An institutional process is designed where the results of the evaluation of each phase may cause the teacher to return to any previous phase. 2. The final product of each phase is the starting product of the next phase.
Evaluation Strategies	More value is placed on memorized exams.	1. The way to evaluate is through the learning process. 2. It looks for the student to be responsible and to control the teaching-learning process. 3. The functionality of learning is of interest.	This has a disadvantage in that it has no technological guidelines or evaluation strategies to follow beyond the framework itself.
Promotes Values	1. The curriculum is followed as such and sometimes forgets to include values in the core subjects. 2. They are educated as a class subject.	1. Student participation is encouraged by creating groups where everyone interacts and shares information and ideas. 2. Values are promoted and lived in the classroom on a daily basis due to the high degree of interaction.	1. Its implementation design can be adapted to e-learning. 2. Content can be created to promote values.

4 Model Proposed

This section presents the proposal of virtual reality and augmented reality environments focused on the educational context. The objective is to have virtual

environments that support activities in the classroom and are used by elementary school children through cognitive, multidisciplinary tasks, aiming to be integrated into daily practices in elementary education centers.

Table 2. Related works of Reality Virtual and Reality Argument.

	Use of augmented reality in the classroom [8]	**Reading habits in 5th-grade students in a rural context, mediated by augmented reality [27]**	**Gamified extended reality in the teaching of natural sciences [26]**
Objective	To promote the inclusion of futuristic technological tools in school institutions.	To generate reading habits in students and provide them with meaningful and motivating experiences so that they can adequately develop their reading skills.	Addressing current educational issues through gamification by focusing on game mechanics.
Activities	Combination of musical content with the use of technology.	Through Cospaces software and the use of the Merge cube, generate literary texts in virtual content that can be visualized through AR in real time and space.	By means of the game to obtain good results and improve the way in which knowledge is obtained, this as a way to motivate the student.
Benefit	Meaningful and experiential learning of students and encourages their interest and motivation in the learning process.	AR is intended to be the tool that enables the acquisition of reading habits, since it allows direct interaction with multimedia content and allows for the creation of attractive scenarios for students.	This fosters a behavior of commitment to their own learning and allows them to internalize the knowledge as a positive and fun experience.
Use of Methodology	The work uses the ScapeRoom methodology in which students work in teams and use critical thinking to solve proposed challenges.	Method selected (5 phases)	A methodological development proposal and the results of the evaluation with the ISO/CEI TR 9126-3:2003 standard are presented.
Relationship to the proposed Method	Yes	Yes	Yes

Next, each phase of this proposed model depicted in Figure 2 is detailed, supported by VR and AR as technological tools to enhance classroom activities. This user-centered model is designed to serve as a learning-teaching framework.

Fig. 2. Model for the Development of Virtual and Augmented Reality Environments.

The main objective is to introduce a teaching method enriched with VR and AR tools that is interesting and supportive for educators, allowing them to address important topics in the classroom such as inclusion and the promotion of values through cross-curricular activities. The model consists of five phases, each with its own functionality to achieve its objective. The following sections describe each phase of the model shown in Figure 2.

Table 3. Identification of characteristics for the adoption of AR and VR environments in the educational context.

Methodology	VR	AR	Pedagogical model	Immersive learning	Inclusive environments	Gamification
VR and AR as a constructivist learning-teaching experience.	✓	✓	✓	✓	✓	✓
Pedagogical models and learning theories.	×	×	✓	✓	✓	×
User-centered designs using VR and AR.	✓	✓	✓	✓	✓	✓

User research In this phase, questionnaires will be formulated and applied to assess the level of knowledge and adoption of VR and AR among users, as

well as their proficiency in other technologies, skills, and abilities in the use of ICTs that can be utilized within the classroom. Additionally, students are identified in advance based on their knowledge by education experts, teachers, and educational staff. Some important aspects of this phase include:

- Understanding the needs and objectives of the students and/or users who will use these VR and AR environments.
- Providing information about the context of use, the tasks to be performed, and the intended outcomes (knowledge).
- Defining the features of the product that will be presented or offered.

