# YaniWawa: An Innovative Tool for Teaching Using Programmable Models over Augmented Reality Sandbox

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**Abstract.** In the last decade, new technologies have emerged and proved being useful in the teaching-learning process. In this paper, a playful interaction system for learning about Andean Mountain range in Ecuador is presented. The interaction was achieved using natural gestures, images visualization, frontal and vertical projection over an augmented reality sandbox. Additionally, a flexible learning mode has been developed, where children can learn by exploring. An initial study was carried out to compare whether the learning outcomes were achieved by a free exploratory experience or traditional learning methods. Forty children from 10 to 12 years old participated. The analysis of the pre-tests and the post-tests indicated children increased their knowledge about Ecuador's mountains after using YaniWawa. Our study reveals the potential of exploratory learning games. The questions about satisfaction and usability showed that 80% of children had fun while learning; 60% would recommend it to their friends; and 80% of the participants liked YaniWawa, moreover YaniWawa was scored with a mean of 4.70 over 5 .

**Keywords:** Augmented reality · Elementary and secondary education · Topographic maps · Graphics systems and interfaces · Experiential learning modes · Interactive learning games.

## 1 Introduction

The teaching-learning process cannot be restricted to traditional classrooms, children require new styles of learning and new ways of teaching [11]. They require methods that capture and hold their attention, engaging them in the learning process when they are in a state of flow [5]. Children and adults like to


M. Botto-Tobar et al. (Eds.): ICCIS 2020, AISC 1273, pp. 378–388, 2021.
https://doi.org/10.1007/978-3-030-59194-6_31

"play" with games, puzzles and perform activities which provide an opportunity to experience, interact and learn. They prefer learning through a well-designed and effective concrete experience, tools easy of use and most natural [14]. Game interactive based learning are considered appropriate approach for teaching and engaging children in a more successful way than traditional learning methods [4].

Exploration is crucial when the development of innovation and creativity is needed. High levels of exploration imply variance seeking rather than mean seeking learning processes. Learning is more effective when the tasks operate with autonomy with respect to goals and supervision [12]. In this context, educational theorists Kolb and Fry developed the Experiential Learning Model (ELM) [9]. In this model of learning, individuals are stimulated to reflect on their actions and consequences, in order to foster understanding and applying these skills in future actions. The model helps teachers design lessons experiential, interactive in order to develop critical and creative thinkers.The model consists of four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. ELM is an integrated process, each stage being mutually supportive of and feeding into the next [6,9,15]. It is possible to start the learning at any stage, the important is to follow the sequence, as seen in the Fig. 1 [9].

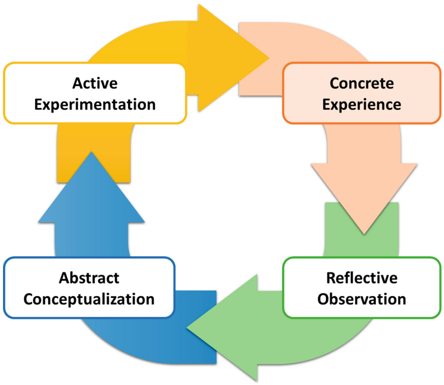


**Fig. 1.** Learning model [9].

On the other hand, design-based-learning focuses on using the game as a tool for learning. In this line, new and interesting opportunities have presented to develop game-based learning (GBL). Within game-based learning, a particular sub-genre is learning through sandboxes. The sandbox-style game play, suggests more-or-less indirect free-play, less-structured, something pure and free, promotes creativity, suggests imaginative capability, nurtures decision making, critical-thinking skills, and self-awareness.

Nowadays, the teaching-learning processes demand new challenges to provide more and better interactive tools. In this paper, a novel playful interaction system for learning about Andean Mountain Range in Ecuador is presented. It incorporates Natural Human-Computer Interaction based on video game technology sandbox-style, and exploratory learning method with natural gesture interaction. The game was called YaniWawa.The name of our game is in a native language of Ecuador, Quechua. Yani means thought and Wawa means children, therefore, YaniWawa can be understood as children's thoughts. The objective of YaniWawa is to reinforce the learning of topics related to Ecuadorian Geography, such as the Andean Mountain Range, the relief, the highest volcanoes and snow falls in Ecuador.

