AREdu 2019 – How augmented reality transforms to augmented learning

Arnold E. Kiv[1], Mariya P. Shyshkina[2][0000-0001-5569-2700], Serhiy O. Semerikov[2,3,4][0000-0003-0789-0272], Andrii M. Striuk[4][0000-0001-9240-1976] and Yuliia V. Yechkalo[4][0000-0002-0164-8365]

[1] Ben-Gurion University of the Negev, P.O.B. 653, Beer Sheva, 8410501, Israel
kiv@bgu.ac.il
[2] Institute of Information Technologies and Learning Tools of the NAES of Ukraine, 9, M. Berlynskoho Str., Kyiv, 04060, Ukraine
shyshkina@iitlt.gov.ua
[3] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
semerikov@gmail.com
[4] Kryvyi Rih National University, 11, Vitaliy Matusevych Str., Kryvyi Rih, 50027, Ukraine
andrey.n.stryuk@gmail.com, uliaechk@gmail.com

Abstract. This is an introductory text to a collection of papers from the AREdu 2019: The 2nd International Workshop on Augmented Reality in Education, which was held in Kryvyi Rih, Ukraine, on the March 22, 2019. It consists of short introduction, papers review and some observations about the event and its future.

Keywords: virtualization of learning, augmented reality gamification, design and implementation of augmented reality learning environments, mobile technology of augmented reality, augmented reality in science education, augmented reality in professional training and retraining, augmented reality social and technical issues.

1 AREdu 2019 at a glance

Augmented Reality in Education (AREdu) is a peer-reviewed international Computer Science workshop focusing on research advances, applications of augmented reality in education.

AREdu topics of interest:

- Virtualization of learning: principles, technologies, tools
- Augmented reality gamification
- Design and implementation of augmented reality learning environments
- Mobile technology of augmented reality
- Aspects of environmental augmented reality security and ethics
- Augmented reality in science education
- Augmented reality in professional training and retraining

– Augmented reality social and technical issues

This volume represents the proceedings of the 2nd International Workshop on Augmented Reality in Education (AREdu 2019), held in Kryvyi Rih, Ukraine, in March 22, 2019 (Fig. 1). It comprises 19 contributed papers that were carefully peer-reviewed and selected from 25 submissions. Each submission was reviewed by at least 3, and on the average 3.7, program committee members. The accepted papers present the state-of-the-art overview of successful cases and provides guidelines for future research.

Fig. 1. AREdu 2019 moments

The volume is structured in five parts, each presenting the contributions for a particular workshop track.

2 Session 1: Virtualization of learning: principles, technologies, tools

The article [1] of Olga V. Bondarenko, Olena V. Pakhomova and Włodzimierz Lewoniewski clarifies the concept of "virtual information educational environment" and examines the researchers' views on its meaning exposed in the scientific literature. The article determines the didactic potential of the virtual information educational environment for the geography students training based on the analysis of the authors' experience of blended learning by means of the Google Classroom. It also specifies the features (immersion, interactivity, and dynamism, sense of presence, continuity, and causality). The authors highlighted the advantages of virtual information educational environment implementation, such as: increase of the efficiency of the educational process by intensifying the process of cognition and interpersonal interactive communication; continuous access to multimedia content both in Google Classroom and beyond; saving student time due to the absence of necessity to work out the training material "manually"; availability of virtual pages of the virtual class; individualization of the educational process; formation of informational culture of the geography students; and more productive learning of the educational material at the expense of IT educational facilities. Among the disadvantages the article mentions low level of computerization, insignificant quantity and low quality of software products, underestimation of the role of virtual information educational environment in the professional training of geography students, and the lack of economic stimuli, etc.

Volodymyr H. Shamonia, Olena V. Semenikhina, Volodymyr V. Proshkin, Olha V. Lebid, Serhii Ya. Kharchenko and Oksana S. Lytvyn in [15] establish that the use of augmented reality as an innovative technology of student training occurs in following directions: 3D image rendering; recognition and marking of real objects; interaction of a virtual object with a person in real time. The main advantages of using AR and VR in the educational process are highlighted: clarity, ability to simulate processes and phenomena, integration of educational disciplines, building an open education system, increasing motivation for learning, etc. It has been found that in the field of physical process modelling the Proteus Physics Laboratory is a popular example of augmented reality. Using the Proteus environment allows to visualize the functioning of the functional nodes of the computing system at the micro level. This is especially important for programming systems with limited resources, such as microcontrollers in the process of training future IT professionals. Experiment took place at Borys Grinchenko Kyiv University and Sumy State Pedagogical University named after A. S. Makarenko with students majoring in Computer Science (field of knowledge is Secondary Education (Informatics)). It was found that computer modelling has a positive effect on mastering the basics of microelectronics. The ways of further scientific researches for grounding, development and experimental verification of forms, methods and augmented reality, and can be used in the professional training of

future IT specialists are outlined in the article.

