Model for the Development of Virtual Reality Applications for Learning Geometry in Basic Education.

Humberto Muñoz Bautista [1], Héctor Cardona Reyes [2, *], Miguel Angel Ortiz Esparza [2], Jaime Muñoz Arteaga [1] and Cesar Gonzalo Vera-Vasquez [3]

1 Universidad Autónoma de Aguascalientes, Aguascalientes, Ags. México

2 Centro de Investigación en Matemáticas, Zacatecas, México

3 Universidad Continental, Arequipa, Perú

Abstract

Activities for pedagogical purposes are implemented following instructional techniques; being these in turn part of the strategies; Therefore, in education there is a great diversity of educational resources that are used in the teaching and learning processes, that are part of a remarkable contribution. In Mexico, at the basic and upper secondary levels, the educational model is currently based on competencies. Where it is sought that the student has the necessary tools to face the situations of daily life, so the use of Virtual Reality (VR) would allow students to find themselves in virtual immersive situations similar to the real ones and prepare for the real world. The VR opens an option in the teaching-learning process that allows students to live experiences that they may not be able to live in the real world, but in a virtual world they can experience it.

Keywords

Virtual reality, Basic education, model, Math Skills.

1. Introduction

In general, mathematical skills have become the most difficult skills seen by students [1, 2], whether they are moved by the historical part, the little interest or by the complexity of the same, taking into account the above and the advances in information and communication technologies, in the present work a model proposal is made that will allow having tools that allow reducing or removing the rejection of mathematics, through the use of virtual reality devices, which would make the teaching of mathematical skills; specifically the skills in geometry and the development of spatial thinking; in an interactive teaching-learning process.

With the great technological development that has occurred in recent years, we can see how technology has led to what some authors call the new "social revolution", with the development of "the information society". With this, we want to refer to the fact that the raw material "information" will be the engine of this new society, and around it, new professions and jobs will arise, or existing professions will be adapted. We see a clear example in education where technology is used to a greater extent every day, where ICTs allow the development of new electronic teaching materials that use different media.

For this reason, the work of the classroom and outside of it in education has undergone important changes thanks to the inclusion of ICT in education. According to the OECD report [3] All countries seek to improve the quality and efficiency of education, so the use of ICTs was used to achieve this objective.

CITIE 2022: : International Congress on Trends in Educational Innovation, November 8-10, 2022, Arequipa, Perú
*Corresponding author.
EMAIL: hmuntista@gmail.com (H. Muñoz-Bautista); hector.cardona@cimat.mx (H. Cardona-Reyes); ing.miguel.o.e@gmail.com (M. Ortiz-Esparza); jaime.munoz@edu.uaa.mx (J. Muñoz-Arteaga); cverav@continental.edu.pe (C. Vera-Vasquez);
ORCID: 0000-0003-1720-0554 (H. Muñoz-Bautista); 0000-0002-9626-6254 (H. Cardona-Reyes); 0000-0001-8762-5780 (M. Ortiz- Esparza); 0000-0002-3635-7592(J. Muñoz-Arteaga); 0000-0003-4168-5117 (C. Vera-Vasquez)

2. Problem Outline

One of the many sections of technology is Virtual Reality, technology that is considered new; however, it has been in use since 1965 when the first case was built and the first program was created [4] and its concept was proposed in 1973 [5]. This technology has a wide range of applicability, resulting in the fact that today we see Virtual Reality applications in the entertainment, training, tourism, marketing, productive and industrial sectors, medicine and education.

Allowing in each area an advance and understanding of the processes in an interactive and immersive way; by the very nature of technology; which allows its use in a natural way in the teaching-learning process, where it is sought to obtain new tools to benefit the fulfillment of competences in the students.

The basis of most Virtual Reality applications focuses on using the theory that directly experienced knowledge is better retained than when listening to or observing a situation; This theory uses the concept of knowledge in the first person[6], which goes hand in hand with the main axis of the teaching-learning process of current educational models, where the construction and acquisition of knowledge is intended through experiences, projects and own situations, which unlike the method used in the methodologies traditional educational, it is sought that the student is the central protagonist of the process.

The implementation of didactic learning methods has been tested in a large number of works. According to a study by Bloxham and Wileman [7, 8] published in the Journal of Virtual Studies, students who experienced hands-on education using virtual reality increased their retention rates by up to 18.1% in math, followed by 13.1% in mechanics and 2.9% in engineering.

Taking into account these possibilities, not only is it possible to improve the teaching-learning process, but it would allow students to have the opportunity to live experiences that in many cases they already have at an adult age or many occasions such situations cannot be experienced; An example is being able to interact with ecosystems, animals, plants, cities that are not in the student's place of origin.

In Mexico, the teaching-learning process is undergoing a series of reforms that seek to privilege the achievement of skills by students and that they achieve a construction of their knowledge through lived experiences [9], Therefore, by implementing virtual reality technology, the experiences that students will have can be enhanced, allowing them to overcome the barrier of distances, times and adverse situations such as the current pandemic, providing an interactive and immersive opportunity in their education through virtual environments and interactive, encouraging students to be more active and involved in classes, allowing greater student involvement in their training and strengthening the construction of their knowledge in the teaching-learning process.

