

A Mobile Augmented Reality Application for Primary School's History

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Abstract: *Technological developments of recent years can provide the ability to use innovative techniques and tools in education. One of these useful tools is Augmented Reality, a technology that enables users to enrich the real world with virtual content. This paper presents the development of a mobile augmented reality application for primary education in order to make history course a more interactive and joyful experience. By combining the traditional school book with AR technology, physical images come to life and give more information about specific historical events or figures related to the Persian Wars, accompanied from a Quiz test that each student has to answer. Furthermore, a pilot study was conducted, in order to examine the educational performance of the application under real conditions. Further research may be focused in examining the expansion of such technologies in secondary and higher education situations (e.g. physics, biology), where traditional teaching methods do not manage to create a concrete base of knowledge due to the low level of experiential learning.*

I. Introduction

Education of the 21st century can provide a wide variety of tools that lead towards the achievement of better results. Traditional teaching methods, such as face-to-face instructions, along with some socio-cultural beliefs jointly shape an educational procedure where everything is controlled by the teacher (Nincarean, Alia, Halim, & Rahman, 2013). These educational systems are often described as monotonous, since they do not offer many possibilities for enhancing students' creativity (Tomi & Rambli, 2013). One of the most recent technological advances that could be used as creativity promoting educational tool is Augmented Reality (AR), a technology that enables users to see and experience the real world mixed with various virtual objects, without losing the sense of reality (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013). The use of AR in education can transform school environment to a more technology friendly one, with a bigger variety of opportunities of learning for students (Kerawalla, Luckin, Seljeflot, & Woolard, 2006). According to researchers the use of AR can increase the level of participation, understanding and learning, three key elements of all educational systems' targets (Nincarean et al., 2013). Since the Information Technology (IT) tools have already been implemented in school class, the incorporation of AR in education is something that can be accomplished easier, as students are familiar with handling IT devices (Chiu, DeJaegher, & Chao, 2015). In this paper the basic characteristics of AR are presented. Also it is described the development of a mobile application with the use of AR for increasing content comprehension and learner's engagement and finally the results of a pilot study were the application was tested.

II. Augmented Reality

According to Cuendet et al., "Augmented reality refers to technologies that project digital materials onto real world objects. This definition suits a large spectrum of technologies that range from a pure virtual environment to the real environment." (Cuendet et al., 2013). Under the light of this statement, AR applications and systems should satisfy most or all of the below mentioned properties (Roesner, Denning, Newell, Kohno, & Calo, 2014):

- Sense properties about the real world.
- Process in real time.
- Output information to the user, including via visual, audio, and haptic means, often overlaid on the user's perception of the real world.
- Provide contextual information.
- Recognize and track real-world objects.
- Be mobile or wearable.

Some of the most popular development tools and stand-alone development platforms in order to create AR applications are listed below.

2.1 AR Browsers

Junaio

A famous AR browser created from *Metaio Company*, is *Junaio*. It can be used from mobile phones that support 3G and 4G applications. Designers, with the use of an API, are able to create applications that can upload to special channels of *Metaio Cloud*, where user have access. In order to do so they have to be able to produce XML codes. An important element of *Junaio* is the innovation that presented, since it's the first AR browser that manage to overcome the boundaries of accuracy due to GPS, with the use of LLA markers (latitude, longitude and altitude markers). It also allows the use of QR codes, barcodes and 3D objects. Both the smartphone application and the API can be free downloaded from Android and iOS devices (Bieringa, 2011; "Junaio," ; *Metaio*). *Junaio* was used at *La Laguna University (Spain)*, from the *Maritime Engineering Department* for an AR project in Chemistry practice (Luis, Mellado, & Díaz, 2013).

Layar

The AR browser *Layar* was developed from *Layar Company* that belongs to *Blippar Group*. This browser allows users to get in contact with AR objects. It uses the following device features: accelerometer, build-in camera, compass and GPS, in order to identify the location and the landscape where the user is. As soon as the identification is achieved, AR data are presented in the device's screen like layers of the image. After the user downloads for free the application, can have access to the browser data which are created from third parties which use a free API in order to upload them. The basic features of *Layar* are the use of 3D objects, animation and geolayers (information related to location), proximity triggers, audio and authentication (creation of personal network) ("Business Location," ; "Layar, "). *Layar* was used from *Fu-Jen University (Taiwan)* for a mobile campus touring system (Chou & ChanLin, 2012).

2.2 AR Development Tools

ARToolKit

ARToolKit was created in 1999 from the University of Washington. It is a computer tracking library in which user has the ability to create AR applications. The development of AR is based on the calculation of the camera's real position and orientation. Once this happens, computer markers are created which overlay the real marker. It comprises the following features: single camera position/orientation tracking, tracking code, use of square marker patterns, camera calibration code and fast response in real time AR applications. *ARToolKit* is a free and open source tool that is really popular in education. In order to be able the creation of AR applications without programming skills, *ARToolKit* can be combined with *ATOMIC Authoring Tool* ("ARToolKit," ; SourceForge). Some examples of *ARToolKit*'s educational use are: teaching primary school science with AR (London), library instruction in elementary schools via AR (Taipei) and AR application in chemistry course at junior high school students (Shenzhen, China) (Cai, Wang, & Chiang, 2014; Chen & Tsai, 2012; Kerawalla et al., 2006).

BuildAR

BuildAR is a program that allows users to create AR applications with 3D objects and videos. It uses a marker-based tracking where 3D models lay on physical markers that the user has designed. It is widely used for education, entertainment, marketing and architecture. Some of its basic features are: the ability to upload 3D models and digital objects, location identification, use of real markers, scaling models, tracking patterns (GPS), videos (embedded YouTube), sounds and other dynamic content and the ability of instant translation and rotation ("buildAR," ; Dunleavy & Dede, 2014). It has been used for vocabulary teaching applications, simulations of the solar system and other educational purposes (Ramirez, 2013; Slijepcevic, 2014).

2.3 AR Platforms

ARlearn

ARlearn was created from the Open University of Holland as an AR tool for educators and learners. It supports mobile serious games and can be used for many projects, e.g. organization of a school trip or for the creation of a simple logic game for mobile phones. It is open and free but can only be used from Android devices. Also, with the use of the web based authoring tool someone is enabled to create his own games. As a platform, *ARlearn*, can support two types of games, games with messages in a list view and viewmap games. It provides four types of media objects (video, sound, narrative and multiple choice questions), map based positioning of media objects, a notification framework and the ability to download games to PC in order to be reused (Classroomaid, 2013; Open_University_of_Netherlands). Several projects have been made where *ARlearn* was used as an education tool. Some of these projects are: The *ELENA* project and "*Elena goes shopping*" mobile game for e-learning of languages from young children (4-6 years old) and the "*Emurgency*" program for decision and behavior training for cardiac arrest (Open_University_of_Netherlands).

Aurasma

Aurasma is an AR platform that was created in 2011 in Cambridge by *Autonomy*. It can be downloaded as an application or as SDK from iOS and Android devices. With image recognition, Aurasma provides the ability to overlay data over identified images. These data can be videos, images or informations. It is one of the most famous AR platforms for educational use. In conclusion, Aurasma provides the above functions: use of digital objects and 3D models, embedded YouTube and dynamic triggers(Aurasma; "Aurasma Review," 2013).Some examples are the Shaw Wood Primary School in Doncaster (UK) and Northwest High School in Texas (USA) where Aurasma is used in classroom in order to aid learning and cooperation between students(Aurasma, 2012; Cooper, 2013).

III. Purpose of the Application

Since AR is considered to be a relatively new technology, its incorporation in education is in a quite embryonic stage, but experimentation has led scientist to its application on primary, secondary education and higher education institutions in order to conclude whether it is really going to help students(Kerawalla et al., 2006).The present experimental approach consists an effort of applying AR in a primary education class, in order to prove whether it can achieve a better level of engaging, motivating and supporting the creativity of students and also increase the level of content comprehension. It must be noted that the purpose of the designed application is not to abandon nor the teacher or the school book, but reinforce them with a technology that can provide an interactive learning environment which can turn passive students into active learners(Tomi & Rambli, 2013).

IV. Design of the Application

The current paper was an effort to apply AR in the educational procedure via the history of the fourth grade of primary school, for increasing content comprehension and learner's engagement (Th. Katsoulakos, I. Karioti, M. Lena, & Katsarou). History is considered a theoretical course and with this application it is aimed to create a more interactive content for the children, using the existing course material with no additional cost. The cognitive abilities of young students (e.g. mentally combine,separate, order, and transform objects and actions,conserve mass and area, apply logic reason and thought-out strategies etc) were taken into account during the development procedure.(Anthony)



Figure 1: Schematic representation of the application.

In Figure 2 the application's flowchart is presented.

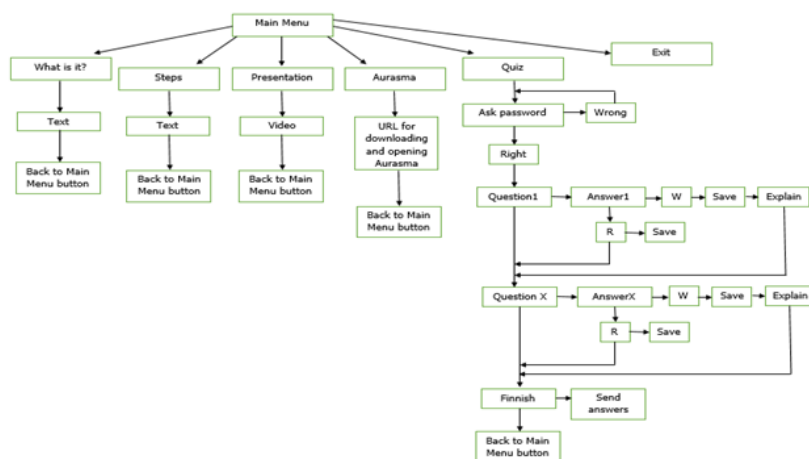


Figure 2: The application's flowchart.

The application is initiated via a *Main Menu* and six buttons which trigger different actions accordingly. These buttons are:

- *What is it?:* When the user presses this button a new screen will be opened and information related to the purpose of the application will be viewed.
- *Steps:* This button will provide the guidelines for the user in order for him to use the application successfully.
- *Presentation:* The *Presentation* button leads to a new screen where a video is uploaded that shows briefly how to use the Aurasma feature.
- *Aurasma:* When this button is pressed the application opens the Google Play URL which is uploaded and gives the user the ability, at first, to download the Aurasma application and afterwards to open it.
- *Quiz:* This is the most complicated button that leads to the Quiz test. For this its use will be presented in more detail in the next paragraph.
- *Exit:* The last button will give users the opportunity to immediately close the application.

The most complicated feature of the application was the Quiz, since it is a small game that provides the ability to evaluate the results of the use of AR during a history chapter. When pressing this button each user will have to type his personal password in order to enter the quiz. This is used in order to achieve a personal “test” for each user. After a successful log in the student has to answer a set of multiple choice questions in a form of a Quiz and utilizing the additional content related into via AR application to test and evaluate his/hers progress as regards to the content comprehension.

4.1 Development Tools

Another important aspect of the designing procedure is the choice of the development programs. For the development of this application two different tools were needed, one for the creation of the AR content and one for the smartphone/tablet application.

4.1.1 PART 1-AR Development

Since the present project aims to use AR as an educational tool and there are some limitations from the writer's side related to programming skills, the platform that has been chosen is Aurasma. It comprises an easy to use environment that does not require programming skills, something that can make easier the extended use of AR from teachers at schools. Also it is easy for a child to get familiar and use the Aurasma application, as it only has to scan images with a tablet or a smartphone. More specifically Aurasma is comprised from two different applications, “Aurasma Studio” where a user is able, after creating a free account, to view and create his own private or public “auras” and Aurasma “Viewer” which enables following various channels and having access to AR features (Aurasma; Autonomy). As a result was believed that it can provide a greater variety of options for educational material. This material can be videos of great battles or information related to generals and politicians

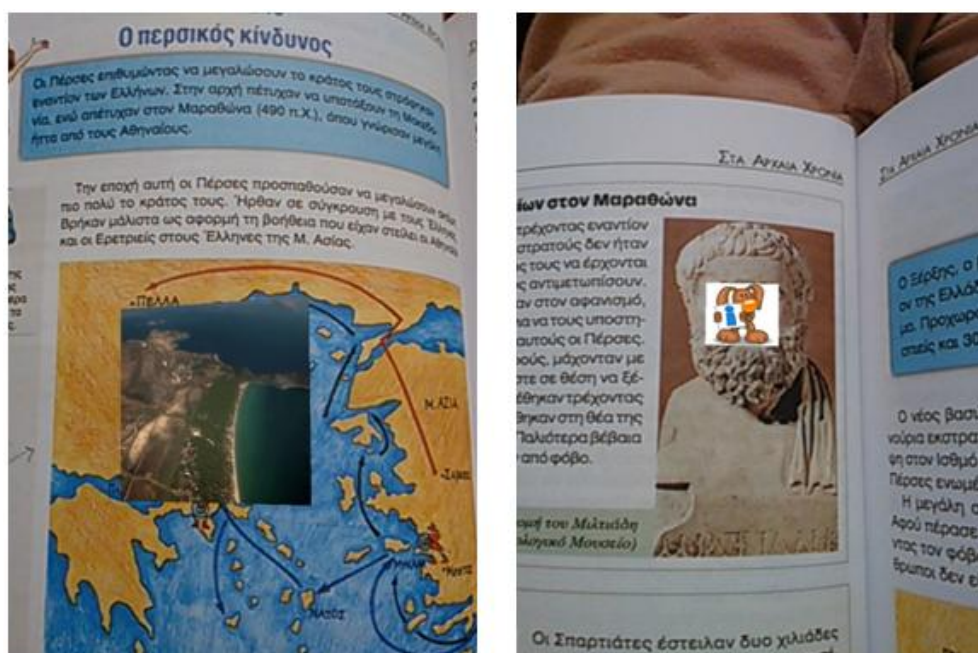


Figure 3: The AR content combined with the school book

4.1.2 PART 2-Mobile Application Development

The platform that has been chosen for creating the mobile application is MIT App Inventor 2. This platform enables the user to create mobile applications without any programming skills. It uses a *Lego* logic where different components are chosen and then can be combined in order to produce a program. It can enable the creation of offline and online applications that may embed pictures, sounds videos and also connection with social networks as Twitter, Facebook and e-mail accounts. The creator is able to develop his application according to his needs both in visual and technical level. Via *MIT AI Companion* creators can check the exact appearance of the application in a smartphone/tablet, also it enables users to download their application and store it in their devices. The biggest advantage of this platform is the fact that the application can be created without programming knowledge and without sacrificing important aspects of the initial thought. (Abelson & MIT, 2014)

V. Development of the Mobile Application

Main purpose of this chapter is the short presentation of the development of the application. This will be performed via images of the application's basic features from the *MIT App Inventor 2* platform, both from the *Designer* and the *Blocks* features.



Figure 4: The Main Menu

The *Main Menu* of the application is parted from six buttons. Each button leads to a different event as it has been described in the flowchart. The background image was added from the internet. Also the font size and type were set by the designers. The *Quiz* screen is considered the most complicated as it contains many visible, non-visible and semi-visible components. Also it contains the quiz test. This is why this screen will be analyzed extensively, while the others will not be mentioned in this paper.



Figure 5: Designer and Components view of Quiz screen

Initially users see a *Password Textbox*, a *Submit* button and a *Go back to Main Menu* button. After entering the personal passwords, which are set by the designer, the *Password Textbox* and the *Submit* button disappear. Their place is taken by labels for the questions and feedback, an *Answer* button which shows the available answers, a *Next* button for going to the next question and a *Finish* button which is linked to a non-visible component called *Sharing*. This component enables the exchange of data between the user and the programmer. In this particular case this component was added for sending the answers of the user to the programmer for storage and long-term evaluation. The Quiz starts with the password acceptance. When the user clicks the *Submit* button, if the entered password is one of the two that the designer has defined then the *TableArrangement1*, which contains the *Password Textbox* and the *Submit* button disappears and the following features are visible: *Question* label, *Answer* button, *Next* button and *Finish* button. Also the *Question* label takes the price of the first element from the *questionList* variable and the *Answer* button leads to the first element of the *answerChoices* variable. This is due to the index variable which is initialized to one.