The article of Svitlana V. Symonenko, Nataliia V. Zaitseva, Viacheslav V. Osadchyi, Kateryna P. Osadcha and Ekaterina O. Shmeltser [18] deals with the urgent problem of application of virtual reality in foreign language training. Statistical data confirms that the number of smartphone users, Internet users, including wireless Internet users, has been increasing for recent years in Ukraine and tends to grow. The coherence of quick mobile Internet access and presence of supplementary equipment enables to get trained or to self-dependently advance due to usage of virtual reality possibilities for education in the stationary classrooms, at home and in motion. Several important features of virtual reality, its advantages for education are discussed. It is noted that virtual reality is remaining a relatively new technology in language learning. Benefits from virtual reality implementation into foreign language learning and teaching are given. The aspects of immersion and gamification in foreign language learning are considered. It is emphasized that virtual reality creates necessary preconditions for motivation increasing. The results of the survey at two higher education institution as to personal experience in using VR applications for learning foreign languages are presented. Most students at both universities have indicated quite a low virtual reality application usage. Six popular virtual reality applications for foreign language learning (Mondly, VRSpeech, VR Learn English, Gold Lotus, AltSpaceVR and VirtualSpeech) are analyzed. It is stated that the most preferred VR application for foreign language learning includes detailed virtual environment for maximal immersion, high-level visual effects similar to video games, simple avatar control, thorough material selection and complete complicity level accordance of every element and aspect, affordability, helpful and unobtrusive following up.

Michael S. Lvov and Halyna V. Popova in [7] argued that introduction of simulation technologies of virtual reality in the educational process of higher maritime educational institutions increases the efficiency of education, promotes the development of professional thinking of students, enhances the quality of professional competence development.

The article [19] of Tetiana A. Vakaliuk, Valerii V. Kontsedailo, Dmytro S. Antoniuk, Olha V. Korotun, Iryna S. Mintii and Andrey V. Pikilnyak presents the possibilities of using game simulator Sotware Inc in the training of future software engineer in higher education. Attention is drawn to some specific settings that need to be taken into account when training in the course of training future software engineers. The use of modern ICT, including game simulators, in the educational process, allows to improve the quality of educational material and to enhance the educational effects from the use of innovative pedagogical programs and methods, as it gives teachers additional opportunities for constructing individual educational trajectories of students. A feature of any software engineer is the need to understand the related subject area for which the software is being developed. Authors notes that when the real-world practice is impossible for students, game simulators that simulate real software development processes are an alternative.

3 Session 2: Augmented reality social and technical issues

Vladimir S. Morkun, Natalia V. Morkun and Andrey V. Pikilnyak in [11] argued that for programming the AR tools, interactive objects and creating the markers, the method of fiber spaces (*k*-space) for modeling of ultrasonic wave propagation in an inhomogeneous medium using coarse grids, with maintaining the required accuracy was used. The algorithm and AR tools are introduced by authors into the adaptive control system of the pulp gas phase in the iron ore flotation process using a control action based on high-energy ultrasound dynamic effects generated by ultrasonic phased arrays. The AR tools based on *k*-space methods allow facilitating wider adoption of ultrasound technology and visualizing the ultra-sound propagation in heterogeneous media by providing a specific correspondence between the ultrasound data acquired in real-time and a sufficiently detailed augmented 3D scene. Such tools allow also seeing the field of ultrasound propagation, its characteristics, as well as the effect of the dynamic effects of ultrasound on the change in the gas phase during the flotation process.

Svitlana I. Pochtoviuk, Tetiana A. Vakaliuk and Andrey V. Pikilnyak in [14] study presents the possibilities of using augmented reality in the learning mathematics, anatomy, physics, chemistry, architecture, as well as in other fields. The comparison of domestic and foreign proposals for augmented reality is presented.

4 Session 3: Augmented reality in science education

Article [17] of Mariya P. Shyshkina and Maiia V. Marienko presents the AR-based open science tools of the European Research Area (ERA). An open science foundation seeks to capture all the elements needed for the functioning of ERA: research data, scientific instruments, ICT services (connections, calculations, platforms, and specific studies such as portals). The article deals with the concept of open science. The concept of the European cloud of open science and its structure are presented. According to the study, it has been shown that the structure of the cloud of open science includes an augmented reality as a component.

