AUGMENTED REALITY EXHIBITION DEPICTING THE AESTHETIC PERIODS OF MUSIC HISTORY

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Abstract — This paper presents an interactive exhibition supported by Augmented Reality (AR) technology. The exhibition focus the Aesthetical Periods of Music History and it is aimed at an audience of students from the 2nd and 3rd Cycle of Basic Education in Portugal public schools. In this paper, we will discuss the concept, definitions and current use of AR technology in teaching-learning processes. Topics as constructivism, the relation between art education, information technology (IT) and student motivation are also addressed in this paper.

Index Terms — Augmented Reality, music history, constructivism, art education, student motivation.

I. Introduction

New and advanced technologies continue to change every aspect of home, life and work: the way we communicate, learn and socialize. Computer technologies are changing the ways we think and make sense of our world [1].

While educators may legitimately debate strategies and methods of education, all agree that participation in the world of the 21st century will demand technology competence. Technology is essential in teaching, communications, mathematics and science, and it is no less important in the arts. Technology is an important tool that can improve the educational system, but the challenge of integrating technology into the delivery of content remains. Digital technologies, in all areas, can enhance student achievement by addressing introductory and advanced skills, assessment of student progress and student motivation [2].

Presently, Information Technology (IT) has become a ubiquitous component of undergraduate education. The use of computers, and mobile computing devices in educational context are commonplace in terms of usefulness and acceptance over the past few years and technology has found its place inside and outside the classroom for academic purposes [3].

Constructivist pedagogical approaches are inherent in most performance-based music courses. Students can apply new knowledge and receive synchronous feedback from teachers. However, knowledge-based courses such as music appreciation, theory and music history have historically relied on direct instruction and the lecture-model. Technology offers new opportunities to bring constructivist pedagogy to knowledge-based music courses, adding the possibility of autonomous exploration of interactive multimedia content [4] into the teaching-learning process in music history.

Augmented Reality (AR) Musical Gallery aims to provide a constructivist pedagogical approach to the Music History teaching-learning process and to promote advanced AR technology to deliver educational multimedia content to young students.

This paper introduces the concept of an interactive exhibition based on AR technology, focusing an audience of 2nd and 3rd Cycle of Basic Education students. The exhibition goals are the promotion of student motivation and to improve learning outcomes.

The paper is organized as follows: Section II introduces AR technology and its potential for use in educational environments. Section III introduces the concept of the constructivist pedagogic model. Section IV addresses the topics of art, motivation and technology. Section V describes the concept and development of the AR Musical Gallery. Section VI presents conclusions and further work.

II. Augmented Reality Technology

Augmented Reality (AR) is a technology that allows computer-generated virtual imagery information to be overlaid onto a live direct or indirect real-world environment in real-time. AR differs from virtual reality (VR) in that VR user experience a computer-generated virtual environment, whereas in AR, the environment is
real, but extended with information and imagery from the system [5].

According to Jaramillo, Quiroz [6] AR is also defined as a technique that allows interacting and visualizing virtual graphics on top of the real-world view. Milgram’s continuum (Milgram and Kishino, 1994) proposes that AR is a mixed reality environment, with one part belonging to the real-world, and other purely virtual. However, the real environment predominates (figure 1).

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<table>
<thead>
<tr>
<th>Real</th>
<th>Augmented Reality (AR)</th>
<th>Augmented Virtuality (AV)</th>
<th>Virtual</th>
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<tbody>
<tr>
<td>Environment</td>
<td>Mixed Reality (MR)</td>
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Fig. 1. Milgram's continuum (Milgram and Kishino, 1994)

This mixed-reality environment presents large possibilities for human-computer interaction (HCI) and it has been used in different areas, namely medicine, architecture, education, training, military, astronomy, chemistry, biology, mathematics and geometry education, amongst many others.

AR can contain various functions, namely, interaction or display. A good example of this can be a museum, where the visitor uses a given application to scan a bar code on the base of a statue and the application shows a picture of the statue with a fully interactive description [7].

In comparison to virtual reality, aimed to immerse the user in a synthetic environment, AR supplements the user perception of the real world by adding computer-generated content registered to real-world locations. A significant part of the AR environment consists of real-world objects, for which it is not necessary to create detailed 3-D models, while offering a high level of reality [8].