The first objective of this work was to develop a game that included playful interaction with sandbox-style and exploratory learning. The second objective was to carry out a study to find out if children had a higher increase in knowledge playing in pair with the exploratory learning method or traditional learning method. Our main hypothesis is that children will learn more by playing the game in the exploratory mode than in the traditional mode.

There are plenty amount of research about interactive games and systems used to teach like: storytelling interfaces [16] for preschool children that is a two-page book, it uses picture cards to trigger animations; CheMO [17] is a system where users can perform virtual chemistry experiments and learn about all the procedures that involve experimentation; FlowBlocks [8] used to teach children how interconnection works; AR Sandbox [10] is a system used to learning about Geoscience Education by the use of a 3D physic model that shows with layers and colors the height of landscapes; even in Ecuador there are some research about this topic, like NAR [7] that is a robot developed to help children to learn numbers and colors, but there is no research about the use of Augmented Reality (AR) to teach children about our geography.

The paper is organized as follows. Section 2 mentions Materials and Methods. Section 3 presents the results obtained after pre and post test, and Sect. 4 is a brief discussion of results about this research. Section 5 presents conclusions and future work.

## 2 Materials and Methods

This sections contains the materials and method that were used to perform the research. As it was said in the previous section in Ecuador there is no study about this kind of systems, however at countries like Australia, Tailand, USA and Spain among others there are much rich information in this matter. In [10] is said that there are more than 150 AR sandboxes around the world and in the web page [2] can be seen their distribution. It is important to denote tree aspect involved to implement the systems:

### 2.1 Learning Process

There are works developed to motivate in training and learning, of this technically speaking [1], who have developed a work in which they show how the Kinect sensor can be used, together with Unity, and Gamification techniques to develop virtual 3D Game-Like training environments, where users are highly motivated during training, maximizing at the same time the learning and retention of contents during the process. This case study is the prevention training environment and fire escape aimed at children that was developed for the Cochabamba Fire Department explaining the advantages over traditional methods.

Ayala [3], mentions that learning mathematics using technology offering a kinesthetic learning results in better understanding of mathematical concepts, graphics and formulas. the AR provides a big boost in the learning curve but is limited to the use of markers and the amount of movement that is why the complement with the Kinect becomes a fundamental equipment for kinesthetic learning, the main objective of this work is the development and the graphic application position versus time that allows the student to replicate with their hands several different types of movements and the software will detect, calculate and generate graphs based on the positions in the selected period of time.

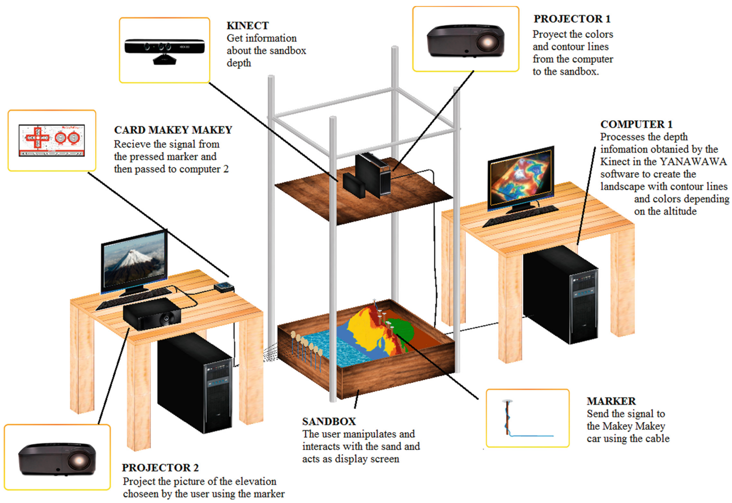


**Fig. 2.** YaniWawa physical structure.

### 2.2 Structure

The structure proposed in the present research, is a generic way uses two systems that interact with each other. A steel support was built to hold the two devices. The first one is the basic ARSandbox as showed in [10,13] and the second one consist in a computer used to project the elevation chosen by the user thought a marker connected to a Makey Makey card as can be seen in Fig. 2.

