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Extended Abstract—Using Augmented Reality to Teach the History of Classical Athens: A Presentation of the Methodology and Preliminary Findings

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Abstract. In this extended abstract, the methodology for a study in progress regarding the design, development and evaluation of an Augmented Reality application for the teaching of the History of Classical Athens to students of Greek descent living abroad is presented. Following a review of the reasons necessitating the adoption of this technology for the teaching of History – and specifically relating to fifth-century B.C. Athens – the preliminary findings including a review of the literature and results of interviews with teachers, students, and parents are also shared. The detailed methodological framework of Design-Based Research guiding this study is detailed, as well as the corresponding steps related to the ongoing design, development, and evaluation of this application.

Keywords: Augmented Reality, Classical Athens, Design-Based Research.

1 Introduction

Augmented Reality (AR) is increasingly recognized as a leading 21st–century emerging technology [1] that features a wide variety of affordances to education, including visualization of objects, interaction with 3D objects [2], interactivity with virtual objects in real time [3], contextualized information, spatial ability, practical skills, conceptual understanding [4], and decreased cognitive load [5]. Increased use has fostered growing research interest regarding AR's role as an educational resource [6], with key findings including its positive impact on students' academic performance [7], and students' motivation and attitudes [8]. AR has been implemented as a resource across various subjects, including History in both primary and secondary education [9].

AR has the potential to prove beneficial in the teaching and learning of History, considering the complexity of the subject matter [10]. The enrichment of historical texts through augmented audiovisual content could improve student comprehension, considering that AR instructional material could facilitate understanding of historical events and combat misconceptions [11]. Moreover, although it occupies a place as a basic subject in school curricula worldwide, History is sometimes associated with boredom due to the teacher-centered manner in which instruction is delivered, which might lead to the perception that it is not aligned to 21st-century skills and technologies perceived to be in demand by future employers [12]. The use of AR could support a more student-centered approach to teaching and learning History, which is in line with contemporary best practices rooted in constructivism [13] and the development of historical empathy [14], which are hailed as bolstering learning outcomes among students. Utilizing AR technology could enhance History's standing in the school curriculum, better enabling students to develop an appreciation for pluralistic democracy, cultural diversity, global citizenship, critical thinking, and awareness of themselves or significant in-groups to which they belong [15].

Although some AR studies on the teaching of History to primary and secondary school students do exist, based on the literature review presented in the next section, there do not appear to be any specific studies examining its use in teaching primary and secondary-school students about Classical Athens (circa fifth-century B.C.). Considering the historical significance of this era and its legacy, this absence constitutes a void in the literature. The period of Classical Athens is one of the most significant and frequently studied [16] eras in world history. Among other things, it is credited with establishing democracy, drama and comedy, philosophy, as well as breakthroughs in mathematics and astronomy, and many architectural and artistic wonders, including the

Parthenon [17]. The historical events and achievements in Classical Athens continue to preoccupy scholars in a variety of fields [18] and influence many diverse aspects of modern life and contemporary thought [19].

Furthermore, the history of Classical Athens holds a special importance for millions of Greeks living abroad, numbering anywhere between 2.5 and 7 million, thus corresponding to approximately at least a quarter of the population of modern Greece [20]. This subject represents an integral part of their ethnic history and plays an important role in shaping modern Greeks' collective identity [21]. As such, the ability to utilize AR to present this significant era in Greek history to students of Greek descent living outside of Greece can be expected to have an impact on their knowledge of the content, as well as their attitudes toward it and motivation to learn about it.

The aim of this extended abstract is to outline the steps and present the preliminary data associated with a study currently being undertaken on using AR in teaching Ancient Greek History – specifically, regarding its impact on learning outcomes and motivation on students of Greek descent living abroad. Following the Design-Based Research methodology (DBR), this extended abstract presents the recognition and analysis of the problem of teaching Greek History, details the methodological steps being taken toward the design and development of an AR application covering the period being studied, as well as plans regarding the evaluation of the impact of the application on learning outcomes and student motivation.

2 Review of Literature

A review of the literature reveals a number of studies conducted on the use of AR to teach the subject of History to students at the primary and secondary education levels in formal and informal environments dating back as early as the Neolithic era [22] and up to the mid-20th century [23, 24]. These studies were conducted in both formal [22, 25–29] and informal [23, 24, 30–35] learning environments to both primary-school [22–24, 28, 31, 32, 35] and secondary-school [27, 29–31, 33, 34] students. The main results of these studies included improved learning outcomes, favorable attitudes toward using AR in teaching and learning, and increased motivation to interact with AR technology.

