Augmented Reality Tools in Physics Training at Higher Technical Educational Institutions

Tetiana V. Hruntova[0000-0001-6775-6361], Yuliia V. Yechkalo[0000-0002-0164-8365], Andrii M. Striuk[0000-0001-9240-1976] and Andrey V. Pikilnyak[0000-0003-0898-4756]

State Institution of Higher Education "Kryvyi Rih National University",
11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
{tatianagru, uliaechk, andrey.n.stryuk, pikilnyak}@gmail.com

Abstract. *Research goal:* the research is aimed at theoretical substantiation of applying the augmented reality technology and its peculiarities at higher technical educational institutions. *Research objectives:* the research is to solve the problems of determining the role and place of the technology in the educational process and its possible application to physics training. *Object of research*: teaching physics to students of higher technical educational institutions. *Subject of research*: the augmented reality technology as a component of the training process at higher educational institutions. *Research methods used:* theoretical methods include analysis of scientific and methodological literature; empirical methods include studying and observation of the training process. *Research results:* analysis of scientific publications allows defining the notion of augmented reality; application of augmented reality objects during laboratory practical works on physics is suggested. *Main conclusions*. introduction of the augmented reality technology in the training process at higher technical educational institutions increases learning efficiency, facilitates students' training and cognitive activities, improves the quality of knowledge acquisition, provokes interest in a subject, promotes development of research skills and a future specialist's competent personality.

Keywords: mobile learning technology, augmented reality technology, training at university, a physics laboratory practicum.

1 Introduction

1.1 The Problem Statement

Professional competences of IT and engineering students are formed through learning both professional and fundamental subjects, physics in particular. That is why a lecturer's task is to search for new training technologies, i.e. training methods, tools, and organization forms to master the content of a subject and realize training principles aimed at forming a competent specialist and improving his/her competences.

Introduction of modern ICT is a priority of Ukraine's education development. It especially concerns the technologies aimed at improving the training process, making

training material more available, enhancing educational mobility and efficiency, preparing students for professional activity and life in the information society. Mobile learning is an example of such modern technology, which is associated with the concept of mobile learning [13] and the augmented reality (AR) technology.

Modern mobile learning tools are those that call for ensuring more efficient mastering of theoretical material and practical skills [14].

Students themselves are reluctant to apply mobile devices to learning regardless of high-level technological advancements [26]. It is the educator who sets all internal and external mechanisms of learning in motion for students to acquire necessary knowledge [9]. Therefore, basic advantages of mobile learning (an unlimited access to the training content, a free choice of a place and time of learning, elimination of nonproductive time, convenience, consideration of individual peculiarities, absence of restrictions as to class schedules) [12] and increased number of software tools (mobile applications) for working with AR objects should be taken into account while organizing classes and preparing students for them [7].

1.2 Theoretical background

Issues of introducing ICT and modern learning tools in teaching physics and initial experiment work have been raised by Petro S. Atamanchuk [1], Valerii Yu. Bykov [4], Yurii M. Oryshchyn [21], Mykola I. Sadovyi [22], Valentyna D. Sharko [25], Illia O. Teplytskyi [28], Stepan P. Velychko [29], Myroslav I. Zhaldak [31], Yurii O. Zhuk [32], and other domestic researchers.

Yurii O. Zhuk indicates that relations between man and technology can be normal if they are rational and efficient [32].

Myroslav I. Zhaldak thinks that ICT application to the training process provides wide opportunities to make training creative, inquisitive and attractive with its results evoking satisfaction, the desire to work and search for new knowledge [31].

Mykola I. Shut [15], Volodymyr F. Zabolotnyi [30], Vadim A. Ilin [16], Bohdan A. Sus [27], Volodymyr P. Serhiienko [23] considered problems of data visualization in physics training at higher school.

Volodymyr F. Zabolotnyi states that active perception of visual information oc-curs when it is structured and accompanied by explanations. It requires special organ-ization and deliberate methods of material presentation [30].

