# Development of Virtual Reality (VR) as an Affordable Learning Method with Species of Nature

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**Abstract.** Virtual reality (VR) has been implemented in developed countries to facilitate visual, experimental, and sensory communication; in this project a test was performed to evaluate the interaction, acceptance and experience of users with the VR as a tool for learning in Colombia by building a lower cost simulator VR affordable to the community which enables teachers, students or any user interested in environmental issues to interact with 4D models and experience physical and psychological immersion in natural environments. The methods used for data collection were the survey and the panel of users, yielding data supportive to the conclusion that this technology can be replicated in the region to improve the quality of learning adapted to local conditions, which strengthens the knowledge of fauna and flora of Colombia.

**Keywords:** Virtual reality · Experience design · Interaction · Learning methods · Sensory experience · Industrial design · Affordable costs

## 1 Introduction

Virtual reality (VR) is defined as the representation of an environment or space by capturing high-definition video and 3D modeling, described by its ability to provide physical and psychological immersion (Gutierrez 2002); the concept of "immersion" refers to the degree to which a user is isolated from the real world and is transported to a situation or environment, in order to exert influence on his feelings and sensations. A research concerning the issue of VR is the study by Reilly (1991), in which the potential of this technology applied to archeology is extolled, by enhancing factors such as interactivity, visualization and realism transmitted to observers immersed then, in a multi-sensory experience to enjoy the works of art and archaeological finds. This project intended to explore possibilities of wide implementation of the method for learning purposes in Colombia.

## 2 Hypothesis

Virtual reality generating a multi-sensory experience by virtual immersion can be implemented at affordable costs as a learning tool in developing countries.


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## 3 Methodology

The methodology used in this research is explorative, with phases of design and construction, data collection and analysis of results, keeping in mind the needs of a developing country with the requirement of accessibility and affordability of technology. A method to evaluate the VR system was developed starting from the study of the methods of usability and user-centered design, with a cycle of interaction between the simulator, the stimuli generated for user experimentation, feedback and developed experiences that the learning of a topic contribute, which resulted in the user's physical and psychological immersion in a virtual environment (Fig. 1).

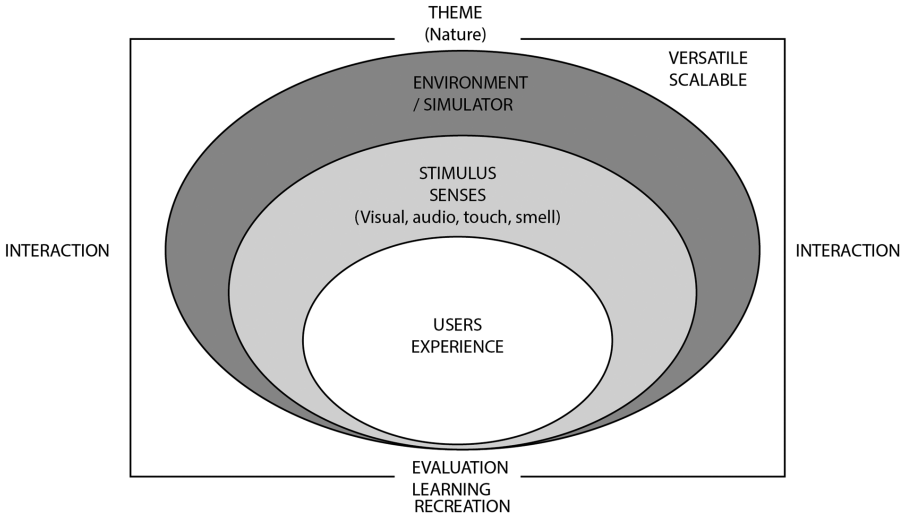


**Fig. 1.** Methodology interaction (VR). Immersive environment to evaluete the user experience.

In this project, a test was conducted in the department of Valle del Cauca, south-west Colombia, where an experience on the topic: Birds and their habitat, is implemented due to the high diversity of species found in this area of the country since according to Echeverry-Galvis (2013), more than 817 species are identified here; this richness of information can generate the user interaction with technology and nature. The project was developed in 6 phases: data collection in actual environment, design and construction of prototype, preliminary test, an interaction test measured by survey and panel of users, analysis of results and conclusions. In the first phase the data of nature were collected and an immersion took place in the wooded area of the hamlet Chicoral of the township Dapa in the Valle del Cauca, Colombia, the photographic and video recording was made through the capture of high definition images of the area to be simulated, observing the characteristics of the space in terms of scents, sounds more

