AREdu 2021 – