Learning How to Play a Guitar with the Hololens: A Case Study

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***Abstract*—This paper introduces a novel application for augmented reality in which it is possible to learn how to play the guitar for a beginner level. It was developed for the Hololens device, following the Suzuki method for instructing the first lesson of the instrument. This prototype utilizes a 2D marker, using the video game engine Unity3D. The prototype was tested comparing the learning experience it offered to the one of a non-immersive learning methodology. As a result, the study did not show any considerable difference between the two methods, but it revealed learners' acceptance towards the augmented reality teaching tool, and it showed information which could be considered to define the research approach for the following stages of the project. It is still necessary to implement several design and functionality improvements to the initial prototype for a new process iteration.**

***Keywords*—Augmented Reality, Teaching, Unity3D, Guitar, Hololens.**

I. Introduction

This work aims to describe the development and implementation of an augmented reality application and test the hypothesis which supposes that learning with an immersive tool can be comparable to the experience with a non immersive tool, like books or videos. The application offers an introductory lesson for learning to play the guitar and it is based on the commonly used Suzuki teaching method. The application for the Hololens device was developed in the Unity 3D video game development engine. The first testing phase shows a good acceptance towards the new teaching tool, revealing improvements both in the prototype development as well as in the test's implementation.

A. State of the art

Augmented reality has been evolving very rapidly in recent years, and a wider segment of industry is supporting this technology and proposing products to expand it and increase its popularity [1]. This technology, which was proposed about fifty years ago, raised a bunch of expectations when it emerged [2]. However, after novelty faded away, the community lost interest in it until the Oculus Rift was launched in 2016 and generated a new approach to Virtual and Augmented Reality that keeps being explored and studied up to these days [3].

With the boom of AR in recent years, new ways of dealing with educational necessities have emerged. Now it is possible to use virtual reality and augmented reality devices in order to train people for getting the skills they need at work or for getting involved in activities that are too expensive or dangerous in real life [4] [13] [14], such as training aircraft pilots, maintaining electrical networks or learning to play musical instruments [5] [6] [7] [8].

According to the studies carried out in the Virtual Human Interaction Laboratory of Stanford University, the sensations —which are referred as 'presence'— people experience using this type of devices are an important factor in the perception of virtual and augmented reality [9]. By experiencing subtle movement or by making the objects around users palpable, they can feel the environment is more real and get immersed in this reality. Therefore, 'presence' is very important for immersion and that is why it was decided to stimulate different senses in the interaction, rather than having hyper realistic graphics. Sound, video and touch, such as vibration on the floor or incidental movement through a shared real-virtual object, can convince human brain, it is actually in the reality he is experiencing, even if it is an emulation [9].

As it was mentioned before, there are a lot of activities virtual reality has helped to improve and optimize. For instance, the New Mexico College of Medicine [18] conducted a study comparing different learning tools with 25 first-year medical students. The test was carried out with complete (HMD) and partial immersion (screen-based). The results of the experiment were more positive for complete immersion than for partial one. Similarly, studies conducted by the University of Alabama at Huntsville showed very similar results when comparing the performance of county firefighters trained with virtual reality to firefighters trained in normal situations and a control group made up of some untrained firefighters [19].

Likewise, other studies that evaluate student learning through multimedia games were found. One of them is a a research with botany students [20] in which several experiments were carried out, including screen-based learning, HMD and walking with an HMD. The results showed that the level of presence increased with the HMD. Additionally, there are other related studies that focus on looking at the difference between traditional teaching methods and multimedia methods such as games and virtual reality applications [23]. It has been shown that for cognitive activities users always have an inclination towards games. On the other hand, it has also been shown that teachers do not see any difference, which might suggest a certain resistance to change on the part of the educating community. The main conclusion that could be drawn considering these studies is that virtual reality is an

effective alternative for training and education, as far as it is used correctly.

Augmented and virtual reality have been studied in situ, through various experiments on the physical and social distribution of people in the classroom as well as the teacher-student relationship [21]. The percentage of teacher's eye contact with his students was examined, so that he could know how much visual interaction he has in the classroom and, based on that information, could make decisions regarding his performance during the class, distributing his attention evenly among participants. Other experiments were carried out with students who sat within a short distance and were introduced companions who had the role of "co-learners" or "distractors". This research pretended to measure the effect that people and their attitudes have in the classroom and in learning [22]. In these cases, it is possible to see how getting the feedback of a tech tool could contribute to education optimization when teachers receive indicators about their interaction with students, the distribution of their attention and how even their communication of knowledge is.