3. Model

The model for the development of virtual reality applications in learning determines the necessary elements for the development of virtual reality educational environments to be used in the teaching-learning process of the students. Scenarios are designed primarily that allow a playful environment for students that by integrating components such as; rules, achievements, prizes, 3D models, interaction, and immersion, allow achieving the skills and learning objectives set by the teachers, with special emphasis on facilitating the explanation of complex or abstract concepts [10]; like math concepts. Figure 1 shows the general phases of the proposed model, in which education professionals participate, who are the primary agents for the implementation of virtual reality applications in the teaching-learning process, providing the necessary objectives for learning and development of skills. student competencies.

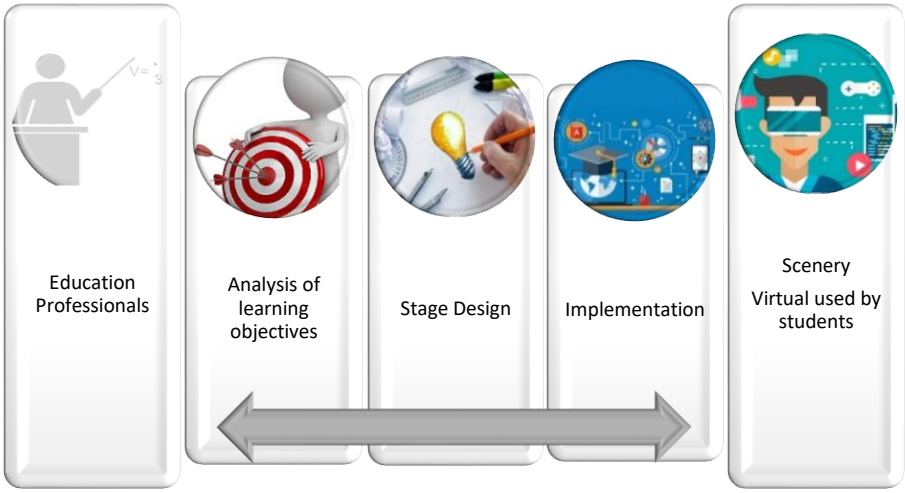


Figure 1: Model for the development of virtual reality applications for learning geometry in basic education.

For the first phase corresponding to the analysis of learning objectives, it is proposed as a phase of analysis of requirements, where the goals, educational needs and competencies that are desired to be fulfilled in the student's learning are defined. In order to be included in the script of the virtual reality educational environment. In the second phase; stage design; It will be the modeling and creation phase of each of the virtual reality elements that allow the fulfillment of the learning objectives set out in the previous phase; to carry out the development of the application and to be able to fulfill the necessary elements for virtual reality applications. In the last phase corresponding to the implementation, the interpretation of the learning objectives and the design of the scenario for the realization of the technical specifications required by the system take place, obtaining as a result the virtual scenario that is the set of elements that implement the requirements and models obtained in the previous phases, with which the student will have the interaction to fulfill objectives and develop skills in their learning process.

For virtual reality applications, the objective is to give the user the sensation that he is in the place that the virtual world shows, so we require a set of elements that allow said sensation. Among the main elements that virtual reality applications have are those shown in Figure 2 and described below:

- Script: based on the goals set in the learning objective analysis phase, it will guide the user to meet goals and develop skills.
- Materials and textures: Digital components for the construction of objects for the virtual world, providing characteristics and realism to the objects.
- 3D Models: Objects that will model reality on the virtual stage for interaction with the user.
- Scenario: definition of the place and/or environment where the student is for the fulfillment of objective.
- Immersion: defines the level of immersion that the user will have in virtual reality, use of glasses, helmets, 360 audio and video components that allow students to feel in the virtual world.
- Interaction: components for the identification of the student in the real world and transfer actions and movements to the virtual world. Use of monitoring system and controls to carry out actions.