Indicatively, several researchers reported clear learning gains for students interacting with AR [22, 26, 27, 29–32, 34]. Nonetheless, a few researchers reported the persistence of certain comprehension problems, such as correlating years to centuries [31] or fully understanding space-time concepts regarding the historical period being studied [24]. Elsewhere, one study [32] indicated that Grades 3-4 were best suited to participate in blended learning AR interventions compared to working alone or with mixed-age groups, while another study [35] found primary-school students to be the ideal demographic for working with low-fidelity AR environments. These findings informed the selection of the sample group detailed in the "Methodology" section below.

Another finding that emerged from the literature review was the prevalence of favorable attitudes among students who interacted with AR applications to study History [23, 25, 30, 32, 35]. These studies reinforce the constructivist concept highlighted in the previous section that students prefer a hands-on, active learning approach where they can digitally interact with artifacts [35] as opposed to a teacher-centered instructional focus [32]. The fact that students expressed the desire to engage with the AR content again or have an opportunity to try out new AR applications further illustrates the favorable impact of this technology on their attitudes [30].

Finally, a smaller number of studies also highlight AR's impact on students' motivation to learn [26, 30, 32] with [31] directly crediting student motivation from the AR intervention to improved ability to recall instructional material and overall knowledge. Another study [26] points to the element of competition present in the AR game in which students were engaged as a factor in their observed interest and cooperation. Nonetheless, these results were not replicated in every study, with [34] noting no significant difference between an experimental group using AR technology and the control group engaged in project-based learning.

Of the studies reviewed, a few [25, 30, 31] focused on the classical period in ancient Greece, however, none of these specifically addressed the history of Classical Athens, constituting a gap in the research.

3 Methodology

The methodology chosen for the design, development, and evaluation of an AR application for the teaching of the History of Classical Athens to students of Greek descent living abroad in a formal learning environment was Design-Based Research (DBR). This methodology was developed by education researchers to bridge the gap between basic and applied research practices [36] through the study of innovative interventions in teaching and learning employing a combination of manifold approaches [37], and was used in prior AR studies [38–40]. According to Reeves [41], this methodology is composed of four phases: a) analysis of practical problems by collaborating researchers and practitioners, b) development of solutions informed by existing design principles and technical innovations, c) testing and refinement of solutions, and d) reflection to produce "design principles" and enhance solution implementation. This study will use the first three, as detailed below:

3.1 Recognition and Analysis of the Problem

The purpose of this phase was to investigate the problem addressed in this study by identifying a gap in the research and studying existing approaches to teaching Classical Greek History to formulate a solution. The input of experts and stakeholders was also sought to secure a pluralistic perspective shaped by diverse views.

Systematic review of the literature regarding the design, development, and evaluation of mobile applications and books using AR for the teaching of History. The review was conducted using the following databases: "ERIC," "SpringerLink," "ScienceDirect," "IEEE Xplore," "Scopus," "ACM Digital Library," "Taylor and Francis,' while a target search was also conducted on "Google Scholar" and the existing literature cited by already published studies to identify related articles not found during the keyword search. It took place between 22 March – 26 April 2023 and covered years from 2008 until the present. The following keywords were used for the search: Augmented Reality AND History AND Education OR School OR Students OR Image–Based Games OR Location–Based Games. The results from the initial search yielded 21,979 articles. After an initial review, 53 studies remained following the exclusion of the other articles because they were duplicates or did not meet the search criteria due to irrelevant titles, abstracts, or content. 39 studies subsequently excluded as unrelated to the aim and research questions formulated during the literature review. Ultimately, 14 related articles were identified to be used in the literature review – 12 related to the use of AR and two more that investigated the combined use of AR and virtual reality, which were incorporated because the AR component was deemed to be seminal enough to justify their inclusion in the literature review. The results of this literature review are presented in detail in the related study by Tripoulas and Koutromanos [43].

Analysis and study of the existing print and digital instructional content. The analysis and study of the existing print and digital instructional content regarding the teaching of Greek History was conducted to determine students' knowledge in this subject matter and formulate the objectives and requirements for the design and development of the application in question. Similar practices were adopted by Moore et al. [44], where examples for the teaching of STEM were analyzed with the help of experts in this field.

