Virtual flute: electronic device that uses virtual reality to teach how to play a flute

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Abstract—**In this paper is described the process that should be done for developing a interactive tool for supporting the musical learning specifically on how to play a flute on its basics. This device has two main stages, the first one takes over the teaching part and guidance to the student by an software interface and the second one has the responsibility of captured how is being played the flute using a pressure sensor and reflective transducers. With this example is expected to contribute in research and implementation of teaching devices around the world.**

Keywords-acoustoelectric devices; computer applications; learning systems; music; technological innovation; virtual reality

I. INTRODUCTION

Nowadays, the learning process needs a complement tool which could make it more efficient, enjoyable and accessible for every person who wanted to acquire knowledge in certain area. The virtual reality helps in making the education more contemporary it generates in young people the desire to research and learn about different stuff.

Many of the increasing challenges are arising from the emerging generation of new learners who are far more proficient with VR and other computer applications. The trend in professional society is also changing based on new learning tools and modes. Recently, virtual worlds have become an important part of teaching and training, transforming the way people work and learn. As technology allows more and more content to be virtual, so improves the possibility of better learner engagement [1].

Along with the device an educational pedagogy is integrated it ensures the success of student learning through implementing constructivist pedagogy instead of the traditional way of education giving a greater and more representative role to the student, recognizing that he/she is the main actor in the learning process.

The significant changes that today's students bring with them when they start their post-secondary education creates an urgent call to understanding the different ways they learn and therefore, to change the ways institutions educate them. But it is time not only to radically change the way teaching takes place, but also, to redesign curriculum, graduation processes, evaluation methods, infrastructure needs, and so on [1].

Making the teaching more interactive allows the student to learn on his/her own way, especially in music areas there are some difficulties for students who are subjected to inappropriate patterns of study. The skills and abilities could be different from each other.

At the same time, it is seen in our society the need to develop teaching tools and technology of interactive models more efficient and attractive, making the learning process more enjoyable. The non Immersive virtual reality offers in this case, an option where the interesting and useful interactive educational simulators are an innovative way of presenting to a student the information that is required to learn, giving the opportunity to be evaluated and followed throughout this process, leaving behind the traditional teaching, instead implemented a constructivist pedagogy.

Virtual reality is not a representation of a specific experience in the actual world, but it is a new mode of experience where various sensory and imaginary experiences are fused. This is not simply a way to understand and effectively access the actual world, but it is a driving force that carries forth the human activities and it is an independent reality that gets feedback from those activities. Users can experience virtual reality that is unrelated to the physical world [2].

Therefore it was decided to develop the "Virtual flute" in which an electronic device with software has the purpose to accompany and guide the student through the process of learning how to play a flute. The dynamic of the device has three stages a first one that gives all the instructions to the user, a second one where the hardware senses the note and finally a feedback of these data to the computer.

The following document shows the systems implemented for the realization of the device. Will present all needed to understand the functioning of the hardware, the progress made with their results and applications where the device would operate in an optimal way.

II. VIRTUAL REALITY

VR is a kind of technology that enables users to get sensory experiences on real things in a similar way to the one that they use when they interface normally with physical world. Such experience is only simulated; it does not mean a new experience has occurred. In other words, virtual reality is nothing but an artificial reality which is a substitute for natural reality that is felt in the actual world [2].

This device implements non immersive (desktop) virtual reality which offers less real sense than immersive virtual reality, but when it is accompanied by hardware it permits the possibility to the student of being in contact with the instrument that needs to play. The feeling is much more real than if they only see the information in a computer. In addition the feedback from the captured data from the sensors allow for seamless interaction between the student and this educational tool.

To stimulate creativity and productivity, the virtual experience must be credible. The "reality" must both react to the human participants in physically and perceptually appropriate ways, and conform to their personal cognitive representations of the microworld in which they are engrossed [3].

In the music field when someone wants to learn how to play an instrument is important to use a hardware which simulates the musical instrument and the student could be in contact with an object similar to the real one and be prepared for when he/she needs to play a real instrument.

New technologies related to computer music make it possible to not only create new types of music by ourselves, but also to learn conventional music more easily [4].

The principle purpose of the "Virtual Flute" is to facilitate the learning process on how to play a flute, offering a new way to practice and study the basic musical notes. Using this tool the student could practice whenever he/she wants as fast as each one decides, this allows a more enjoyable learning process.