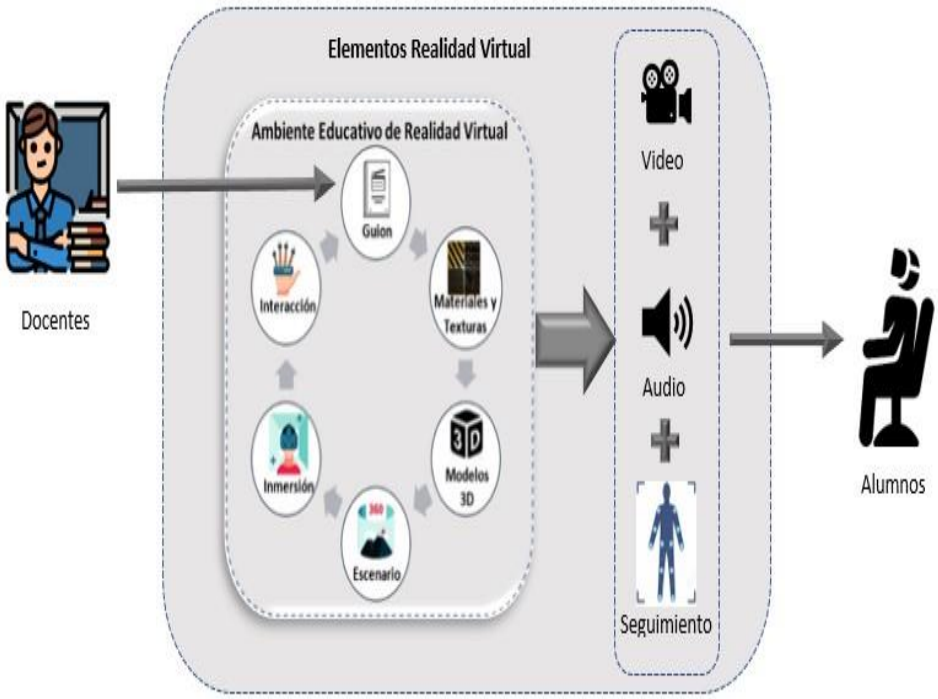


Figure 2: Virtual reality elements in the educational environment.

The sum of the above elements make up the virtual reality educational environment, where through the implementation of video, audio and user monitoring resources, they will contribute to the degree of immersion that the student can have. The virtual reality educational environment will allow students to carry out practical activities of their skills in a safe environment, becoming excellent educational tools [11, 12, 13].

The set of components mentioned above can increase the school development of students, improving their cognitive skills, obtaining skills defined by the education model and improving attention and concentration in solving specific problems due to its playful nature [14, 15].

4. Case Study

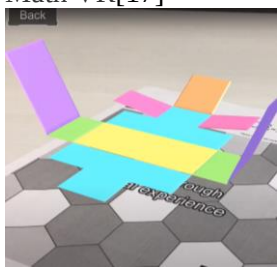
Following the proposed model, the table of key learnings for integral education was carried out together with the teachers (table 1) that according to the "Secretaría de Educación Pública (SEP)" establish the competencies that basic education students must comply [16]; Specifically, those corresponding to the competences of geometry and spatial thinking were selected.

Table. 1.
Key learning for Comprehensive education (skills in geometry and spatial thinking).

Axis	Competition	Expected learning
Number, Algebra and Variation	Patterns, geometric figures and equivalent expressions	✓ Analyze sequences of numbers and figures with arithmetic and geometric progression ✓ Formulates first degree expressions to represent properties (perimeters and areas) of geometric figures and verifies the equivalence of expressions, both algebraically and geometrically (analysis of figures).
Form, space and measure	Spacial location	✓ Locates objects and places whose location is unknown, by interpreting spatial relationships and landmarks. ✓ Represents and describes orally or in writing routes to go from one place to another in their immediate environment (classroom, home, school) or in their community. ✓ Read, interpret and design sketches, plans and maps to communicate orally or in writing the location of beings or objects and routes. ✓ Solve situations involving the location of points on the Cartesian plane.
	Figures and geometric bodies	✓ Reproduces models with shapes, figures and geometric bodies. ✓ Build configurations with shapes, figures and geometric bodies. ✓ Construct and analyze geometric figures, particularly triangles and quadrilaterals, by comparing sides, angles, parallelism, perpendicularity, and symmetry.

With the selected skills and the expected learning, defining the requirements established by the teachers, a selection of virtual reality applications was made that allow students to develop and fulfill the skills of geometry and special thinking. The list of applications, skills and description of the scenario is shown in the table 2.

Table. 2.
Relationship skills- VR applications.

Competition	Learning scenarios	App
Identification of patterns, geometric figures and equivalent expressions Location, management, identifies	**Teacher**: Provides the description of activities, jobs and knowledge expected for the development of the competence by applying first degree expressions to obtain properties of geometric figures (perimeters and areas). **Student**: Using 3D figures, explain the characteristics of each one and how their angles, surfaces or bases are measured, as well as their different shapes.	Math VR[17] 
Spacial location	**Teacher**: Provides the description of activities, tasks and knowledge expected for the development of the competence for the student to recognize characteristics of objects and figures; see directions and sizes and identify changing directions. **Student**: Through virtual scenarios such as tours in which the student tries to identify patterns, geometric figures and use directions to locate objects, places and meet objectives through instructions.	Holofit [18] Recorridos virtuales [19] Beat Saber [20] 
Management of figures and geometric bodies	**Teacher**: Provides the description of activities, jobs and knowledge expected for the development of the competence to analyze geometric figures. **Student**: Using 3D figures, build geometric figures to later identify them in real world objects.	Neotrie VR [21] 

5. Conclusions and Future Works

In the present work, the general model for the development of virtual reality applications to be used in the teaching-learning process and a review of virtual reality applications that allow the development of geometry and spatial thinking skills are taken as a starting point. As future work, the model will be taken to adapt it in the development of virtual reality applications that allow to fulfill the competences of geometry and special thinking in basic education, implementing virtual reality applications developed and existing in the market with kindergarten students and primary schools in the state of Aguascalientes.

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