Investigating the views of teachers, students, and parents through interviews. 7 teachers, 6 students, and 10 parents were interviewed to investigate their knowledge of Classical Athens, as well as their knowledge and attitudes on the use of AR to teach about this era. This practice was implemented in related studies involving AR [38, 45] using interviews with developers and teachers to identify important pedagogical aspects or to review the subject matter. These interviews were conducted between April and May 2024 in the New York City area and the open-ended questions were formulated following discussion and collaboration with experts in Education and ICT. The respondents were Greeks living abroad, who were either born in Greece and subsequently migrated or born abroad. All respondents were bilingual, speaking English fluently, with varying levels of proficiency in Greek.

3.2 Design and Development of the Application

Learning theories and design of the application. The design of the application in question will be based on the learning theory of constructivism, according to which learning environments must support diverse viewpoints and perceptions of reality, the construction of knowledge, and activities that are rich in context and empirically based [46]. A number of researchers have noted that the principles of constructivism coincide with the efficient use of AR and can effectively contribute to connecting new knowledge with prior knowledge. Similar studies on the use

7of AR in education were based on the theories of constructivism and situated learning, [47–49], social constructivism [50] and constructivism combined with active learning [38].

Design principles for the development of the application. The design and development of the application will be guided by the following design principles: coherence, multimedia, spatial contiguity, temporal contiguity, and transferring control of learning to the student [51]. It will also adhere to recommended design principles for the development of AR learning environments and streamlined classroom orchestration [52] such as the principles of: a) integration, securing the smooth introduction of activities into the workflow, b) empowerment, where the teacher acts as the facilitator, c) flexibility, which enables the adjustment of activities according to the development of the learning scenario, and d) minimalism, where the environment is not overloaded with excessive information.

Software program for the design of the application. The application will be designed using the software platform Vuforia Engine (https://developer.vuforia.com/) and will be available on both iOS and Android mobile devices. This platform adds advanced functionality to any application, enabling the recognition of images and objects, as well as interaction with real settings.

3.3 Evaluation of the Prototype

The evaluation of the prototype will follow, using heuristic, formative, and summative evaluation on the sample of students of Greek descent living abroad, as well as on teachers serving in Greek parochial schools.

Heuristic and formative evaluation. During the design phase (Phase 2 of DBR), an heuristic and formative evaluation regarding the ease of use of the application using the Technology Acceptance Model (TAM) [53] will be conducted. Moreover, data will be collected via interviews with students, teachers, and parents, as well as through the observation of working groups. The necessary revisions to the application will take place following an analysis of the responses. Similar methods have been used by researchers in the field of AR, where a heuristic evaluation of the software was conducted by teachers and students [47, 48], as well as by small student groups that participated in discussions and filled out anonymous questionnaires [54]. In addition, evaluations were conducted by experts [39] and feedback was provided by designers, researchers, and teachers [55].

Evaluation of the application's impact on learning and motivation. Following the design of the application, a sample of students of Greek descent from the U.S., Great Britain, Sweden, South Africa, and Germany (note: nations with a large ethnic Greeks population) will interact with it over a duration of time to determine if its use impacted their learning outcomes and motivation regarding Ancient Greek History. To examine the AR application's impact on learning, data will be collected regarding students' a) knowledge of Ancient Greek History, b) attitudes about this subject, c) motivation to continue studying this topic, d) factors affecting the application's use in Greek parochial schools. When evaluating the impact of the use of AR applications, previous studies featured instruments, such as questionnaires, that sought feedback for each phase of the application's development [38], interviews and questionnaires [55], a quasi-experimental study featuring pre- and post-tests related to students' interaction with AR under the oversight of experienced teachers [54], observations based on audio-visual materials, pre- and post-questionnaires, semi-structured interviews, and log data [39].

4 Results

4.1 Literature Review

Phase 1 of the DBR framework associated with this ongoing study – the analysis of the problem – has been completed. As previously mentioned, a comprehensive literature review resulted in the identification of 14 related studies. Approximately one–third of the studies had no references to learning theories or pedagogical backgrounds, while learning outcomes included increased student comprehension, motivation, enjoyment, and positive attitudes. More insight is needed to inform understanding of the most popular devices and environments where AR is used for History learning to benefit existing and future pedagogical practices.

4.2 Review of Educational Materials and Comparison of Curricula

Existing print and digital instructional texts were examined to provide a better understanding of the teaching materials currently in use. Furthermore, History curricula from several countries, including Greece, the United States, Australia, England, and Canada were also reviewed. During this stage of Phase 1, a comparison of learning standards for different grade levels was conducted. It was determined that the sample for this research would be limited to the primary school students – specifically 4th graders. This decision was adopted in part due to the findings of the literature review, interviews with teachers and other experts, and an analysis of the curricula. Specifically, in the analytic program of the Greek Ministry of Education, the period of Classical Greece is first introduced to students in Grade 4. Greek schools operating in the Diaspora follow this same sequencing.