Augmented reality as a specific innovative environment of communication has been studied by such foreign investigators as Ronald T. Azuma [3], Reinhold R. Beh-ringer [2], Yohan Baillot [18], Walter P. Donnelly [19], Simon Julier [17], Steven K. Feiner [6], and Blair MacIntyre [5].

In Ronald T. Azuma's opinion, augmented reality is a variation of the virtual environment (VE) or virtual reality (VR). VE technologies plunge a user into the artificially made environment in such a way that he/she cannot see the real world. As opposed to VE technologies, augmented reality enables a user to see the real world while virtual objects are superposed on or combined with the reality. That is why, the AR technology supplements the reality without replacing it entirely. This technology allows incorpo-

rating elements of virtual reality into the surrounding world. Thus, Azuma defined augmented reality as a system combining virtual and real elements, interacting online and operating in 3D [3].

The key feature of augmented reality is possible obtainment of additional information or a virtual action perceived as real by our brain as there are accesses to virtual opportunities in the real environment.

People apply augmented reality to navigation, architecture, medicine and warfare. Nowadays, there are many approaches to the AR technology application to education.

Introduction of AR technologies in education is topical as this innovative system will enhance students' motivation and increase the level of data acquisition due to diversity and interactivity of its visual presentation [24]. Any AR tools can be a training object if it is controlled and facilitates users' interaction with real objects in order to study their properties during experimental investigation [20].

1.3 The objective of the article

The objective of the article is to solve the problems of determining the role and place of the technology in the educational process and its possible application to physics training.

2 Presenting the Main Material

At physics department of Kryvyi Rih National University, possible directions of introducing the AR technology in education are under study including a laboratory practicum on physics.

Skills of experimenting and data analysis are developed during laboratory practicums when a student conducts experiments independently. This organization form of physics classes allows developing such personality traits as diligence, insistence, purposefulness, power of observation in a greater degree than other forms. It also facilitates students' constructive thinking, interest in a subject and creative approach to knowledge acquisition, thus enhancing future specialists' activity in future. Considering advantages of the laboratory practicum, a lecturer is to organize and prepare it so that the above-mentioned advantages reveal themselves in class. At the initial stage of the laboratory practicum, a lecturer should make the material interesting as in interest situations, students' fatigue falls, while efficiency of training rises [10]. Introduction of the augmented reality technology as a visualization tools of training material presentation is an important condition of learning efficiency increase at higher educational institutions.

AR objects, namely video instructions for performing laboratory works, are considered a result of adding virtual objects (extra data) to markers, which are perceived as objects of the real world. Video instructions help visualize the procedure of work performance, indicate specific features of an experiment and facilitate students' perception. These markers for video demonstrations can be schematic draughts of laboratory instructions for performing works, which can be found in classrooms, at the library or

the website of physics department. Students can get ready for a laboratory work easily, even if he/she is not in the auditorium with real installations at this moment.

Students with visual thinking have difficulty in understanding and mastering training material as they are unable to comprehend and study a phenomenon without visualizing it. Students with theoretical thinking, who are able to acquire formalized knowledge, can use mobile learning tools as an additional mean for developing their visual thinking [11] and focus. Therefore, augmented reality is capable of activating all human senses, evoking interest and improving a general impression of a class.

AR objects are created by software tool Aurasma (HP Reveal), a smartphone application developed by the British company Autonomy, which is able to recognize visual images in the real world [8].

When pointing a smartphone or tablet camera at a picture-marker, a mobile device starts scanning it. On the screen, there appears a video of a lecturer demonstrating a laboratory installation, its basic components and commenting on the experiment procedure (Fig. 1). It helps visualize students' step-by-step actions, indicate peculiarities of each work, consider them and save time. AR application to physics workshops facilitates students' understanding of drawings, instructions as it supplements printed information.