As the first activity of the case study, evaluation instruments were created with the purpose of collecting data and investigating the use and satisfaction of virtual reality and augmented reality applications in the educational field. Questionnaires were designed targeting both students and teachers to assess their knowledge and proficiency in these technologies. The first questionnaire was administered to elementary school students, specifically third-grade students, with the aim of evaluating their level of knowledge and proficiency in virtual reality and augmented reality. The second questionnaire was directed at teachers from a primary institution to understand their perception and mastery of these technologies in the classroom. The questionnaires consisted of multiple-choice questions and an open-ended question for additional comments. The reliability of the questionnaires was assessed by calculating the Crombach's Alpha statistical formula. These evaluation instruments were implemented in a school in the San Antonio de los Horcones community, Jesús María. The questionnaires were shared through the Google Forms platform (https://forms.gle/bMSedxTFB7k3Fkt76).

Identification of competencies In the competency identification phase in the educational context, with the support of trained educational personnel, the aim is to identify desired skills and learning objectives through the use of virtual reality and augmented reality technologies. This stage involves analyzing available resources and proposing solutions to meet educational needs, including those of students with disabilities. Assessment strategies are implemented, emphasizing the development of flexible skills, attitudes, and critical thinking to promote user autonomy. Activities include the preparation of tasks, games, and quizzes, as well as the identification of users' abilities, preferences, and socio-affective behaviors. All of this is presented according to each user's profile, as shown in Figure 3. Furthermore, seeking feedback to improve the system being used is a key objective [9].

In the Competence Identification phase, the support of teachers and education specialists is enlisted. After administering the assessment tool to students, the identification of competences to be addressed in the context of virtual reality or augmented reality takes place.

The objective is to identify the students' competences and the learning objectives that are intended to be achieved through the use of these applications. It also aims to determine the students' capabilities, the type of activities that

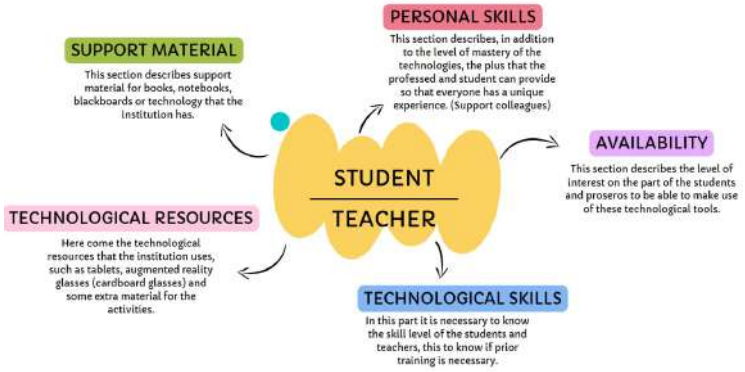

Fig. 3. Process for the identification of competencies

align with their profile, and possibly a learning model tailored to their needs. As shown in Table 5, educational competences are defined as the result of the combination of practical skills, knowledge, motivation, values, attitudes, emotions, and other social and behavioral components that enable an individual to develop effective actions to solve problems in various areas of their life.

It is the responsibility of the teacher to know their students' capabilities in order to decide the most suitable teaching method.

Table 4. Identification of Competencies.

#	Key	Competence
1	CTEX01	Understandig texts
2	IEMT02	Identifying elements
3	PMTM03	Critical thinking

Phase 2. Identification of competencies is presented as a case study oriented to the products that this model has in terms of software, analysis and design, the competencies are presented. It is worth mentioning that the first case study was used to develop this second case. See figure 4.

In Figure 4, examples of the instantiation of the competency analysis from Table 5 are presented. For instance, Example 1 indicates that the competency described as "Reading Comprehension" proposes the application of "Exploring the Ocean: Marine Animals" as an innovative form of traditional reading. This proposal is aimed at individuals aged 5 to 10 years, making it suitable for the targeted profile. The book serves as an effective complement to practice reading, develop imagination, and the application also includes an assessment to ensure the individual's comprehension of the reading. Upon completion, an oral explanation is requested as a complement. Next, phase 2 is presented as a case study. Identification of competencies oriented to the products that this model