4.3 Interviews with Educators, Parents, and Students

The final stage in Phase I involved open-ended interviews with teachers, parents, and students. All seven teachers interviewed worked in either Greek parochial or charter schools in New York City. It is noteworthy that these educators differed on whether their students are knowledgeable about Classical Athens. Keywords they cited include the Parthenon, famous figures from that era, institutions, wars, archaeology, and comparisons between the classical era and today. Teachers agreed that the application should be available from the lowest possible grade, and that it should be bilingual, featuring both English and Greek. They expressed support for all the proposed multimedia features, while adding that text should be limited or augmented through narration. Although their knowledge of AR was limited, they agreed that it has the potential to boost student interest and motivation.

All 10 parents who were interviewed sent their children to Greek parochial schools. Most parents were somewhat knowledgeable about Classical Athens and its era. Among the keywords they noted were ancient philosophers, Pericles, agora, democracy, 12 gods of Olympus, arts, sciences. A common theme was that parents thought it was important to connect Classical Greece's legacy and achievements with today's world. Although they consider digital instruction ancillary, they expect that it will have positive results on learning outcomes, as well as student motivation and attitudes. Most parents did not possess adequate knowledge of AR, however, when explained to them, they noted that the application should include references to philosophy, culture, historical figures and events, architecture, and daily life from that era. Most parents prefer the application to be available in both Greek and English, while agreeing with the proposed multimedia features. Another theme that emerged was that the application should have limited text to avoid overload, as well as cognitive overload among users.

Finally, 6 students attending Greek parochial schools were also interviewed. All the students have visited Greece before, but only half have stayed in Athens or visited historical sites there. Keywords emerging from these interviews are the Parthenon, democracy, ancient philosophers, economy, and military. Most students stated they enjoy the subject of History and are open to visiting classical era historical sites in Athens or museum exhibitions from that period on display in their cities. Another finding was that most students agreed that learning about Classical Athens would increase their pride in their Greek heritage. Although not familiar with AR, the majority of students stated that they wanted to try the application, and all agreed it should be available in both Greek and English, while remarking that learning about the history of Classical Athens would increase their motivation.

Following an analysis of the interviews, related instructional texts and curricula on History, and the results of the literature review, Phase II of the DBR process is now underway. As mentioned earlier, the target audience has now been identified as Grade 4 students. The application itself will concentrate on two elements that are synonymous with Classical Athens – the Agora and the Parthenon.

The Agora was chosen as the quintessential nexus of many of the keywords identified in the interviews and curricula. Through AR interventions, students will be introduced to the institutions of direct democracy as practiced in Classical Athens. The available multimedia will showcase historical figures from that era, while also offering a glimpse into the daily lives of the city's residents. Many of the accompanying achievements in the arts and letters will also be highlighted through an augmented tour of the Agora.

Likewise, the Parthenon was chosen as the symbol par excellence of Classical Athens. This world-famous historical monument provides authentic opportunities to study its architectural importance, as well as its cultural, political, and social significance. Students will learn about the impetus behind its construction, the historical figures associated with it, and other significant features (e.g., association with Athens' military supremacy, the philosophical and political backdrop informing its design, etc.)

5 Conclusions and Next Steps

Through this extended abstract, the preliminary data associated with an ongoing study on the design, development, and evaluation of an AR application for the teaching of Greek History to students of Greek descent living abroad

– specifically, the history of Classical Athens – was presented based on the DBR methodology. According to Phase 1 of the DBR framework, a gap in the research was identified and the need to satisfy it was detailed. The historical period of Classical Athens is an integral part of Greek History and can play an important role in shaping the identity of students of Greek descent living abroad, as well as cultivating their appreciation of Greek History.

Next steps involve designing the proposed AR application in accordance with the learning theory of constructivism and principles of design (collaborative learning, inquiry learning, problem solving) applicable to both AR-based learning and the subject of History. Once this application is designed, it will undergo iterations of heuristic and formative evaluation to improve its functionality, followed by an evaluation to examine its impact on student learning outcomes in terms of improved student academic achievement, favorable changes in student attitudes, increased student motivation to study the subject area, and positive impact on students' Hellenic identity.

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