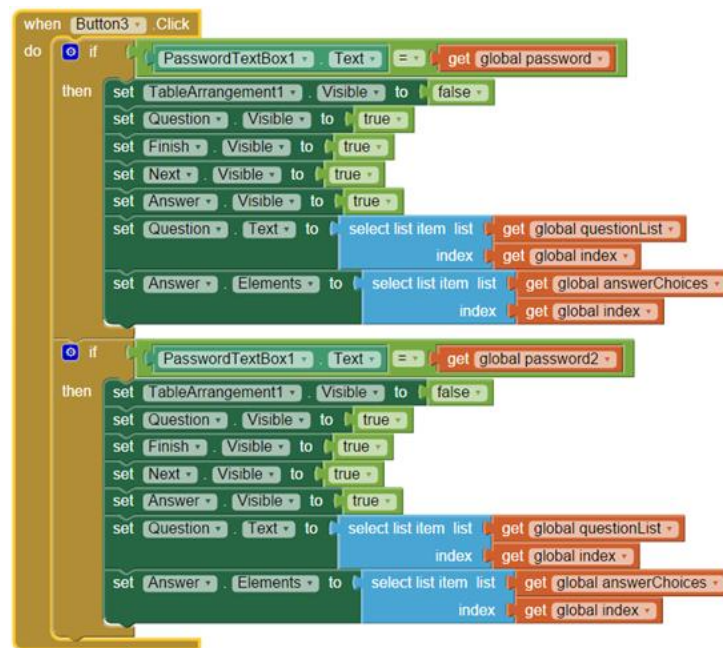


Figure 6: The first step of the Quiz


After the user has picked an answer the application saves it in a new empty list. Also it checks whether this answer is the correct or the wrong one. If it is correct the message Good Job! appears, while if it is wrong the application shows where the user can find the correct one (from the *explain* variable list). Finally, another important component of the application is the *Finish* button. This button is linked to the *Texting1* feature which enables users to send their quiz answers to a particular phone number (teacher's). In this case the selected phone number belongs to the designer. When this button is clicked, the initially empty message gets the price of the *list* variable which is the list of the quiz's answers. After that the message is sent to the designer.

VI. Pilot Testing

5.1 Experimental Procedure

In order to test the results of the use of the mobile application and the AR content, a pilot study was conducted. This study involved 30 students in 4th grade of primary school, including 13 boys and 17 girls. The experiment of the application's impact was conducted in a primary school in Kavala, Greece. This pilot study mainly focuses on the supplemental learning effect of AR-based learning tools in a history course. The testing class was taught the content of "The Persian Wars". Before starting the experiment, a small interview with the teacher took place. The teacher stated that students were not very motivated and did not completely comprehend the materials in this chapter, since they considered them boring. This is why she thought that an approach that combined technology could stimulate students' interest. Before the experiment, students were asked to bring a device (smartphone or tablet) for being able to run the application and have access to the AR content. The next step was to install the mobile application to each device. Afterwards the "Persian Wars" chapter was presented by the teacher and a few simple questions were asked in order to understand the content comprehension of the class. The next step, before the use of the application, was its brief

presentation from the teacher. After using the application the participants had to fill a questionnaire, in order to express their opinion about their experience. This questionnaire was consisted of 6 multiple choice questions, ranged from Yes to No and an open type question

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And finally, what would you change in the application?

Figure 7: The Questionnaire

(The questionnaire may also be found in Appendix 1.)

Finally, the teacher was briefly asked about the experience, and Quiz test's results were collected.