Nijholt, thinks that technology can play two major roles in music education. Firstly, technology can supplement and support skills of parents and teachers essential to the musical development of children that are becoming rare or underdeveloped or for which time lacks. Note that such technology should not replace those skills but rather be accompanied by initiatives that encourage the development of such skills. Secondly, technology can make music education more efficient by taking time consuming, less creative, essentially 'practice' activities and offering them in a context in which students can master them individually, leaving more time for teachers to focus on the communicative/creative skills of music [5].

Therefore is seen the important mission that has the technology to develop different methods of participation in music and its processes: learning and practice.

III. METHODOLOGY

Two methodologies were implemented the first one which handled the development of theoretical research and the second which designs the interactive tool.

The research methodology was based in theories from Mendez [6], Lerma [7], Tamayo [8] and Cerda [9].

TABLE I. RESEARCH METHODOLOGY IMPLEMENTED

.**Stages**
Topic description
Problematic
Objectives
Justification
Similar examples
Definition of the methodology for developing the tool

During the topic description stage was determined the interactive tool scope and its limits then was seen and defined the "what for" of the learning device and clarified all the functions that should have the virtual reality tool after that was determined the motivations for the development of the device and was made a research about existing research and development about similar projects, finally was determined how would be developed the interactive tool

TABLE II. METHODOLOGY DESIGN FOR THE ELECTRONIC DEVICE

Stages
Planning
Requirements
Analysis
Devices design
Construction
Tests

During the planning stage was defined what will be done, the list of activities, team work, materials that constitute the device and the required tools then was set out the different characteristics that the device must have. After that was analyzed the requirements and the possible ways to develop the interactive tool, building a model to determine the physical structure and technology used and were made the sketches, proposals for structural design and performance. Then was made the flute's implementation with the sensors, signal conditioning and data transmission finally were made some tests of the flute's performance including the software.

IV. VIRTUAL FLUTE

A. Materials

Virtual reality's central objective is to place the participant in a virtual environment that gives the participant a feeling of "being there." This requires linking the human perceptual and muscle systems with the "virtual environment." A VR system consists of three types of hardware: 1) sensors, 2) effectors and 3) the reality simulators. [10]

The following are the most important electronic components that have the interactive tool:

The sensor Mpxv 4006 Freescale is used to measure the flow of air from the blow that leads the user when he or she play a music note on the electronic instrument. It works from 0 to 6 kPa, and is responsible for allocating a voltage value to the air pressure with a reference value of 4.8V for the maximum pressure to 0.17V for the minimum.

To identify the parameter of average pressure when the flute is played the right way were taken different samples of people with knowledge about how to play the flute correctly, noting that the results were close to a range of values specified in the driver program to analyze and compare each moment of execution.

The operating characteristics of this pressure sensor are: the pressure range is between 0 and 6kPa or what is the same 0 to 0.87 psi. The current supply could be from 7mA to 10mA. The operating temperature is between -40°C and 125 °C and the response time is 1mS.

The above characteristics determine the ease of using a device like this, its maneuverability in the prototype and its operating qualities that make it an excellent mechanism for implementing within the device.

For sensing the position of the fingers on the virtual flute are used eight reflective sensors. The Reflective Optical Sensor, CNY70 has a compact construction where the emitting light source and the detector are arranged in the same direction to sense the presence of an object by using the reflective IR beam from the object. The operating wavelength is 950 nm. The detector consists of a phototransistor [11].

Fig. 1 shows the construction of the sensor and its operation, this sensor is implemented in each hole of the flute to identify when it is being covered by a finger or not.

At the moment the finger is positioned over the hole, there is a reflective surface that makes the role of the medium of reflection for the infrared beam emitted by the diode, making driving transistor receiver.

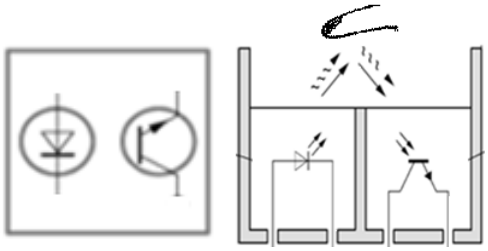

Figure 1. CNY 70 diagram

B. Flute Design

Fig. 2 shows one of the implemented prototypes of housing, which allows opening the main tube, to give the possibility to put the electronics needed to operate. It was made of wood with an original design made particularly for this application.

Figure 2. First designed flute

Fig. 3 shows another implemented prototype of housing, which is a typical flute with a little box which has the electronic components; this model permits an easier and more real way to play the flute.

Figure 3. Last designed flute

The following table shows the values of voltage measured at the output of the pressure sensor, captured in several tests to persons who knows the art of playing the flute, these data are the parameters used to design an algorithm that discriminates between a note that is played the right way and other that is not.

