Applying Augmented Reality in practical classes for engineering students

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Abstract. In this article the Augmented Reality application for teaching engineering students of electrical and technological specialties is introduced. In order to increase the motivation for learning and the independence of students, new practical guidelines on Augmented Reality were developed in the application to practical classes. During the application development, the authors used software such as Unity 3D and Vuforia. The Augmented Reality content consists of 3D-models, images and animations, which are superimposed on real objects, helping students to study specific tasks. A user who has a smartphone, a tablet PC, or Augmented Reality glasses can visualize on-screen virtual objects added to a real environment. Having analyzed the current situation in higher education: the learner's interest in studying, their satisfaction with the educational process, and the impact of the Augmented Reality application on students, a questionnaire was developed and offered to students; the study involved 24 learners.

1. Introduction

According to the New Media Consortium's 2011 Horizon Report [1], Augmented Reality (AR) is a nascent field in higher education; a combination of virtual and real technologies is expected to be used in education. In the near future this technology will be widely used, as evidenced by the annual growth of scientific publications devoted to this topic. Many aspects of the augmented reality are discussed at numerous congresses and conferences, where progress and achievements in this field are demonstrated and evaluated by scientists and specialists.

This article shows an example of the developed mobile AR application and explores the possibility of applying AR technology to practical classes for engineering students, how the training material, based on the technology of augmented reality, helps students in the study of engineering. During the use of this application, virtual models appear on the front panels of the training system (the superimpose process is described below). With the AR app, the process of studying the appearance of the training system elements and their description becomes more interesting. This technology allows one to learn step-by-step the functional scheme of the training system and also helps in carrying out the practical training. Figure 1 shows the process of the Augmented Reality appearance. The Augmented Reality is a real world, which is "completed" by the virtual elements.

The work begins with the camera initialization, the video stream request and the allocation of the frame out of the stream. Then, the necessary image, particularly the QR-code, needs to be found. When the code is found, the information is being exported. After this, the application sends a request to the data base in order to find the right object. Next, the information is being out over the frame.

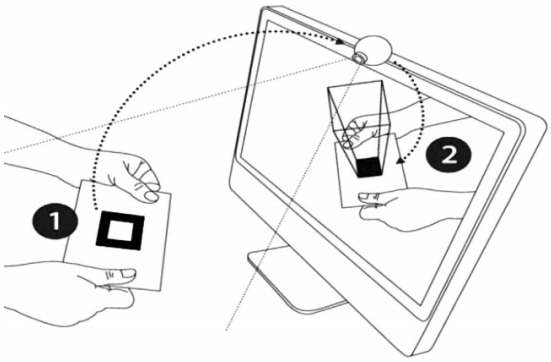

Figure 1. The process of the Augmented Reality appearance

2. Topology of the system

Students, who study at the university, in communication, work and leisure are accustomed to using the latest generation of devices and technologies. All technological progress allows using innovative educational tools in education, thus causing significant changes in educational methods and student methods of teaching. AR in education is a nascent field; the article analyzes how this technology will affect academic performance and stimulate students' motivation to a learning process. Based on the hypothesis that the teaching material, incorporating the AR technology, will contribute to the growth of motivation and performance of learners, a new teaching material was developed by using AR technologies to explain the training system elements, principles of their work and to help students to carry out the practical trainings. Figure 2 shows the topology of the system. It is assumed that the results of this work will allow students, who study at engineering departments, to acquire higher academic results and to increase their motivation for learning when a new generation of technological tools will be integrated into the educational process.

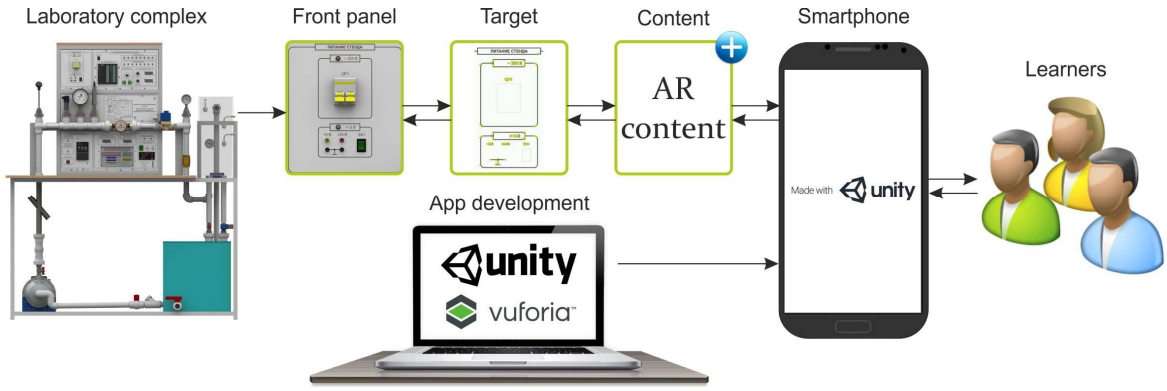

Figure 2. The topology of the system

The main purpose of the mobile app is the development of an innovative AR system that allows students to be trained using the complex in an interesting and understandable form. This technology is a special one, because it allows one to carry out training in the way as if users have real objects in their hands.

The combination of AR technologies with learning subjects creates a new type of automated application for increasing the effectiveness and attractiveness of students' learning and their knowledge in a real life. This technology provides an easy way to make progress in teaching and learning. The advantages mentioned above contribute to "active" learning, both in the psychological and in the physical sense, whereby the trainees are able to have several thinking prospects that should properly activate their daily activities.

Therefore, one of the main requirements for this complex is to ensure the interactivity of the

educational process through the introduction of AR technologies:

- assistance in conducting practical trainings;
- detailed description of the training system elements;
- step-by-step explanation of working principles of the training system according to the functional scheme.

3. Prerequisites for using AR technologies in education

Higher education, or higher vocational education is the level of vocational education, following the secondary general or vocational education. It includes a set of systematic knowledge and practical skills that allow solving theoretical and practical problems in the professional sphere, using and creatively developing modern achievements of science, technology and culture. The term "higher education" also refers to the training of highly qualified specialists for sectors of the economy, science, technology and culture in various types of higher schools [2].

Training systems are an essential component in the training of specialists studying at engineering deparments (see figure 2). They allow students to get acquainted with the industrial equipment, which they will meet in the industry later.

Training systems include didactic material, which contains summarized theoretical knowledge of the course sections, description of practical trainings, as well as the procedure for connecting and working with the stand. In most cases, the didactic material is carried out in paper form. According to them, learners prepare the stand for practical training, assemble the schemes of experiments and consistently perform practical training. This kind of work with paper takes a lot of student’s time and often is not very convenient.

From the above-mentioned, one can conclude that training systems are necessary in the educational process, but require new techniques in our work with them. Significant results in this area can be achieved due to the technology of Augmented Reality. For the functioning of AR app, it is enough to have a standard camera and a mobile device graphics chip. Also, it is possible to use specialized hardware and software. Most of them are a headset that extends the capabilities of a smartphone, such as Google Glass. However, there are also devices that can function independently, for example, Microsoft HoloLens. By adding a mobile phone to the training system, the work process becomes more visual, interactive and understandable.

4. Software Development

Unity3d is a modern cross-platform engine for creating games and applications developed by Unity Technologies. Using this engine, one can develop not only applications for computers, but also for mobile devices (iOS, Android), game consoles, etc. Firstly, it is worth emphasizing that the game engine is integrated into the Unity environment, which makes it possible to test the application in the editor itself. Secondly, Unity supports import of a wide variety of formats, which allows one to develop imported objects in a more convenient application, and Unity is used for its intended purpose - product development. Thirdly, when writing scripts, popular programming languages are used - C# and JavaScript (the authors used C#).

Vuforia is a AR Platform and a Software Development Kit (SDK) for mobile devices developed by Qualcomm.

AR technology is applicable for educational and entertainment purposes, or just "edutainment" [3, 4], and it also has a huge potential for the educational sphere. In addition, it can serve as an example of the developed application and how this technology can help the learner.

- Functional scheme

It is rather difficult to understand a scheme that initially contains a large number of elements. It is much easier to learn these elements step-by-step. For this, one needs to direct his camera of the mobile device to the central stand's panel. As a result, the functional scheme will be displayed in the form of AR elements (figure 3).