IV. Results and Discussion

The teacher's interview showed that she was impressed by the way that traditionally "boring" subject matter could become alive and joyful for children. Also she stated that AR increased students' content comprehension and led to a greater level of engagement. Furthermore, she pointed out that if AR was available to use in her classroom, she would use it as an additional tool since it is easy to use and does not require complex equipment or advanced programming skills and that the ability to collect Quiz's result could help her in keeping a record of each child's progress. Finally she liked the fact that students had to read the instructions and use the application without external help, something that encourages them to be more independent. On the other hand she said that there should be a way for pausing or stopping the animation. Results from the Quiz test indicate that the majority of the students was able to answer the questions with the help of the AR content. Also students said that it was easy to use and more enjoyable than "Just listening to the teacher". Figure 8 shows the results of the evaluation. Questions 1 to 3 depict the participants' opinion about the application from three points, entertainment-level of difficulty-level of engagement. The majority of the students stated that the application was indeed fun, easy to use and interesting. Question 4, which is related to the use of AR, shows that all participants are positively versed to its use, since only one student chose the *No* option. Finally, questions 5 and 6 may be considered the most important questions, since they reflect the general opinion of the students and whether they would like to use again the application. 100% of the participants stated that they liked the application and more than 90% of them showed that they would like to use it again. Finally answers from the open type question point out that improvements can be done that can make the use of the program more effective and enjoyable.

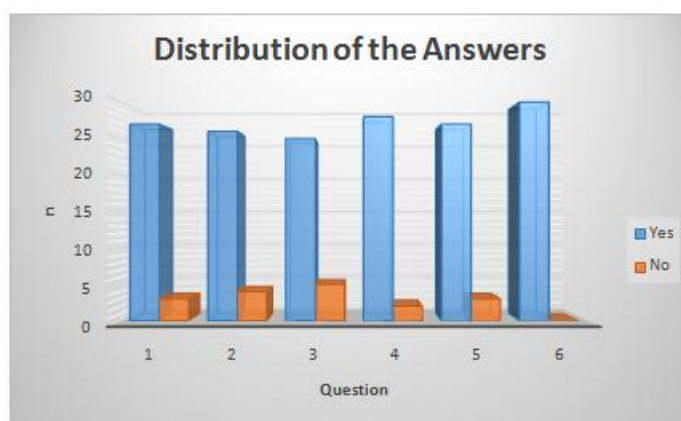


Figure 8: Distribution of the answers.

(Distribution of the answers according to gender can be found in Appendix 2.)

Table 2: Answers of the open type question.

| n | Answer |
|----|---|
| 1 | The videos could be more fun. |
| 2 | More images to scan. |
| 3 | I would like to play with AR. |
| 4 | A game would have been better than the quiz. |
| 5 | I liked the fact that quiz's questions were at the book, but I want more questions. |
| 6 | I would like it to have more videos. |
| 7 | The quiz was not fun. |
| 8 | It will be more fun with animated videos. |
| 9 | I want to play and not only answer questions. |
| 10 | I liked Persian Wars so I want more videos and not text. |
| 11 | I liked the videos, I want more information for the war. |
| 12 | I would like more fun stuff, like a mobile game. |
| 13 | It was slow. Maybe the internet had a problem. |
| 14 | I want more questions for the quiz. |
| 15 | I want more videos. |
| 16 | Sometimes the program takes too much time to load the AR content. |
| 17 | I like playing with my tablet, so a game with will be nice. |
| 18 | There are a few images to scan. |
| 19 | More videos. |
| 20 | More questions. |
| 21 | The videos were a little boring. |
| 22 | I didn't like the quiz. |
| 23 | The quiz was small. |
| 24 | Sometimes AR was slow. |
| 25 | The videos were small. |
| 26 | It would have been better if it was like a game. |
| 27 | War chapters are super. But the quiz was boring for me. |
| 28 | More questions for the quiz. |
| 29 | More videos and more images to scan. |
| 30 | More information for the war. |

V. Conclusions

Summarizing and in an effort to make a review of the present project and of the cognitive engagement field, it would be better if the features and benefits of the created program are the first to be presented. More analytically, regarding the application that was developed in the present paper, it may be mentioned that, according to the pilot test results, it is easy to use and offers users the ability to contact and familiarize with AR. In general, it is worth mentioning the fact that applications that follow the above mentioned path make educational procedure more interactive and reduce the monotony of an anachronistic teacher-centered model. One of the most important benefits that accompany the use of innovative technologies that use a preexisting database, is their ability to combine different systems-techniques. In the present case the traditional school book is not crowded but it is combined with new technologies. The application also provides teachers a more flexible way of immediate valuation, even from their own home. Noteworthy is the extension range of the used technology. It can be expanded to all school subjects since the Aurasma and MIT App Inventor 2 platforms are easy to use and with a little familiarization they can be used from the majority of educators. Finally, another important factor is the cost, where in this case, can be considered as low since specialized equipment is not required. The only needed equipment is a WiFi portable device with build on camera like a smartphone or a tablet.