The article [16] of Viktor B. Shapovalov, Yevhenii B. Shapovalov, Zhanna I. Bilyk, Anna P. Megalinska and Ivan O. Muzyka devoted to the analysis of the efficiency of the functioning of the Google Lens related to botanical objects. In order to perform the analysis, botanical objects were classified by type of the plant (grass, tree, bush) and by part of the plant (stem, flower, fruit) which is represented on the analyzed photo. It was shown that Google Lens correctly identified plant species in 92.6% cases. This is a quite high result, which allows recommending this program using during the teaching. The greatest accuracy of Google Lens was observed under analyzing trees and plants stems. The worst accuracy was characterized to Google Lens results of fruits and stems of the bushes recognizing. However, the accuracy was still high and Google Lens can help to provide the researches even in those cases. Google Lens wasn't able to analyze the local endemic Ukrainian flora. It has been shown that the recognition efficiency depends more on the resolution of the photo than on the physical characteristics of the

camera through which they are made. In the article shown the possibility of using the Google Lens in the educational process is a simple way to include principles of STEM-education and "New Ukrainian school" in classes.

Tetiana H. Kramarenko, Olha S. Pylypenko and Vladimir I. Zaselskiy in [5] improves the methodology of teaching Mathematics using cloud technologies and augmented reality, analyzing the peculiarities of the augmented reality technology implementing in teaching mathematics. In the result of the study an overview of modern augmented reality tools and their application practices was carried out. The peculiarities of the mobile application 3D Calculator with Augmented reality of Dynamic Mathematics GeoGebra system usage in Mathematics teaching are revealed.

Svitlana L. Malchenko, Davyd V. Mykoliuk and Arnold E. Kiv in [8] emphasize in astrophysics, a significant role is play the observations. During astronomy classes in the absence of surveillance tools interactive programmes such as Universe Sandbox[2] can be used. Using this programme students have an opportunity to get acquainted with the existence of stars with different masses, their differences, to observe changes in the physical characteristics of stars such as: mass, temperature, speed velocity, luminosity, radius and gravity. It will help to develop the ability to analyze, to compare, to form scientific worldview, to develop the attraction for research, to raise the interest for studying astronomy.

The purpose of the article [12] of Pavlo P. Nechypurenko, Viktoriia G. Stoliarenko, Tetiana V. Starova, Tetiana V. Selivanova, Oksana M. Markova, Yevhenii O. Modlo and Ekaterina O. Shmeltser is an analysis of opportunities and description of the experience of developing and implementing augmented reality technologies to support the teaching of chemistry in higher education institutions of Ukraine. The article is aimed at solving problems: generalization and analysis of the results of scientific research concerning the advantages of using the augmented reality in the teaching of chemistry, the characteristics of modern means of creating objects of augmented reality; discussion of practical achievements in the development and implementation of teaching materials on chemistry using the technologies of the augmented reality in the educational process. As a result of the study, it was found that technologies of augmented reality have enormous potential for increasing the efficiency of independent work of students in the study of chemistry, providing distance and continuous education. Often, the technologies of the augmented reality in chemistry teaching are used for 3D visualization of the structure of atoms, molecules, crystalline lattices, etc., but this range can be expanded considerably when creating its own educational products with the use of AR-technologies. The study provides an opportunity to draw conclusions about the presence of technologies in the added reality of a significant number of benefits, in particular, accessibility through mobile devices; availability of free, accessible and easy-to-use software for creating augmented-reality objects and high efficiency in using them as a means of visibility. The development and implementation of teaching materials with the use of AR-technologies in chemistry teaching at the Kryvy Rih State Pedagogical University has been started in the following areas: creation of a database of chemical dishes, creation of a virtual chemical laboratory for qualitative chemical analysis, creation of a set of methodical materials for the course "Physical and colloidal chemistry".

5 Session 4: Augmented reality in professional training and retraining

The aim of the article [13] of Liubov F. Panchenko and Ivan O. Muzyka is to provide an analytical review of the content of massive open online courses about augmented reality and its use in education with the further intent to create a special course for the professional development system for the research and teaching personnel in postgraduate education. As results of the research the content and program of specialized course "Augmented Reality as a Storytelling Tool" for the professional development of teachers was developed. The purpose of the specialized course is to consider and discuss the possibilities of augmented reality as a new direction in the development of educational resources, to identify its benefits and constraints, as well as its components and the most appropriate tools for educators, to discuss the problems of teacher and student co-creation on the basis of the use of augmented reality, and to provide students with personal experience in designing their own stories and methodical tools in the form of augmented books and supplementary training aids with the help of modern digital services.