### 2.3 Software

YaniWawa application was programmed in C# language. The game combines NUI and Frontal Projection. It simulates a tactile screen. The required elements are a sort throw projector and a Kinect. The screen area is a box filled with sand. To achieve the user interaction, the Kinect device was used. It was located next to the top projector. The top projector and the Kinect devices were located above the sandbox. A interactive interface were connect with the Sandbox by means of a Makey Makey and alligator clips. Buttons were built in the model for each mountain. This card was configured to perform the interaction among the sandbox, the the buttons, and the application hosted on a laptop. The main interface includes a map of Ecuador that has been adapted to the model and presented eight of the most important mountains learned in school. The interfaces of each mountain show its image, a video of of the local wildlife, in addition, an audio describing the most important characteristics of it. YaniWawa architecture is selfexplained in Fig. 3.

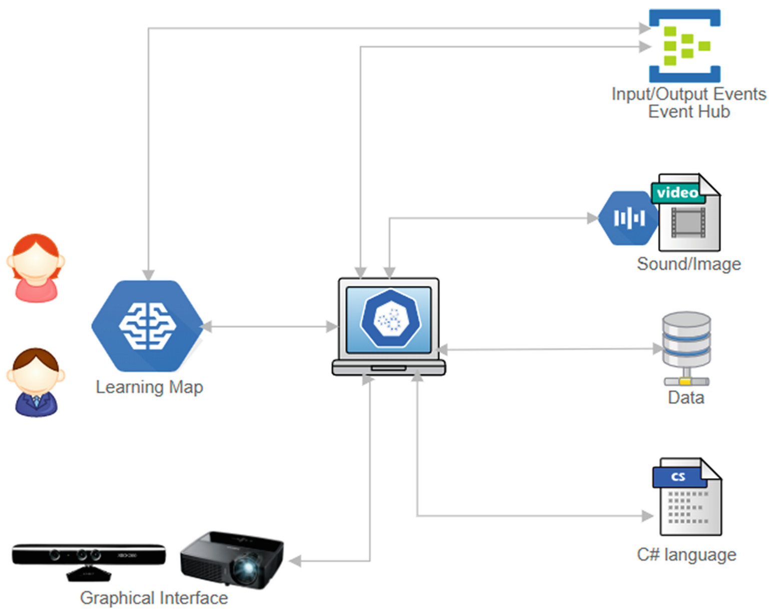


**Fig. 3.** YaniWawa architecture.

## 3 Results

This section presents the results obtained in the research, for a better explanation there are three subsections:

### 3.1 Game Description

There are two game modes, the first is to teach the Ecuadorian Andean System, here the children have to complete a test to know how many mountains and snows they know, then with YaniWawa the teacher show them how many and where the mountains are. The markers in the system help the children to get information about a specific mountain or snow by touching them. At the end of the lesson the children have to answer another test remembering as much mountains as they can. The second mode uses the Ecuadorian coastal profile to teach children about peninsulas, inlets, gulfs, etc. The first mode can be seen in the Fig. 4.

**Fig. 4.** The main game interface.

### 3.2 Study Description

The study was carried out taking four groups of 10 participants each, with ages of 11, 12 and 13 years, with 23, 45 and 32% respectively.

Before playing, each child answered a questionnaire writing how many mountains and snowy mountains they know. After playing with the platform, a new questionnaire was conducted asking how many mountains and snowy mountains they remember. The phases of the study are shown in the Fig. 5.

After the experiment all the data were stored and organized and showed that the children were able to learn whit this method as can be seen in the Fig. 6.

The mean values for each series in the Fig. 6 are 3.3 correct answers in the pre-test and 5.8 correct answers in the post-test.