In psychology and pedagogy studies, several currents have already been investigating the effect of virtual reality on learning by comparing it to physical reality [9] [10]. The contributions that have been made in this field are important, such as the recognition of the avatar's eye gaze [11], and evaluating how the person immersed in virtual reality feels and the effects it produces, as well as attention deficit, poor communication or lack of understanding of the subject matter. The facial expressions of the avatar or virtual teacher are also a very important factor that has been studied by the community. For example, the Stanford University released a study about mouth movement, and more specifically the avatar's smile [12] and facial expressions. The results show that they are essential factors for a deeper immersion in virtual reality. In this area, several important studies have been carried out for evaluating the impact of avatars in the virtual world. The experiments have been carried out with Second Life and they measure the social presence of an avatar. They intended to show how much presence avatars have and how real and identified a person feels under those circumstances [26]. The results showed that not everybody could feel identified with avatars, since it is a complicated virtual process which might be difficult to assimilate by users [24]. Similarly, studies on trusting avatars have concluded that they actually modulate communication with users. That means that their body expression, skin color, gender and gestures can define the behavior of individuals who are interacting with the virtual presence [25].

In the musical field, there are also several studies that demonstrate which the best teaching techniques are for developing skills to play instruments and understanding music theory [15]. These studies reveal the best practices for teaching music [16] and show that the class atmosphere as well as the teacher's behavior are essential factors for having a successful learning experience, whether for children or adults. Another study that was conducted in four music schools in several countries [17] —Sweden, Spain, Australia and England— aimed to teach music lessons for reinforcing notions as "the value of taking risks", "music is a universal language", etc. and it revealed some common teaching issues such as having to deal with students who speak different languages or who belong to different cultures in the same classroom. On the other hand, it concluded that visual experiences are more enriching than simply writing information, and suggested that teachers should listen to children who are experiencing frustration with an instrument, and let them know that it is possible to be successful with discipline and practice. These insights are really meaningful for a music class and they should be considered in the design of computer-mediated learning atmospheres. Therefore, It is necessary to build a tool that besides providing scaffolded teaching material, also integrates notions of effective teaching practices into a virtual reality environment in order to provide optimal learning experiences.

II. Methodology

In order to address the issues discussed in the previous section, the development of an augmented reality application is proposed. It aims to provide a technology-mediated learning environment in which users could access basic guitar lessons and practice as they learn using a real guitar as well as its virtual simulation.

The application was designed for providing an interface for a face-to-face virtual guitar class with a step-by-step teaching approach. Students are taught the fingers, strings and frets nomenclature and then, in the practice stage, when the teacher instructs the learner to perform an action, the application indicates where the string should be pressed, the fret position and the finger that should be used.

The Suzuki method is a world-known music teaching technique that teachers and music academies use for instructing children and adults on how to play a wide variety of instruments. That is why it was selected as the teaching methodology and the first lesson of this method was applied to the prototype. Additionally, this methodology could be used either in traditional academy classrooms or in other platforms such as tutorials on the internet, and that flexibility enables comparing traditional teaching approaches to innovative ones.

The HMD (Head Mounted Display) selected to run the application was the Hololens, which allows a high-quality application deployment in its operating system. For the construction of the prototype, several software tools were used including the game development platform Unity3D. Within this software, different plugins were also used to achieve the objectives and functional requirements of the application. The plugin Vuforia for Unity3D was used for recognizing and tracking the objects to which all the information was attached. The use of these software tools along with the hardware allow the user to have an actual augmented reality experience because through the glasses it

Figure 1. Hand movement recorded with the Perception Neuron and visualized in the avatar.

was possible to interact with the real world and its objects, but having a digitally enriched vision with relevant information for the class.

Within Vuforia different trackers or elements of visual recognition in 2D were used to obtain the musical instrument position and to indicate to the user what he should emulate for developing the skills proposed for the class. The plugin Twine, that is used for the generation of decision trees for stories and video games, was run for structuring the class and including the dialogues and the steps the teacher follows, as well as the decisions that the end user can also make such as repeating the lesson and practicing more if he does not feel ready to continue yet.

On the other hand, it is intended to address a second problem which was found to be relevant for the research by including an avatar within the augmented reality application in order to allow the user to see a presence in front of him and customize it so that he could feel more comfortable and trust his mentor. This avatar is an integral part of the class and the user will have the possibility to see how he performs the movements and positions of the hand as well as the articulation of his fingers and body alignment. It will be similar to a face-to-face class where students have the teacher in front of them modeling and instructing how to play the musical instrument.