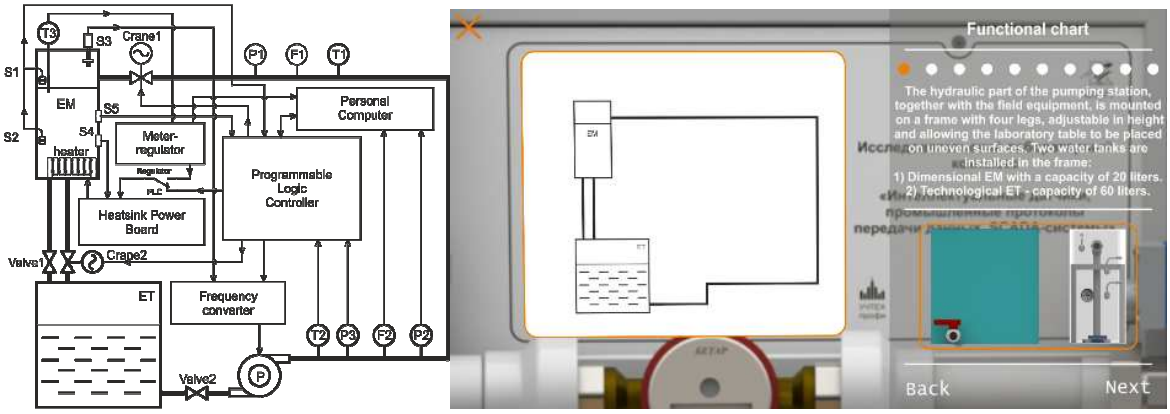

Figure 3. The functional scheme

- A description of the stand elements

This section displays a list of the training system elements, when one selects any of these devices. On the right screen side, its description is displayed. Next, one should direct the mobile device camera to the central stand's panel. As a result, the virtual object with animation will be superimposed on it; the object rotates clockwise around the vertical axis. Due to it, one can study the object from all sides (figure 4).

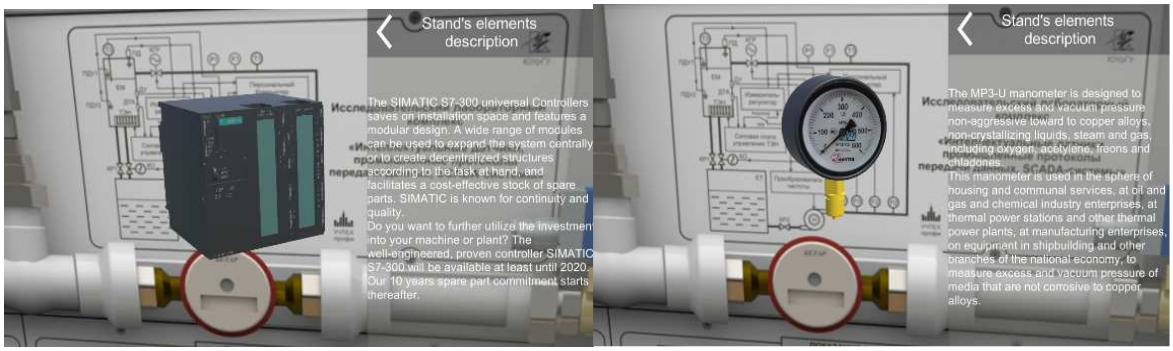

Figure 4. The description of the stand elements

- The initial state of the training system

All the elements of this section (tumblers, switches, buttons, etc.) contain animation elements, indicating in which position they need to be switched to install the stand into the initial state - this must be done when starting a new practical training. In addition, if one turns the mobile device camera to the training system's central panel, then it displays a "pointer" and highlights the area in which one should send the mobile device camera (figure 5).

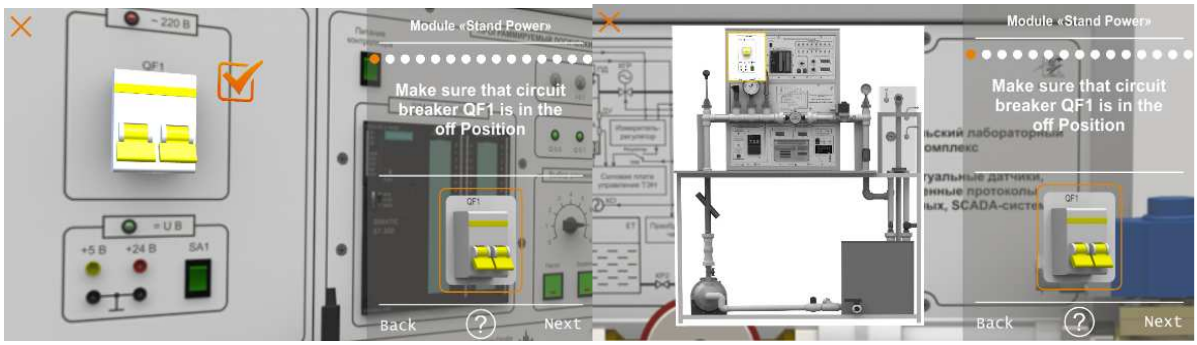

Figure 5. The initial state of the training system

5. Analysis of the completed modernization

To analyze the current situation in higher education, the degree of student's interest in training, overall satisfaction with the educational process, and the impact of the AR app on students, a questionnaire was prepared and offered to 24 students. They were offered 15 questions, concerning their motivation for learning, general impression and satisfaction with higher education, with the following answers: "Totally agree", "Agree", "Disagree", "Totally disagree", "Neither agree nor disagree". After answering these questions, a group of students had the opportunity to become acquainted with the AR technology, with its idea of applying in higher education. The AR app [5], which is also considered in this article, was provided as an example. Further, students had to imagine that now they are trained through the AR technology and to respond again to the same 15 questions.

Some of the questions were constructed in such way that if a person is satisfied with the educational process, then he expressed his agreement (A. Express your agreement, figure 6). The other part of the questions implied "disagreement", in case of satisfaction with the educational process (B. Express your disagreement figure 6). Table 1 shows examples of questions.