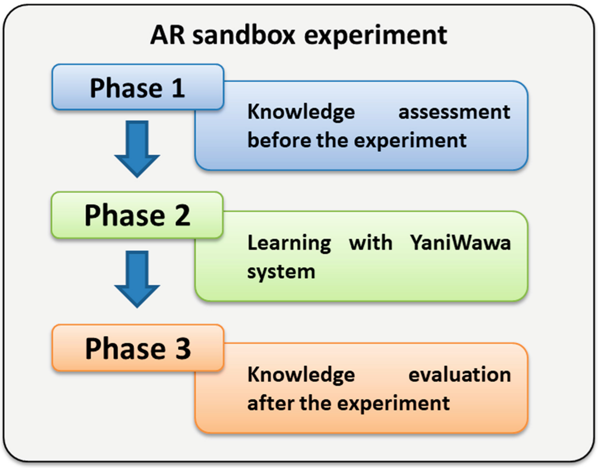


**Fig. 5.** Study phases of research.

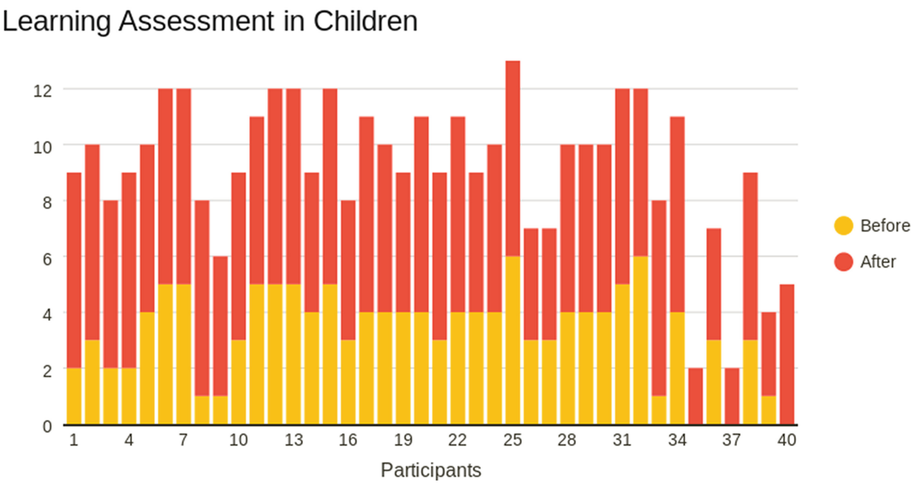


**Fig. 6.** Results of learning assessment before and after playing YaniWawa.

### 3.3 Measurements

In the current research, the impact that the system generated on children was also evaluated thought a short questionnaire. It has seven items that evaluate ease of use, understand and learn, also a part of the questionnaire ask the children if they had fun and recommend this game to a friend. All the questions were scored from 1 to 5, being 5 (very satisfied) the greater value.