The field of learning and training, both in academic and corporate settings, has seen in the last few decades a growing interest by researchers focusing on the potential of AR to enhance the learning and training efficiency of students and employees. Concerning the educational uses of AR in school contexts, AR has not been much adopted into academic settings due to the insufficient funding by the government and lack of awareness regarding the needs for AR in academic settings [5].

This is particularly true in Portugal regarding the academic environment of Basic Education. The use of AR to enhance the teaching-learning processes, apparently, is addressed only by a minority of Portuguese researchers.

However, although AR technology is not new, its potential in education is just beginning to be explored, and some examples are stated below:

- Woods et al. (2004), enumerated benefits driven by AR technology, such as improvement of the interpretation of spatial, temporal and contextual content;
- Freitas and Campos (2008), have confirmed that AR enhances student learning;
- Seo, Kim and Kim (2006) state that a number of authors have suggested that AR technology improves kinesthetic learning because students interact directly with the educational material, associating the content with body movements and sensations;
- Lin, Hsieh, Wang, Sie, and Chang (2011) used AR and a touchscreen to enhance the educational resources about fish conservation in Taiwan and their results were focused on system usability;
- Ibáñez, Delgado, Leony, Garcia, and Maroto (2011), developed a multi-user AR platform for learning Spanish as a second language. Results showed that AR has a positive effect on student motivation and improves the language learning process;
- Connolly, Stansfield, and Hainey (2011) developed an AR game for learning English to study how motivation could be improved through collaborative methods;

In general, all of the above research studies evaluated system usability and student’s results in order to show improvement in learning processes [9].

III. AR Musical Gallery: A constructivist approach

Piaget stated that education cannot succeed without recognizing, using and extending the “authentic” activity with which a child is “endowed”. Piaget was an early adopter of the constructivist pedagogy, and in this view of learning, the meaning that is constructed by an individual is dependent on the situation itself, the individual’s purposes and active construction of meaning. Constructivism also recognizes that prior experiences and knowledge influence perception and interpretation [10].

The theory of constructivism stems from the field of cognitive science, particularly of the works of Jean Piaget, Lev Vigotsky, Jerome Bruner, Howard Gardner and Nelson Goodman and describes the construction of knowledge through learning as a process of active meaning construction in relation to the environment in which the learning takes place [11].

The most important feature of constructivism resides in focusing activities and environments, rather than learning objects.

The constructivist approach effectively motivates students, allowing active learning processes, based on exploration and interaction. This means that students build their own knowledge [12].

AR Musical Gallery aims to deliver a constructivist learning environment by providing students an
experience where the following characteristics are present and valued:

- The role of previous knowledge;
- The role of context and concrete learning experience;
- The interactive and cooperative character of learning;
- The importance of the concept change that must occur to deliver effective learning;
- The new roles assumed by teachers and students;
- The importance on the reflection of the students over the undertaken process: It’s this reflection that will empower the competence to “learn to learn” [13].

IV. Art motivation and technology

Music and other forms of art are known to develop discipline, higher order of thinking skills, creativity and to engage students in a variety of different learning styles. Technology applied to arts education can be thought as an applied science (anything that uses science to achieve a desired result) and can act as the extension of student capabilities and as a way to expand their ability to learn [2].

The use of technology can accelerate the learning of the arts, and this is also true in the Music History field, where the comprehension of a given aesthetic period requires students to listen the musical works of that period, to read about composer biographies and works, and to analyze musical instruments, images, paintings or photography, depicting historical backgrounds and environments. Different types of media are essential to comprehend the evolution of music in time and how it relates and influences different cultures.

AR technology can deliver digital content (audio, video, image, 3-D models) by using real-world educational resources (books, schoolbooks, posters, images, and so on), improving the quality of these educational resources.

In Portugal, currently, Musical Education is part of the Arts and Expressions Curriculum defined by the Ministry of Science and Education and educational goals are clearly defined concerning students from the 1st, 2nd and 3rd Cycles of Basic Education. However, in 1st cycle, Music Education is only offered as complementary activity and Music History it is not relevant to younger students. In the 2nd cycle, Musical Education it is part of the curriculum, but weekly class hours are insufficient to convey the extensive program to the 5th and 6th grades. 3rd Cycle Music Education has gradually become an optional educational area, as the official entities tend to neglect and undervalue the importance of Music Education in public schools. Technology in musical education is addressed in the official programs, but it’s clearly outdated. AR technology educational potential can contribute to improve this situation, by delivering music related educational content in informal learning environments and exploring the native young student’s motivation towards technology and technological devices.