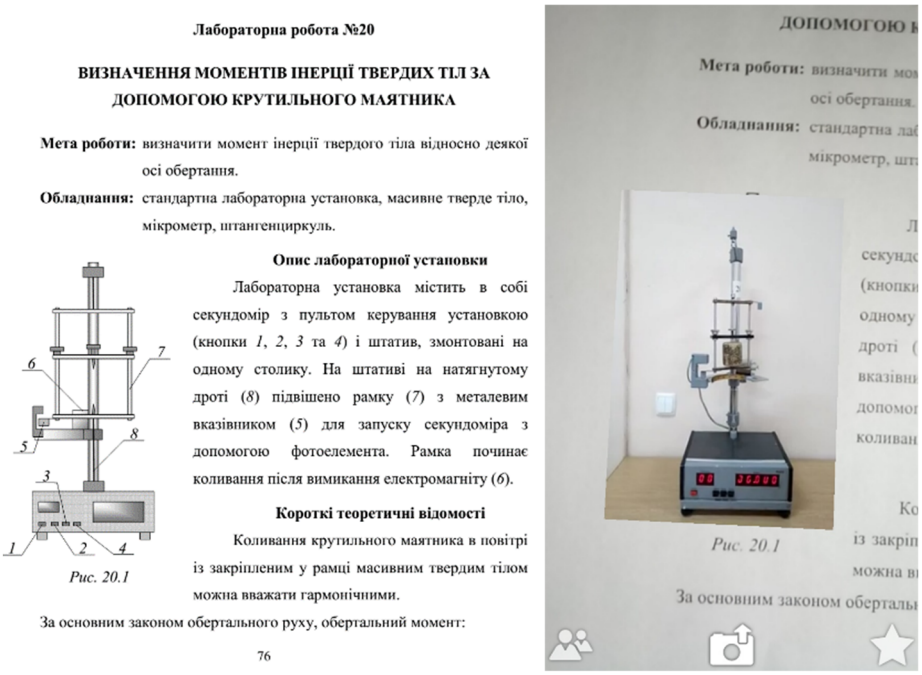

Fig. 1. Application of AR objects to methodological recommendations to physics laboratory works

As a rule, there is one lecturer for groups of up to 20 students at classes of physics laboratory workshops. His/her duties include giving a permission for students to work,

consulting on performing experiments and calculation of physical values, checking obtained results, assisting in building graphs and statistical processing of results, questioning students (according to questions on laboratory work defense) and assessing them. It is a great amount of work to be done by one lecturer considering the fact that all students perform different works.

Application of AR objects makes perception of procedures of experiments and theory presentation simpler, provides opportunities for students to get ready for laboratory works at home more thoroughly. Both full-time and correspondence students who do not have enough time during lecture periods can do it.

AR objects help students process information in their own pace [12]. There is an opportunity to watch a video instruction several times without disturbing a lecturer during classes. A lecturer has more time to consult other students as to their calculations, laboratory work defence, etc.

Students, who were offered to use the AR technology, got interested in applying it to performing laboratory works as an additional learning tools and liked the idea of visualizing training material through a mobile application.

Application of mobile devices (smartphones, tablets, HMD, etc.) as basic elements of the AR technology in the training process is substantiated only in case of providing sufficient capacity of mobile processors, great resolution of modern screens and built-in cameras, an access to additional facilities of the system (a gyroscope, Wi-Fi, GPS, 3D data transmission, etc.), which are available in most modern devices.

Most students have mobile devices, which can be accompanied by AR objects for providing distance learning in out-of-class periods.

3 Conclusion

Thanks to the AR technology, mobile learning tools allow making classes interesting and diverse. Mobile-oriented learning material becomes visualized and understandable, thus enhancing students' perception, understanding and acquisition of complicated notions, phenomena and laws of physics [12].

Thus, application of AR as a visualization tool at physics laboratory practicums at technical universities motivates students and allows solving the problem of learning efficiency [14] by increasing their knowledge quality and interest in a subject, developing research skills, active independent knowledge acquisition and forming a competent personality of a future specialist.

In conditions of intensive informatization of modern educational institutions, a lecturer has to work in a new way. He/she is to be a mediator in the world of multiple sources of information and help students find it and teach how to deal with it. Thus, there arises a necessity to develop a mobile-oriented tutorial on physics based on the augmented reality technology.

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