Teaching-Learning System Using Virtual Reality and Haptic Device to Improve Skills in Children of Initial Education

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Abstract. A virtual system for teaching - learning is presented using a haptic device, to improve the skills in children in initial education. Two interactive games were created using Unity 3D software. The first allows identifying the primary colors and notions of space. The second identifies the geometric figures as circle, triangle, square and rectangle. Both games has visual, auditory and strength feedback, which allows performing the tasks correctly. The outcomes allow evaluating the children learning process in initial education in a qualitative way by a educator.

Keywords: Virtual reality · Haptic device · Initial education
Learning strategies

1 Introduction

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The learning in childhood is the base of educational development. Studies show that human intelligence can be greatly increased if it is stimulated early at home and school. Nowadays, the new technologies could help a lot in education; unfortunately, early

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childhood does not have the enough researching [1]. A complete education is more useful when it is a commitment of all members, especially teachers, who must structure each process [2] and organize the study groups correctly [3]. This is possible when the child has the resources and the support enough from the family to develop as expected. Many factors influence learning like family, society, nutrition and cognitive abilities [4]. A little-known fact that affects the children development is the learning trouble, when child does not progress in the way expected. According to studies carried out by UNICEF in Ecuador, it is said that the main problems in children learning are "attention deficit, difficulty of compression and low level of reasoning" [5]. Nevertheless, problems related to learning are not always linked to a low intellectual capacity. These problems can differ in specific abilities like reading, writing or calculation deficits [6].

The teaching-learning process in scholar centers in the country is based on an Initial Education Curriculum, which considers interculturality in equal learning opportunities [7]. The contributions mainly of Vigotsky are taken into consideration in the curricular design issued by the Ministry of National Education in Ecuador, where learning in boys and girls is both a process and a product. "Consider that learning promotes the development and establishes that teaching always anticipates learning" [8]. Game is the methodological principle that stands out. This essential activity in children involves them in a general way, also stimulates the development and learning in all areas [7].

Games encourage children to be active, relate to society and the environment that surrounds them when comparing knowledge with objects of daily life. When children play, they explore and experiment safely. While they are learning about the environment, they solve problems and acquire new skills [9].

The existence of new alternatives for teaching must be constantly considered. Technology advances can't be ignore because they can contribute to the improvement and update of education. Several years ago, countries seek to introduce new technologies in education [10–15].

Computer is a very versatile tool in the teaching-learning process, it has advantages and disadvantages and these have been analyzed in education [16]. Computers advantages are a lot, to mention a few: computers can work with virtual reality, augmented reality, create 3D environments and work together with other devices to give sensations to users. This makes it a very useful even for education of people with special abilities.

Virtual Reality (VR) allows creating realistic and dynamic images along with diverse sensory information like hearing and touch. This fact allows the user to interact within the virtual 3D model [9]. In recent years, the field of Virtual Reality application has extended from entertainment to interactive teaching for engineering or medical training [17, 18]. In addition, it has been possible to encourage learning and convert it from a routine teaching process to a fun activity. This process showing that it is helpful when delivering knowledge in any subject [19]. A research includes virtual reality in games with a dynamic interface in a multi-touch panel, where child can make drawings and identify figures. These techniques are entertaining and they have had good outcomes in children [20–22].

When virtual reality works with haptic devices allows the child to touch, feel, manipulate and remodel virtual objects. Through haptic feedback the user feels the geometry, texture, smoothness, vibrations of objects [25]. Thus it can achieve a greater concentration of the infant and reinforce the knowledge acquired [23]. The results are

satisfactory like the improving of handwriting in children of five years. Through using a haptic device combined with a virtual reality, software allows children to practice and improve calligraphy in an early age [24]. An entertaining tool is helpful in learning when leaves the typical teaching methodology. User is completely immersed in a virtual world and face situations based on real cases with the certainty that he maintains his personal security. User can apply for increase their knowledge in a shorter time [25].

In this context, a 3D virtual reality application is presented that complements the teaching-learning process in children in early childhood education. A haptic device that obtains the movement generated by child builds the system. This fact allows evaluating skills, notions and knowledge of the user.

2 Ease of Use

This chapter exposes the different stages of the virtual system; in Fig. 1 each one is indicated in a block diagram.