At present, many educational institutions in developed countries are facing a lack of interest and motivation in students towards academic practices. The growing distance between teaching procedures and student’s technological way of life contribute to widen the gap.

Recent research shows that the relation between learning and motivation goes beyond any pre-established condition, it is mutual, and in that sense, motivation can induce changes in student learning and performance, as the learning itself can interfere with the motivation. In educational contexts, student motivation remains an important challenge to overcome, and has direct influence in the teaching-learning processes: “the motivated student seeks new knowledge and opportunities, showing engagement in the learning process, participating in the proposed tasks with enthusiasm and being open to new challenges” [14].

According to several researchers, it is possible to enhance and strengthen student motivation for learning through the use of AR by adding realism-based practices. “AR has the potential to further engage and motivate learners in discovering resources and applying them to the real world from a variety of diverse perspectives that have never been implemented in the real world” [5]

Motivation is directly linked to learning achievements, and AR applications, which are interactive and visually attractive seem more appealing and motivating than traditional tools [9].

The AR Musical Gallery delivers digital interactive educational contents supported by AR technology. The technology is easily accessible through widely available mobile computing devices as smartphones and tablets, both for Android and IOS platforms.

The AR Musical Gallery aims to:

- Explore the potential of the ubiquitous mobile computing devices as smartphones and tablets to deliver interactive educational content;
- Use mobile-learning and informal learning environments;
- Offer alternative strategies to the teaching-learning process;
- Improve student motivation and educational outcomes.
- Explore the potential of AR technology in educational context.
- Promote student motivation towards learning and improve their educational outcomes.
V. AR Musical Gallery: Concept and development

The AR Musical Gallery exhibition aimed to promote music history learning and motivate students to autonomous learning in a constructivist-based approach, by using mobile computing devices, such as smartphones and tablets and the AR technology.

The exhibition was presented in ten A3 size posters featuring imagery and textual information. In order to enhance the information available on the exhibition posters, allowing students to know more on the given subject, additional digital content and interaction was delivered through AR technology, namely video, sound and 3-D musical instrument models.

The posters were placed on two vertical panels, at the library’s entrance, allowing individual or group exploration (figure 2).

The exhibition was organized according to a logical sequence: The first two posters included information about the AR technology, and instructions concerning the proper configuration of student mobile computing devices; the remaining posters presented the educational content.

The poster sequence, and their real-world/ digital content is enumerated as follows:

Poster 1
- Real-world content: Introduction to the technology of AR.
- Digital content: 3-D animation intended to demonstrate AR capabilities.
- Interaction: No interaction available

Poster 2
- Real-world content: Information on how to configure student mobile computing devices. The poster included two Quick Response Codes. The first leading to a video tutorial on how to install the app Aurasma in mobile computing devices, the second was used to load the proper Aurasma channel.
- Digital content: Video depicts the 3-D exploration of the painting Guernica by Pablo Picasso and the music of Manuel de Falla.
- Interaction: Double tap on the device surface makes the video full screen.

Poster 3, 4 and 5
- Real-world content: Musical instrument presentation and history. Violin, upright piano and trumpet.
- Digital content: 3-D animated models and musical excerpts from these instruments.
- Interaction: Three digital buttons allow user to switch 3-D mode on and off and to choose the musical excerpts (figure 3).

Poster 6
- Real-world content: XXth century composer timeline.
- Digital content: Video presenting composer name and surname, date of birth and musical excerpts.
- Interaction: Video control, pause, play. Double tap on the device surface makes the video full screen.

Fig. 2. AR Musical Gallery exhibition

Fig. 3. AR Musical Gallery, user interaction
Poster 7, 8, 9, 10
- Real-world content: Composer full name, date of birth and death, biography.
- Digital content: Video presenting pictures, musical excerpts and important biographical information.
- Interaction: Three digital buttons allow user to access web pages featuring full composer biography, the most relevant composition in video format and to a blog dedicated to XXth century composers (figure 4).