Anna V. Iatsyshyn, Valeriia O. Kovach, Yevhen O. Romanenko, Iryna I. Deinega, Andrii V. Iatsyshyn, Oleksandr O. Popov, Yulii G. Kutsan, Volodymyr O. Artemchuk, Oleksandr Yu. Burov and Svitlana H. Lytvynova in [2] describe the application of augmented reality technologies for preparation of specialists of new technological era. Number of scientific studies on different aspects of augmented reality technology development and application is analyzed in the research. Practical examples of augmented reality technologies for various industries are described. Very often augmented reality technologies are used for: social interaction (communication, entertainment and games); education; tourism; areas of purchase/sale and presentation. There are various scientific and mass events in Ukraine, as well as specialized training to promote augmented reality technologies. There are following results of the research: main benefits that educational institutions would receive from introduction of augmented reality technology are highlighted; it is determined that application of augmented reality technologies in education would contribute to these technologies development and therefore need increase for specialists in the augmented reality; growth of students' professional level due to application of augmented reality technologies is proved; adaptation features of augmented reality technologies in learning disciplines for students of different educational institutions are outlined; it is advisable to apply integrated approach in the process of preparing future professionals of new technological era; application of augmented reality technologies increases motivation to learn, increases level of information assimilation due to the variety and interactivity of its visual representation. Main difficulties of application of augmented reality technologies are financial, professional and methodical. Following factors are necessary for introduction of augmented reality technologies: state support for such projects and state procurement for development of augmented reality technologies; conduction of scientific research and experimental confirmation of effectiveness and pedagogical expediency of augmented reality technologies application for training of specialists of different specialties; systematic conduction of number of national and

international events on dissemination and application of augmented reality technology. It is confirmed that application of augmented reality technologies is appropriate for training of future specialists of new technological era.

The article [6] of Olena O. Lavrentieva, Ihor O. Arkhypov, Olexander I. Kuchma and Aleksandr D. Uchitel discusses the theory and methods of simulation training, its significance in the context of training specialists for areas where the lack of primary qualification is critical. The most widespread hardware and software solutions for the organization welders' simulation training that use VR- and AR-technologies have been analyzed. A review of the technological infrastructure and software tools for the virtual teaching-and-production laboratory of electric welding has been made on the example of the achievements of Fronius, MIMBUS, Seabery. The features of creating a virtual simulation of the welding process using modern equipment based on studies of the behavioral reactions of the welder have been shown. It is found the simulators allow not only training, but also one can build neuro-fuzzy logic and design automated and robotized welding systems. The functioning peculiarities of welding's simulators with AR have been revealed. It is shown they make it possible to ensure the forming basic qualities of a future specialist, such as concentration, accuracy and agility. The psychological and technical aspects of the coaching programs for the training and retraining of qualified welders have been illustrated. The conclusions about the significant advantages of VR and AR technologies in comparison with traditional ones have been made. Possible directions of the development of simulation training for welders have been revealed. Among them the AR technologies have been presented as such that gaining wide popularity as allow to realize the idea of mass training in basic professional skills.

The article [10] of Yevhenii O. Modlo, Serhiy O. Semerikov, Stanislav L. Bondarevskyi, Stanislav T. Tolmachev, Oksana M. Markova and Pavlo P. Nechypurenko is devoted to the methods of using mobile Internet devices in the formation of the general scientific component of bachelor in electromechanics competency in modeling of technical objects. An analysis of the experience of professional training bachelors of electromechanics in Ukraine and abroad made it possible to determine that one of the leading trends in its modernization is the synergistic integration of various engineering branches (mechanical, electrical, electronic engineering and automation) in mechatronics for the purpose of design, manufacture, operation and maintenance electromechanical equipment. Teaching mechatronics provides for the meaningful integration of various disciplines of professional and practical training bachelors of electromechanics based on the concept of modeling and technological integration of various organizational forms and teaching methods based on the concept of mobility. Within this approach, the leading learning tools of bachelors of electromechanics are mobile Internet devices (MID) – a multimedia mobile devices that provide wireless access to information and communication Internet services for collecting, organizing, storing, processing, transmitting, presenting all kinds of messages and data. The competency structure of the bachelor of electromechanics in the modeling of technical objects is reflected in three groups of competencies: general scientific, general professional and specialized professional. The implementation of the technique of using MID in learning bachelors