The Perception Neuron Tool was used for the visualization of the movements articulated by the avatar. It made possible to record and stream the movements in real time with a high degree of accuracy and that enabled the production of animations that were used to model how to get certain chords and notes on the guitar.

Figure 2. View of the guitar in the application when the user is practicing the final version of the song.

The evaluation of the application was made by gathering the subjective perceptions of the participants through a test and also by the objective evaluation of the participants' performance. It was assessed if they had accomplished the lesson objective, which was learning to play the song they were taught. The learners answered a survey with questions about their own perception of the learning process they experienced in the class. The results of two control groups were compared: participants who took classes through a Youtube video tutorial and the users who tried the application. Finally, the skill acquisition was assessed as well as their ability to perform the exercises proposed in class.

The variables that were defined to be measured in the evaluation were knowledge acquisition, and skill development. Moreover, using Likert scales, the level of user satisfaction was also assessed as well as the usability of the application. The measurement scale ranged from 1 to 5, with 1 being the lowest value and 5 being the highest one in the scale.

The protocol that was followed for the implementation of the test consisted in creating two groups of 20 users. The first group used the application prototype and the second was the control group, who had access to the same contents, but in a non-immersive way by taking the class from a video tutorial.

The aim of the test was to determine if the users of the application felt they could learn without having the guidance of an actual teacher. To achieve this, the users got the instrument they wanted to learn which, in this case, was the guitar. The application was designed to be handled with voice commands that users could activate and, additionally, it was necessary to place a marker on the upper section of the guitar in order to be able to track it in the 3D space.

The population who took the test consisted of people aged 18-30 years old, who were undergraduate or postgraduate students of the University of Los Andes from different

Figure 3. View of the multimedia elements that helps the user during the class.

Figure 4. View of the buttons that controls the class.

faculties. The people who agreed to have the experience and took the test, had practically no knowledge in terms of guitar playing or music training. The population profile was defined taking into account that the application was designed for beginners who could benefit from taking lessons following the Suzuki Method.

III. Results

The tests' results show that the control group users' perceived they could learn from the video. On the other hand, the group who used the application expressed several levels of satisfaction. They also provided favorable feedback and concluded that the use of augmented reality has teaching and learning potential in spite of some of the difficulties they experienced.

The statistical analysis shows that the class explanation provided in the immersive device was clear. In a preference scale in which 5 was the highest score and 1 the lowest one, 4.15 was the average for assessing the explanation of the parts of the guitar, and 3.95 for the explanation of the songs that should be learned. Despite the difficulties, 30% of participants said they had an effective learning experience, another 30% expressed that with more practice they could have done it, while the remaining 40% reported they had not learned the last song. In general, the population who participated in the study –young adults, mostly university students– liked the

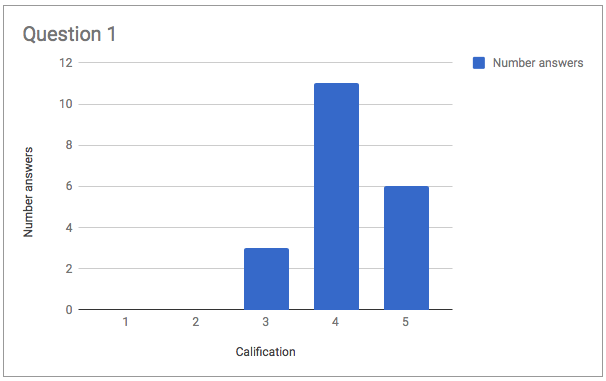

Figure 5. Results of the first question: How clear was the explanation about the parts of the guitar for you?

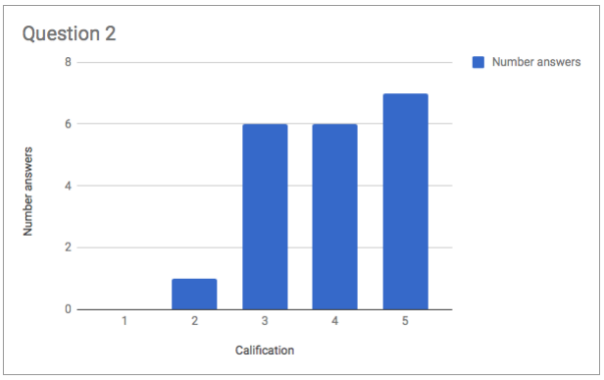

Figure 6. Results of the second question: How clear were the exercises instructions for you?