Naturally as every technology or software, and especially new ones, the presented application has its weaknesses. It could be mentioned that: the application should be applied more widely for checking the validation of the initial results, the controller (teacher) must have a level of familiarity with MIT App Inventor 2, since he/she will be asked to insert the code of each student and his phone number (for the results' collection), students, when sending the results, are charged with the cost of an SMS and use of WiFi is necessary sending the results. Results from the pilot study indicate that the use of AR with a mobile application has positive effects over the educational procedure and that extended use of them could improve students' progress and participation. Of course, in an academic level science has a "continuum" and thus the background for the next researcher should always be provided. In the present case as "further research" it could be mentioned the further development of the range of AR examples and the creation of more valuation ways that do not refer to examination. Concluding, maybe the most important point is the extension of the method to people with learning difficulties and the personalization according to the needs of each student related to the method of recruiting knowledge

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APPENDIX 1

Program Evaluation "Persian Wars" App

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Gender: Boy Girl

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And finally, which feature of the program you liked the most?

APPENDIX 2

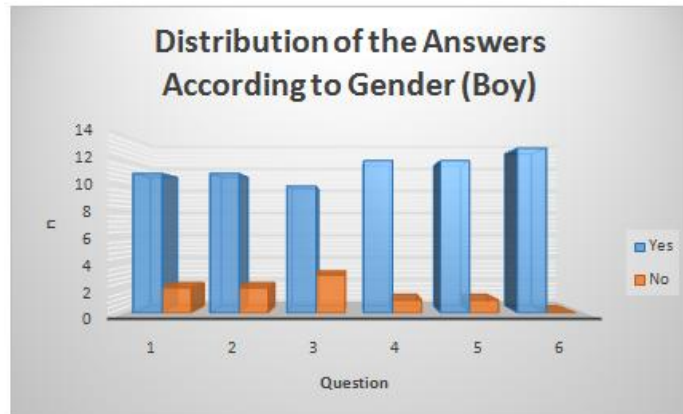


Figure 9: Distribution of the answers according to gender (boy).

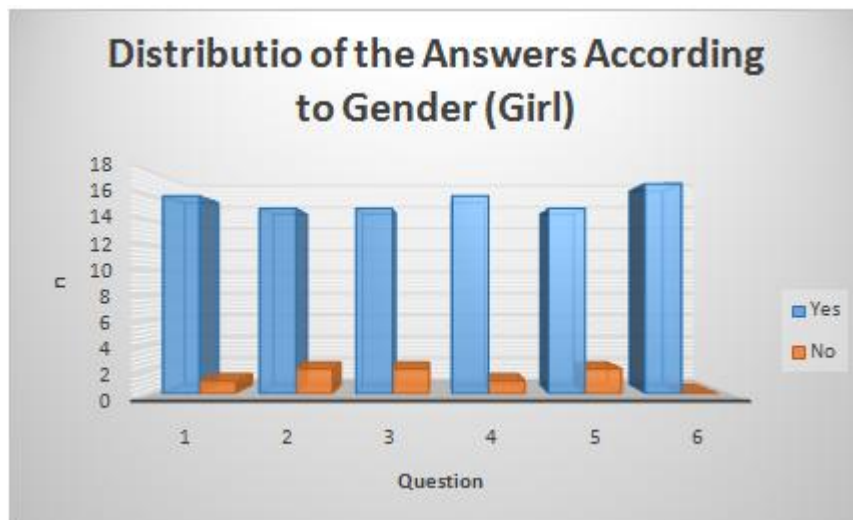


Figure 10: Distribution of the answers according to gender (girl).