of electromechanics in modeling of technical objects is the appropriate methodic of using, the component of which is partial methods for using MID in the formation of the general scientific component of the bachelor of electromechanics competency in modeling of technical objects, are disclosed by example academic disciplines “Higher mathematics”, “Computers and programming”, “Engineering mechanics”, “Electrical machines”. The leading tools of formation of the general scientific component of bachelor in electromechanics competency in modeling of technical objects are augmented reality mobile tools (to visualize the objects’ structure and modeling results), mobile computer mathematical systems (universal tools used at all stages of modeling learning), cloud based spreadsheets (as modeling tools) and text editors (to make the program description of model), mobile computer-aided design systems (to create and view the physical properties of models of technical objects) and mobile communication tools (to organize a joint activity in modeling).

6 Session 5: Design and implementation of augmented reality learning environments

In the article [4] of Yaroslav M. Krainyk, Anzhela P. Boiko, Dmytro A. Poltavskyi and Vladimir I. Zaselskiy the development of historical guide based on Augmented Reality technology is considered. The developed guide application it targeted to be used in different scenarios, in particular, during history learning classes, for guidance of the tourists to exhibits both indoor and outdoor. Common features of all these scenarios are generalized and according to them main information and objects model for forming scene are identified. This part is followed by detailed description of objects and scene representation, markers usage, employment of additional services, etc. Finally, the developed historical guide application has been introduced. It harnesses A-Frame library for processing of models and their representation. The application is able to work with different markers so that it can be extended easily. In addition, one of the main benefits of the developed application is support of multiple platforms because it works from web-browser and does not require installation of additional software. The developed application can be effectively used for all provided scenarios and has potential for further extension.

Lilia Ya. Midak, Ivan V. Kravets, Olga V. Kuzyshyn, Jurij D. Pahomov, Victor M. Lutsyshyn and Aleksandr D. Uchitel in [9] creates an Android mobile application LiCo.STEM for visualization of chemical structure of water and to display video-data of laboratory experiments that can be used by the teacher and pupils for an effective background for learning natural cycle subjects and performance of laboratory experiments in the elementary school using lapbook. Representation of the developed video materials on the mobile gadgets is conducted by binding them to individual markers for every laboratory experiment. Applying such technologies gives an opportunity to establish educational activity, based on interference of adults with children, oriented on interests and abilities of each kid, development of curiosity, cognitive motivation and educational energy; development of imagination, creative initiative, including the speech, ability to chose the materials, types of work,

participants of the common activity, promotion of conditions for parents participate in the common study activity.

Oleksandr V. Kanivets, Irina M. Kanivets, Natalia V. Kononets, Tetyana M. Gorda and Ekaterina O. Shmeltser in [3] conduct an analysis of training tools used at the study a general technical disciplines. This made it possible to draw an analogy between physical and electronic models and justify the mobile application development for tasks performing at projective drawing. Authors showed a technique for creating augmented reality mobile applications. The main stages of development an augmented reality application are shown electronic models development, Unity3D game engine installation, and mobile application development, testing and work demonstration. Particular attention is paid by the scripts use to rotate and move electronic models. The authors presents an augmented reality mobile application for help to performance tasks from projection drawing.

7 Conclusion

The second instalment of AREdu was organised by Kryvyi Rih National University (Ukraine), in collaboration with Kryvyi Rih State Pedagogical University, Institute of Information Technologies and Learning Tools of the NAES of Ukraine and Ben-Gurion University of the Negev (Israel).

We are thankful to all the authors who submitted papers and the delegates for their participation and their interest in AREdu as a platform to share their ideas and innovation. Also, we are also thankful to all the program committee members for providing continuous guidance and efforts taken by peer reviewers contributed to improve the quality of papers provided constructive critical comments, improvements and corrections to the authors are gratefully appreciated for their contribution to the success of the workshop. Moreover, we would like to thank the developers and other professional staff of EasyChair, who made it possible for us to use the resources of this excellent and comprehensive conference management system, from the call of papers and inviting reviewers, to handling paper submissions, communicating with the authors, and creating the online volume of the workshop proceedings.

We are looking forward to excellent presentations and fruitful discussions, which will broaden our professional horizons. We hope all participants enjoy this workshop and meet again in more friendly, hilarious, and happiness of further AREdu 2020.

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