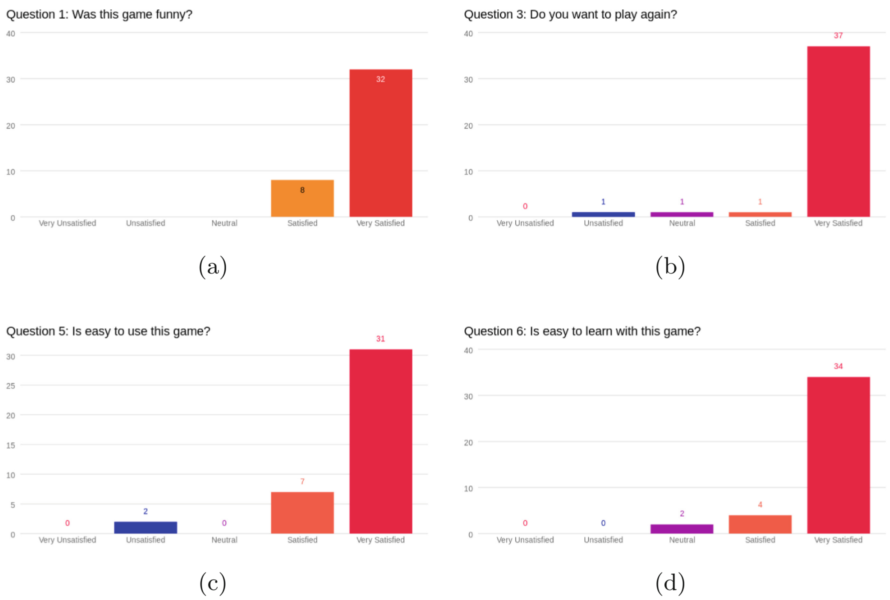


**Fig. 7.** a) Question 1 b) Question 3 c) Question 5 d) Question 6.

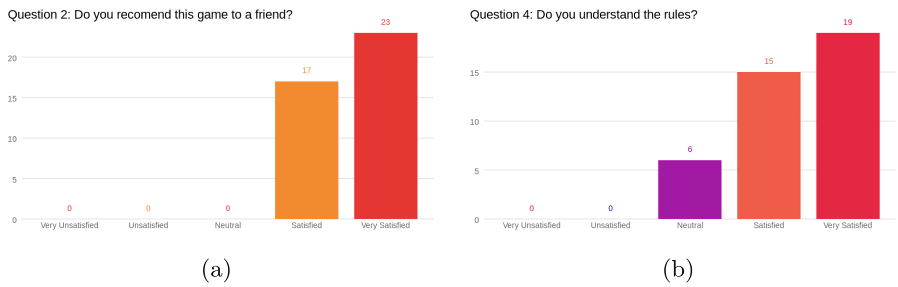


**Fig. 8.** a) Question 2 b) Question 4.

The first, third, fifth and sixth questions show that more the 77% of the participants give the greatest score as can be seen in the Fig. 7. being this questions related to how fun the game was, if the user want to play again and how easy was to use and to learn with tit.

In the questions two and four the largest number of participant rated the game with a value of 4 or more as it is show in the Fig. 8. Question 2 is related to recommending the game to a friend and the question 4 is used to know if the rules of the game were easy to understand.

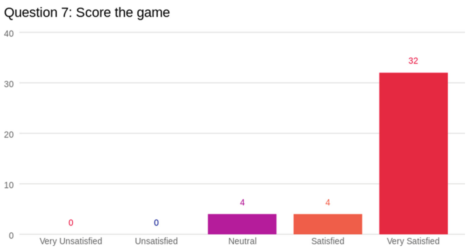


**Fig. 9.** Results obtained on the game score.

Finally, with the last question evaluated all the system as a game. As it is showed in the Fig. 9 the 80% of children said the game scored 5 points (very satisfied).

## 4 Discussion

The results obtained in the test about mountains and snowy mountains revels important information about how the system helps children remember twice the names of the mountains taught. Moreover, almost all the children believe that the game is fun, easy to use, and learn whit it as can be seen in the Fig. 7. The lower score in questions 2 and 4, was mainly due to the scarce experience of the staff in charge of giving the instructions to deal with children, and finally question 5 showed that children found easy to play with it.

Unlike other works [10,13], an extra device help to specify information about landscape, and it help children to get more interested in the game, because it allows to get a deeper interaction with the game.

## 5 Conclusions and Future Work

A game was created that allow children to have a playful interaction with the ARSandbox system called YaniWawa. It uses a exploratory learning method to enhance the memory capacities of children, with an increase to twice of information retained, as it can be seen in the Fig. 6. The research showed that tools as Makey Makey in conjunction with other technologies and methods led children to had a meaningful experience in a short period of time, increasing the knowledge, enriching and complementing the traditional method of teaching. As a future work, it is intend to use printed 3D models to show how different physical phenomenon may affect a landscape, and what kind of consequences it can have.

**Acknowledgement.** This paper and the research behind it would not have been possible without the support and colaboration of Universidad de las Fuerzas Armadas ESPE, specially the Center for Military Applications (CICTE), the Mechatronis and Dinamyc Systems laboratory and IEEE-ESPE student branch, whose efforts and colaboration has been key to develop and test our prototype.

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