Table 1. Examples of questions.

Express your agreement	Express your disagreement
1) I find that from time to time, the learning process gives me a feeling of deep personal satisfaction	1) I do not consider my course very interesting, so I try to do as little work as possible on my subject
2) I work a lot on my studies, because I find the material interesting	2) Usually, I limit my research to what is specifically established, because I think that there is no need to do anything superfluous
3) I feel that almost any topic can be very interesting, when I immerse in it	3) In my opinion, there is no point in going deep into topics, it takes most of my time
4) I am satisfied with the methodology of conducting our classes and I would not like to change anything in it	4) I think that teachers should not expect that students will spend a significant amount of time studying materials that, as is known, will not be put on the exam

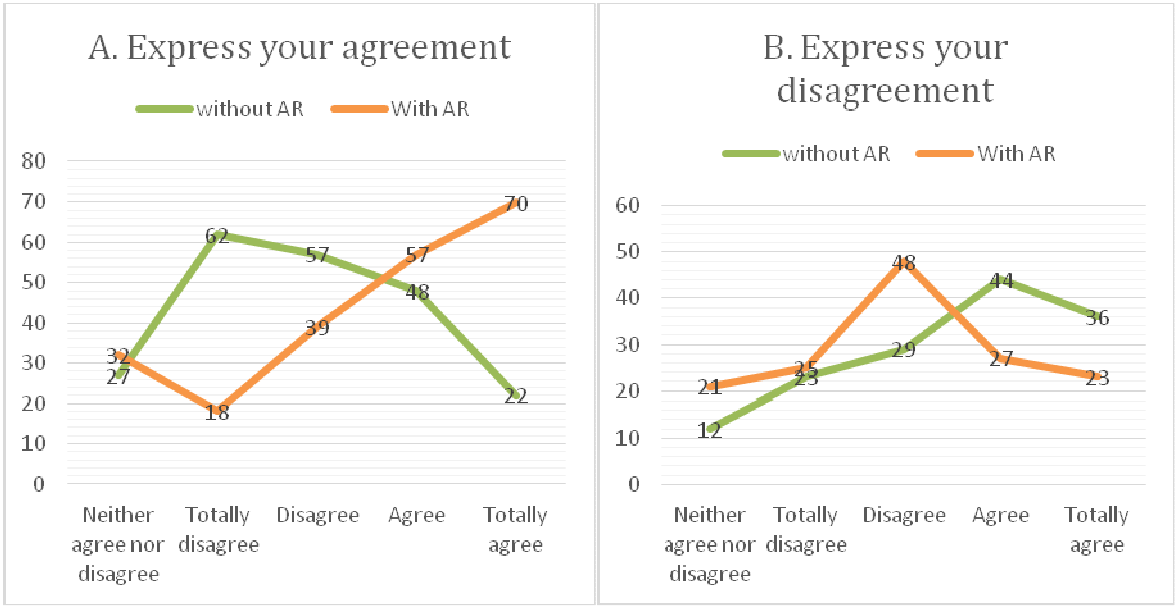

Figure 6. Analysis of students' answers

The analysis of the general impression shows that the majority of students expressed a positive attitude toward this AR technology. As a result, their motivation has increased, as well as their satisfac-

tion with the learning process, which leads to the conclusion that this technology provides an easy way to achieve progress in the field of teaching and learning.

6. Conclusion

The development and implementation of communication and information technologies, both in the public sphere of activity and in the learning environment, is an integral part of the modern world. Significant changes affect each area of activity, and education is no exception. These technologies are introduced as a need, contributing to the improvement of knowledge and requirements for changing education at a higher level. Before integration of innovative technologies in education, the most common method of teaching was direct interaction between teachers and students in the classroom through their attendance. This method is valid now and has proved its effectiveness. But educational institutions are interested in introducing more productive methods for improving learning interaction and increasing the level of information understanding and acquisition by learners. Computer technology has significantly improved these methods.

The AR app allows saving the teacher's time for repeating the explanations; repetitions can be performed by the learner himself using the mobile app. Students tend to show sympathy and affection for this technology, so that they can be motivated in using it. AR is an economically effective technology, it provides students with more attractive and demonstrative content than paper didactic material.

Studies carried out in this sphere have made it possible to develop new educational didactic material. The mobile app materials include AR information intended for carrying out practical training and studying the stand elements. Thus, it becomes possible to compare the methods of education before and after, as well as to evaluate the positive and negative aspects of this training material in relation to the student’s knowledge and motivation in relation to standard didactic materials. Students are comfortable working with the components of 3D graphics; in addition, the mobile AR application is an intuitive program that does not require additional study.

7. Acknowledgments

The work was supported by Act 211 of the Russian Federation Government, contract No. 02.A03.21.0011

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