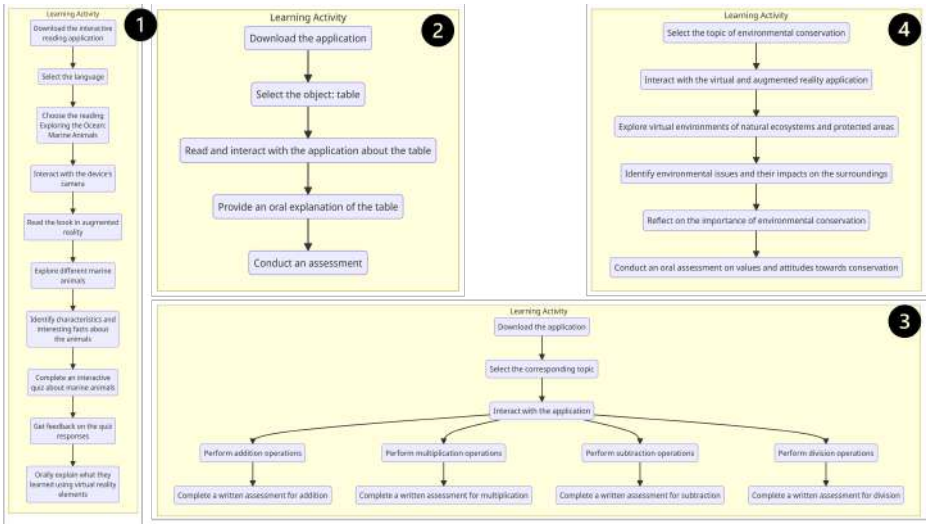

Fig. 4. Examples of instances of identified educational competencies.

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Information gathering In this phase, information will be collected to analyze the results obtained through questionnaires and interviews with the users themselves. These questionnaires will serve to collect information, specific and measurable aspects for the creation of VR and AR environments that serve as support in the classroom.

Table 5. Example of analysis of educational competencies for implementation through the use of virtual reality and augmented reality applications.

Competencies	**Competitive Attributes**
Understanding texts.	The student reads and understands the reading activity clearly according to the identified level.
Identify elements.	That the student is able to identify different elements such as objects, shapes, materials, and colors according to the theme and their level.
Mathematical Thinking (addition, multiplication, subtraction, division)	That the student masters the basic mathematical operations.
Attitudes and values.	That students approach content from the contexts of their personal, cultural, and social lives, in order to identify the relationship between science, technological development, and the environment.

Implementation This stage involves proposing a strategy for users (teachers and students) to incorporate the use of the identified VR and AR applications into their classroom activities in order to reinforce knowledge and provide a playful and interactive alternative where users can construct their learning through various interaction mechanisms.

Evaluation In this stage, evaluation mechanisms are proposed (See Table 5) to obtain relevant information from the previous phase. User experience evaluations, usability assessments [11, 28] are conducted to determine the level of acceptance among students and academic staff regarding the use of VR and AR applications.

Table 6. UX evaluations proposed for the design of scenarios in VR and AR.

UX Evaluation	Measures
UEQ(User Experience Questionnaire) [7]	Attractiveness Efficiency Perspicuity Dependability Stimulation Novelty
SUS (System Usability Scale) [7]	Perceived Usability Effectiveness Efficiency Satisfaction
UMUX (Usability Metric for User Experience) [11]	Reliability Concurrent Validity Sensitivity
CSUQ (Computer System Usability Questionnaire)[11]	Overall System Usefulness Information Quality Interface Quality
AttrakDif[30]	Pragmatic quality. Hedonic quality – identity. Hedonic quality – stimulation. Attractiveness

5 Conclusions

This work aims to highlight the potential of virtual reality (VR) and augmented reality (AR) as content to be used in the classroom for teaching and learning in elementary school. The goal is to integrate them into everyday classes to achieve

a higher level of student participation, integration, and interest, allowing them to develop their skills in a fun and dynamic way. An important aspect to consider is that when implementing VR and AR applications, they must have a pedagogical, inclusive, and adaptable approach that can be implemented in basic education institutions.

These proposed environments are highly useful as they incorporate many of the methodologies used in the educational context, adapting to the needs and characteristics of the students. Additionally, they can consider other aspects such as a communicative and inclusive approach, as well as emotional engagement, to promote student participation and unleash their potential. The future work is extensive, as there are plans to implement VR and AR environments in elementary school students, ensuring that students are motivated to participate in their learning process through interactive, dynamic, flexible, and versatile activities where they can manipulate various real-life situations through VR and AR.

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