frequently sensed, and most constant climate temperature; the information obtained was edited and suited to be projected in the simulator, which was built with easy access resources in the region and at lowest cost to existing solutions in the market. The instruments used for data collection are a survey to thirty persons designed with 5 questions in Likert scale 1–5, through which experience, learning species and acceptance of the technology is measured, and the method of panel of users carried out with 9 persons to debate on usability, interaction and experience in the acceptance of VR as a learning tool. The tests were conducted in the Laboratory of Human Factors of the National University of Colombia in Palmira and included the voluntary participation of students and professors.

## 4 Preliminary Analysis

A collection of preliminary information was obtained. This information was edited and adapted to improve communication between user and VR simulator, evaluating comfort, ease of use and affordability through the method of collecting survey data.

In the design of the simulator, this project studied works by Ju-Ling Shih et al. (2014) and Okita et al. (2013), which enabled the identification of the main elements of these experiences. To construct the first simulator 1.0 various materials that generate stimuli on the senses and easily accessible were evaluated by performing an initial test designed for the interaction of a person with the system. The simulator 1.0 is built in PVC coated in black satin fabric, its measures are 1 m wide and 2 m high to accommodate a person in bipedal position; the structure can be assembled and disassembled in an estimated span of 15 min and the technologies used to stimulate the senses are affordable for the Colombian context: For visual transmission a Smart TV 49 inches, diagonal measurement 123.2 cm, digital tuner DVB cooler - T2 response speed 120 Hz and 4 K resolution was used, for the aural stimulus a 4 speakers RMS power 500 W home theater was handy, the sense of touch (haptic perception) was stimulated by a water mist spray, the temperature control was implemented by means of a 3 in 1 air cooler - heater - purifier fan flowing 800 $m^3$/h, which has the ability to control the temperature in an area of 28 $m^2$ and a humidifier with forest and pine oil scents; the spatial distribution shown in Fig. 2.

The next phase was data collection in which test 1.0 of interaction was measured by means of a survey and a panel of users; the results pointed out that 76.47 % of users had an immersive experience in a virtual environment, with an effectiveness of the impact of the stimulus on the senses of 41.18 %. The learning experience of bird species was measured with a test of 5 questions rated according to the scale: Excellent-Outstanding-Fair-Insufficient-Deficient: 48.79 % of users answered questions correctly.

From the results obtained in the test 1.0, changes arise to enhance the experience of immersion in the virtual environment simulator, reduce costs of the simulator, and improve ease of assembly by developing a simulator and a test 2.0 which will allow the data comparison.