Students received a brochure concerning major aspects of the exhibition and a book marker featuring AR.

Students were also briefed on the principal poster areas, namely the poster information structure and the identification of the images designed to trigger the AR digital content. These areas are depicted in figure 5.

The exhibition was held in the school’s library and featured an introductory session towards the exhibition, its contents and the supporting technology - AR. This introductory session was made available to all students of music education, and focused the gallery educational contents, research objectives, the AR technology and the configuration of student mobile computing devices, namely smartphones and tablets.

Fig. 4. AR Musical Gallery, user interaction

Fig. 5. AR Musical Gallery poster areas

- A - This area identifies the gallery, the underlying AR technology and the supporting engine AR - Aurasma.
- B - This area displays the poster theme, in this case, the violin’s name.
- C - Textual information relating to the presented content.
- D - AR trigger image: This area holds the image that allows access to the AR content, namely, audio, video and 3-D models. Digital content is available by pointing the student’s mobile computing device to the image. User interactions are available, by pressing different icons on the device tactile interface.

Students and other library users explored the gallery using their own smartphones or tablets, or by requesting the library pre-configured tablet.
To develop and implement the AR content displayed in the gallery we have used the AR engine Aurasma\(^1\) and the online tool Aurasma Studio\(^2\).

- Aurasma is a free app available for Android and iOS devices. Digital content was delivered into AR using the online tool Aurasma Studio, which, as the app Aurasma, is free. Both tools are supported by the Hewlett Packard Corporation.

Digital content, namely video and 3-D models were produced by using open-source and free programs. Music history content was adapted from the CD-ROM Musicalis, published by Porto Editora in 2005.

The gallery was on exhibition in October 2014, at Basic School Maria Manuela de Sá Library.

All Students were invited to interact and use the exhibition, discovering new ways of using their mobile computing devices and deepen their music history knowledge. Music education students from the fifth and sixth grades participated in individual introductory sessions concerning the gallery, and the technology of AR. These sessions were followed by the exploration of the exhibition.

VI. CONCLUSIONS AND FUTURE WORK

In this paper, we described the concept and use of an interactive exhibition supported by AR – AR Musical Gallery. The exhibition focus the Aesthetical Periods of Music History and it’s aimed at an audience of students from the 2\(^{nd}\) and 3\(^{rd}\) Cycles of Basic Education in Portugal.

We also introduced the AR technology and its potential use in educational contexts. At present, this technology is effectively being used in several fields of knowledge to support and improve teaching and training processes. AR reveals undisclosed potential to effectively enhance factors as student motivation and educational outcomes. However, how to deliver educational contents with AR technology remains a challenge to be addressed by educators, researchers, developers and education officials.

AR, by combining real-world elements and computer generated content is usually addressed as a mixed-reality environment, where the real-world element is prevalent. This characteristic is key to enhance traditional educational environments where most of the educational resources are based on traditional printed materials, books and manuals.

The AR Musical Gallery proposes a constructivist pedagogical approach applied to a traditional lecture-based course – Music History – by mixing autonomous exploration, informal learning environment, and interactive multimedia educational resources delivered by AR technology. The constructivist approach can enhance motivation, leading to active learning processes based on exploration and interaction, helping students to build their own knowledge.

We have addressed the relation between art education, motivation and technology, and stated that:

- Art education is known to develop discipline, higher order of thinking skills, creativity and the ability to engage students in a variety of different learning techniques;
- Learning and motivation are connected: Motivated students actively seek new knowledge showing engagement towards learning;
- Technology, in general, is a motivation factor to the current “native digital” students, and can accelerate learning and contribute to improve educational outcomes;
- AR technology has the power to engage and motivate students in a variety of pedagogical approaches and perspectives.

From this educational experience, and although a formal study on usability, motivation and educational outcomes hasn’t been carried out yet, direct observation regarding user interest toward the exhibition allowed to collect some empirical data. Early analysis shows that students were very interested in exploring the AR content and highly motivated towards music history learning.

The AR technology aroused increased curiosity among students and teachers, as they realized the educational potential and possibilities to new educational approaches.

Further study is currently underway, focusing on the artifact’s usability, motivation, degree of technology acceptance and possible educational outcomes. Data collection instruments will be based on case study methodology, supported by direct observation, survey and interview techniques.

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