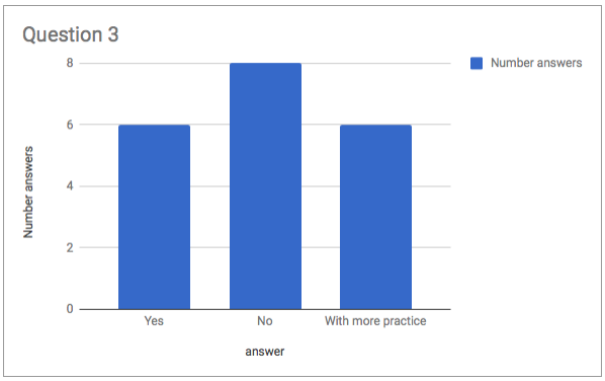

Figure 7. Results of the third question: Do you feel that you learned how to play the song "twinkle twinkle" with a guitar?

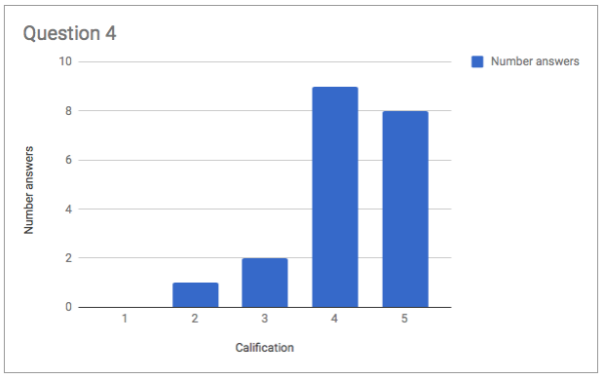

Figure 8. Results of the forth question: How much did you like the experience with the Hololens?

Figure 9. Participant of the test, while using the application.

experience and, on average, their level of satisfaction was graded as 4.2.

IV. Discussion

The application is in its first phase, and improvements in usability, tracking and interaction are being developed. In this first approach to the implementation of the prototype, it was evident that there is great acceptance and expectations regarding autonomous learning, but there are also several obstacles that cannot be overlooked related to technology and hardware. They will be explained in more detail in this section of the paper.

Based on the evidence gathered during the study, some conclusions can be drawn. The first one refers to the positive impact that an Augmented Reality Application has in the field of education, since most of the people who tried the application with the immersive device agreed on the potential of this type of implementation, and how meaningful being able to learn through an application with these characteristics could be.

	Average	Std. Deviation
Question 1	4.15	0.670820
Question 2	3.95	0.944513
Question 4	4.20	0.833509

Figure 10. Results of the question 1, 2 and 4. Average and standard deviation.

This new model of autonomous learning is very attractive for a bunch of people who want to learn how to play a musical instrument and who find it is not possible due to their lifestyle time demands. After testing the prototype, the participants of the test concluded that it would be very useful to have access to an application like this since they could meet the goal of learning to play the guitar without having to deal with difficulties, such as having to hire a teacher or get to an academy on a fixed schedule.

Additionally, it was mentioned that the teaching methodology is compatible with the tool because it is easy to understand and students could go deeper in the subject as they advance in the virtual course.

On the other hand, in the user testing phase it was possible to observe and analyze some of the software and hardware drawbacks and, based on that, some aspects to be improved were identified. For instance, an aspect that about 100% of the users referred to, was the discomfort they experienced wearing a device like the Hololens for a long time. The test subjects showed difficulty after using the hardware for more than 10 minutes, which made difficult for some of them to finish the test since some participants expressed they wanted to complete the test quickly regardless of the result.

Moreover, the library used to track the guitar is a technology that is still being developed and it is not fully reliable yet. Therefore, this type of tracking posed some difficulties for the test taking and, in some occasions, users required assistance to be able to continue.

Regarding software, some issues related to usability were identified. The feedback collected through the surveys provided information about changes that could be implemented in similar applications. For example, the functionalities related to speech recognition should be more precise and the application should provide an alternative to this interaction. Other aspects to improve are the location of the audiovisual materials and texts, as well as the addition of other resources such as tablatures or sheet music with the notes for learners to be able to understand the lesson even better.

After the first iteration, improvements will be implemented in the prototype taking into account the feedback provided by the first group of users. Then, a second one will test the new version of the prototype to validate it as well as the teaching model that was used. Additionally, there is still a second question that was posed in the scope of this project, which has to do with including an avatar or virtual teacher, as in a conventional classroom, in order to find if it changes

the learners‘ experience.

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