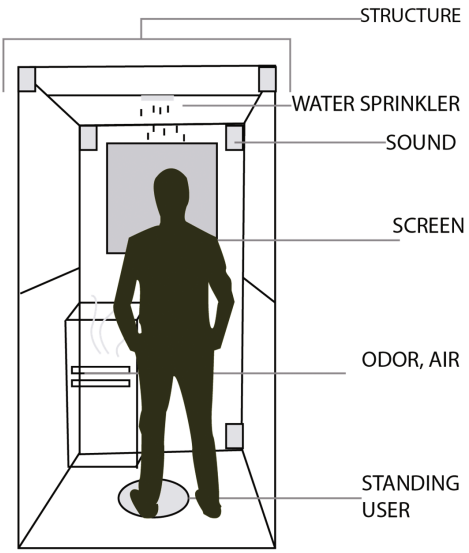


**Fig. 2.** Scheme first proposal simulator

## 5 Test 2.0

To carry out the test a simulator with dimensions 1.80 M high by 1.50 M wide and 1.30 M deep was designed and constructed for 2 users in sitting position. The materials used for the structure were industrial double wall cardboard waterproofed with sealing lacquer, the whole structure can be assembled and disassembled in an estimated lapse of 10 min. Two methods were implemented to stimulate the sense of sight: 1. Using Google virtual reality glasses (Google cardboard), consisting of a cardboard-based viewer, Velcro, magnets and lenses to give a feeling of depth, to transmit the image from a smartphone with a high concentration of pixels per inch the Smartphone maximum size should be 163 mm long and 83 mm high. 2. VR goggles VRBOX compatible with smartphone screens: 4.7–6.0 inches. For the aural stimulus a dome type earphone of 30 mm to guarantee a balanced sound was used, neodymium magnets of high power offered a powerful sound with a frequency range between 12 Hz and 22 kHz, the sense of touch was stimulated by a spray of water mist, the temperature control was implemented with an air cooler - heater - purifier fan flowing 800 $m^3$/h, that controls the temperature in an area of 28 $m^2$ and a humidifier scented pine and forest; distribution within the simulation space is shown in Fig. 3.

## 6 Users Panel

Carried out in the city of Palmira Valle del Cauca with nine users to bring about debate as to the experience, usability and learning resulting from the interaction with the VR simulator. Students and other persons interested in the subject of nature were convened

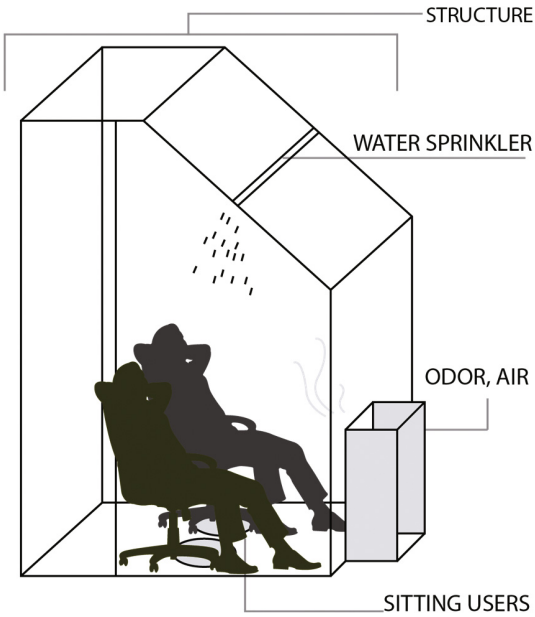


**Fig. 3.** Scheme second proposal simulator

to interact voluntarily with the simulator and undergo the VR experience; it was recorded by videos and photographs of the body and facial gestures of these persons during the test to measure the reactions to sensory stimuli. A single survey was conducted after the experience in the simulator. Later on all users assembled to debate about the recent experience with each of the objects within the simulator with questions about interaction and involvement of their senses, the learning phase was measured through remembrance of the information and acceptance with the frequency of use provided.

The total number of valid questionnaires was 29. The survey measured the variables experience, learning, and acceptance of the technology.

## 7 Analysis of the Data

### 7.1 Survey Results

The analysis of the data was performed by means of descriptive statistical methods calculating the average $(\bar{x})$, and the standard deviation $(\sigma)$ is studied by VR simulator used in test 2.0.

Demographic data collected are sex and age and are studied twelve variables of simulation of the 4D environment are: V1. Immersive experience; V2. Aural test; V3. Visual test; V4. Touch test; V5. Smell test; V6. Environment experience; V7. Audio volume; V8. Projected video; V9. Temperature; V10. Essence smell V11. Experienced