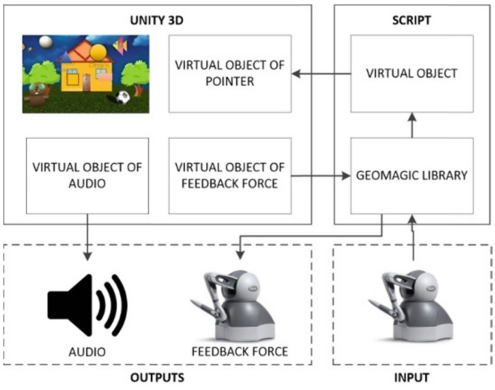

Fig. 1. Block diagram of virtual system stages.

2.1 Input Peripherals

In order to get the input data in the system, a haptic device called Geomagic Touch is used. This device has digital encoders inside, which allows getting the variables of user movement like position and angles while traveling in a virtual environment.

2.2 Scripts Development

The administration of the inputs and outputs are handled by the scripts made in Visual Studio with C# language. Scripts execute several functions in the virtual environment according to the data that is received through the input peripherals. Data is interpreted with the support of the libraries in C#. The handling of the information is illustrated in the flow diagram of Fig. 2.

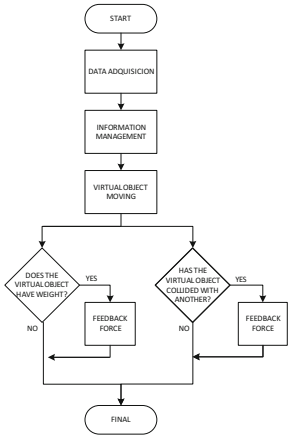

Fig. 2. Flowchart of information management in the virtual system

In general, the different environments follow the same sequence for interaction with virtual objects. Programming the scripts the information is stored for the number of times that both the correct and incorrect options have been selected. The auditory feedback allows the user to perform properly in the virtual environment, as well as the response

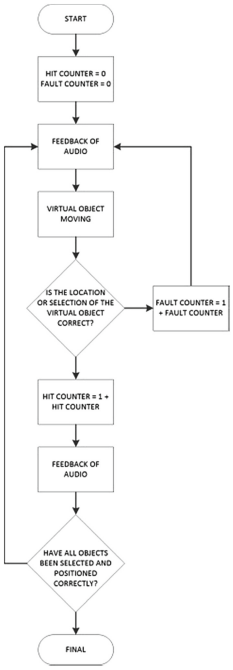

Fig. 3. Operation sequence of virtual environments flowchart.

to a hit or a failure. The forces feedback provides sensations that simulate the management of real objects (Fig. 3).

2.3 Design of Environments in Unity3D

The environments are designed with several virtual objects, which are created based on images or obtained directly from the Unity3D Asset Store. Virtual objects are assigned with a set of properties like animations, rigidity, weight and audio. These features belong to Unity libraries and provide a better experience for the user when operating the virtual environment. Features can also be managed from a script, where the programming is done according to the task that wants to be executed. This script is associated to a virtual object with the sequences of orders and tasks to be executed in the system.

3 Use of the System

In the main screen a menu is displayed which allows choosing the game according to the level of knowledge that the user is. Figure 4 presents the main menu of the system.

Fig. 4. Main menu of the teaching-learning system

Level 1 is a virtual interface that has an introduction of the primary colors. Then the user chooses the color from the elements that appear randomly and places them according to the objective organized by the notions of space. The indications are provided by an audio (primary colors and notions of space are reinforced). The system provides a force feedback when a virtual object collides with another. In addition, the audio indicates when the task was completed (Fig. 5).

Level 2 provides a introduction of the geometric figures. This interface shows a landscape with objects that can be related to the geometric figures (door-rectangle, ball-circle). User must select the element according to the indications given by audio. The elements are hidden as long as their selection is correct (Fig. 6).

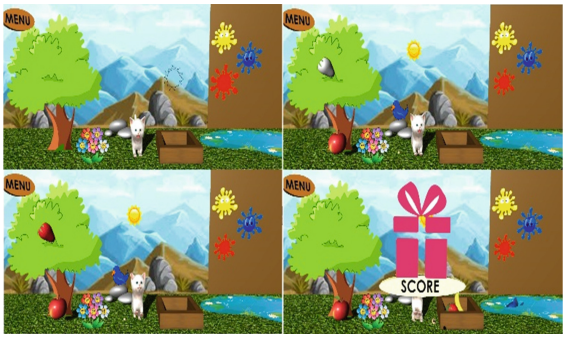

Fig. 5. Game interface of primary colors and notions of space.

Fig. 6. Game interface of geometric figures task.

4 Test and Results

4.1 Test

This process must be carried out under the supervision of an educator or kindergarten teacher. This person evaluates the child's performance. The game starts by presenting the menu with the two levels. When the first level starts child can listen and see a presentation about the primary colors, once this is done, the first instruction is indicated by selecting a color (Fig. 7(a)).