TABLE III. | VOLTAGE AT THE OUTPUT OF THE SENSOR

Student	Voltage at the output of the sensor
1	2.01
2	2.23
3	2.16
4	2.34
5	2.37
6	2.26
7	2.27
8	2.31
9	2.13
10	2.11
11	2.13
12	2.46
13	2.54
14	2.27

The analysis of the results, generates a voltage range in which the note is being well executed, which corresponds to approximately 0.326 psi or 22.2x10 ^ -3 Atm or 2.25 KPa.

V. RESULTS

The main result was the successful implementation of hardware device that captures the basic musical notes which are being played on a flute and transmitted to the computer, where the interaction is consistent and efficient.

The combination of music instruction, the sensors and the communication with the computer, generated a electronic device in which has an application of software that was developed in Java, Netbeans, and it provides the necessary information to the student to learn how to play the basic notes on a flute and gives the opportunity to practice and be evaluated, according to this the computer sends data to an electronic circuit for identifying what note should be captured by a PIC microcontroller, the data are captured from the sensors of the hardware part (air pressure and fingers position) are analyzed and returned data to the software which provides a correction or an acceptance of performance, thus completing a cycle of information and feedback aimed at the understanding and successful learning.

The software makes the instruction to the user, displaying the correct way to play a flute, when the user has reviewed this information with the speed that he/ she wants and how often he/she desired necessary then they could choose the appropriate type of test to perform, creating a kind of constructivist pedagogy which offers to the student the necessary tools for the learning process.

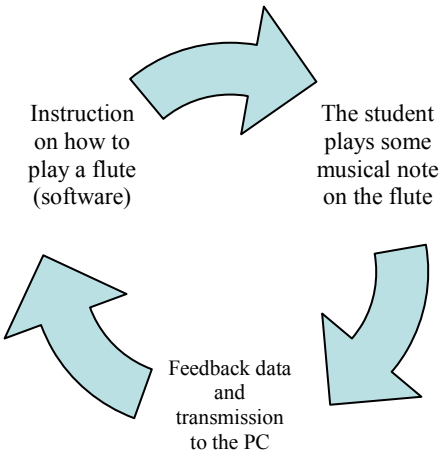

Figure 4. System Dynamic

When the activity is chosen, data are sent to a PIC microcontroller, which identifies the note that must be play by the user in the following seconds, then analyzes the input of the position of the fingers by the digital inputs of microcontroller and the air pressure exerted by the blow of the user, using analogue digital converter from the same integrated circuit to be compared with the expected feedback and response to a computer (USB communication), specifically to the software in Netbeans, indicating the student qualities or their shortcomings in implementation.

Thus, it generates a dynamic conducive to the goal of teaching the correct way to play a flute.

The following figures (*Fig. 5 and Fig. 6)* are samples of the graphical environment of the software application developed for this interactive tool, because the device is primarily designed for children, the graphics are very colorful and animated in order to attract attention.

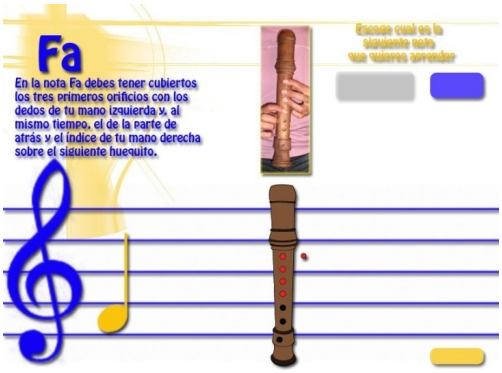

Figure 5. Software designed

Figure 6. Software designed

VI. DISCUSSION

The learning and / or musical training are complex for many students because they do not have enough tools, for example they do not have someone or something that continually motivate and guide them for training in musical performance as a contemporary art. Also there are people who are subjected to inappropriate patterns of study for their skills and abilities in the learning process in this area. These factors cause dissatisfaction in a specific group that wants to work on their artistic abilities.

this paper presents a device able to sense the musical notes that are played by a user, with software that guides a user interested in learning the art of playing a flute, it noted the importance of implementing educational tools, which makes more efficient and effective the learning process, demonstrating the importance of electronic applications in low and high impact exploration in different aspects, as in this case in the arts and music pedagogy.

An academic impact was generated; this project brings improvements in the research and implementation of such devices and at the same time with these devices provides an innovative way of teaching that makes an easier and more interesting learning process.

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