**Table 1.** Studied variables

| Variable | N | $(\bar{x})$ | % | $(\sigma)$ | Minimum | Maximum |
|---|---|---|---|---|---|---|
| *V1. Immersion experience* | 29 | 3.41 | 68.2 % | .78 | 2.00 | 5.00 |
| *V2.* Aural test | 29 | 3.59 | 71.8 % | 1.05 | 1.00 | 5.00 |
| *V3.* Visual test | 29 | 4.41 | 88.2 % | .91 | 1.00 | 5.00 |
| *V4.* Touch test | 29 | 3.38 | 67.6 % | 1.40 | 1.00 | 5.00 |
| *V5.* Smell test | 29 | 3.79 | 75.8 % | 1.18 | 1.00 | 5.00 |
| *V6.* Environment experience | 29 | 2.79 | 55.8 % | .41 | 2.00 | 3.00 |
| *V7.* Audio volume | 29 | 2.41 | 48.2 % | .82 | 1.00 | 3.00 |
| *V8.* Projected video | 29 | 2.79 | 55.8 % | .41 | 2.00 | 3.00 |
| *V9.* Temperature | 29 | 2.83 | 56.6 % | .38 | 2.00 | 3.00 |
| *V10.* Essence smell | 29 | 2.38 | 47.6 % | .68 | 1.00 | 3.00 |
| *V11.* Experienced with VR | 29 | 1.38 | 27.6 % | .49 | 1.00 | 2.00 |
| *V12. Factors nonuse RV* | 29 | 2.10 | 42.0 % | .94 | 1.00 | 4.00 |

with VR, and V12. Factors nonuse VR; Table 1 shows the results of the survey for the set of variables.

Analysis of the results indicates that, overall immersive experiences developed in the VR simulator proposed were perceived as outstanding (68.2 %), according to the results of $(\bar{x})$ 3, 41 y σ = 0,46 in the V1 variable: Immersion Experience; however it is important to note that this result is based on dimensions visual (V3: $(\bar{x})$ 4,41 y σ = 0,91), aural (V2: $(\bar{x})$ 3,59 y σ = 1,05) and olfactory (V5: $(\bar{x})$ 3,79 y σ = 1,18); which yielded much higher results in $(\bar{x})$ and low relative values of σ.

The variables V7, V8, V9, V10, V11 and V12; yielded evaluations close to 50 %, and high coincidence in the responses is noted by the low values of σ. These results suggest the need to go on improving the quality of sensory stimuli to provide a better immersive experience, given that these variables focus on the technical quality of the means used in the VR simulator.

### 7.2 User Panel Results

An agreement was voted out by users for the analysis of qualitative data recorded in the panel discussion the ease of use of the simulator was positive for seven out of nine users. The evaluation of each element of the simulator showed that google cardboard generates discomfort in the area of the nose after five minutes of use. The RV box are more comfortable for eight out of nine users who said that it is more dynamic to interact with the video information by comparison with Google Street view application; the temperature had a positive rating, the space felt fresh and was related to the information transmitted in the video, the smells applied for the test were voted positive by six users and negative by four users, which suggested it would be interesting to have variety of odors according to everything in the video broadcast. It was discussed if it would be of interest for the users to know other places in Colombia by means of the VR system starting from four options: Amazonas, Nevado del Ruiz, Santa Marta, and Medellin;

Amazonas was most voted and the main reasons mentioned were interest in learning culture, and diversity.

The VR system simulator was associated with four main aspects of life: fun, relaxation, medicinal, and learning. Users related the simulator to three main variables: learning was voted favorably by four users, three users chose fun and two users favored relaxation.

## 8 Conclusions

The main contribution of this work is to approach the immersive experience of users in a low-cost simulator as a learning tool in culture and biodiversity through user-simulator interaction. The data obtained support the conclusion that this technology generates in 82.64 % of users sensory experiences that facilitate communication and learning; the simulator design and experience-based information on the diversity of birds allowed the users to discover a new learning methodology of nature and added new vitality to the mechanism of cultural transmission through the support of digital technology. Acceptance is a 68.79 % of users stating that they would use VR to learn about topics of interest and propose new areas of use, such as tourism businesses and advertising campaigns that attract the attention of young audiences in Colombia.

## 9 Future Lines of Research

For the project's progress the simulator must be modified according to the results found in test 2.0 in order to potentiate immersion capabilities mainly in controlling temperature and stimulating touch and smell. It should further investigate which are the most optimal elements to enhance stimuli and interaction continuing with the requirement of affordability.

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