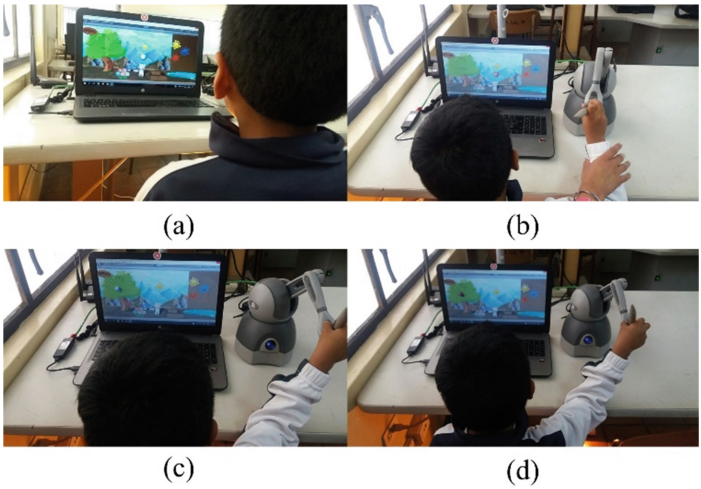

Fig. 7. First level of the virtual system being used by a child.

If the chosen color does not correspond to the order, the system sends an audio response indicating that the option is not correct, as soon as the correct color is selected, a silhouette of an object located in the interface is colored (Fig. 7(b)).

The following instructions give the place where object should be located by taking the object with the cursor. The child can feel the weight that has the object due to the forces feedback of the haptic device (Fig. 7(c), (d)).

In the second level, the main geometric figures are presented as an introduction (Fig. 8(a), (b)). Next, the child listens to the first instruction and selects the figures according to the specified form. In the previous level, the audio response indicates when

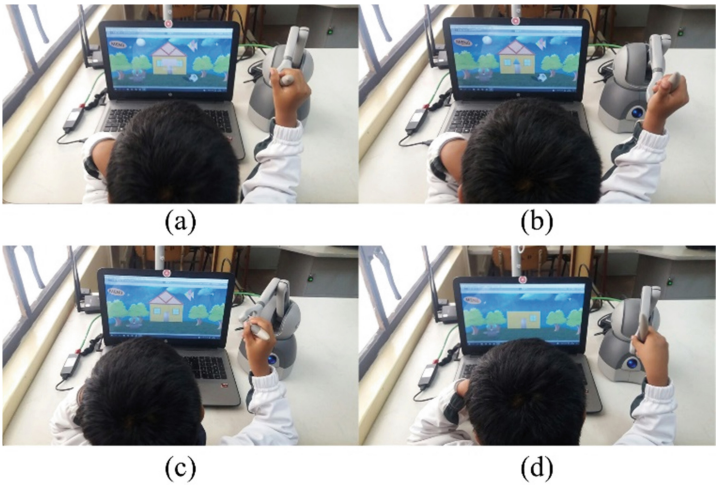

Fig. 8. Second level of the virtual system being used by a child

the selected object is incorrect or correct; the objects disappear from the environment when they are selected (Fig. 8(c), (d)).

4.2 Results

The table of results for level 1 and 2 is presented in Figs. 9 and 10, respectively. The respective successes and failures to the concepts of special notion, primary colors and geometrical figures are shown.

Fig. 9. Table of results in level 1

Fig. 10. Table of results of the first level and second level

The evaluation is carried out qualitatively with parameters A, EP and I. Where A represents "Acquired", which means that the child has the necessary knowledge in the subject. EP "In Process", is equivalent to a regular performance of the student. It has bases in the topics discussed, but is still learning. I corresponds to "Insufficient", and indicates that the child does not have the knowledge enough or has difficulty in learning.

5 Conclusions

The design of the environments is attractive for children in early childhood education: These allows them to focus their attention on the system. Teaching through interactive

games let capturing and learning faster the topics. The use of objects that can be found in real life helps them to associate what they have learned. The use of Geomagic Touch as a haptic device provides a better experience with the environment. The use of force feedback gives the child the feeling of managing a real environment.

This system helps to complement and evaluate basic topics that are taught in the classrooms. It allows the educator to encourage the child's interest in learning and provides the evaluation of the student's performance in qualitative assessments. The development of new environments to cover the different subjects of teaching in initial education will help to complement the development of cognitive and psycho-motor skills. The system represents a support for the teachers.

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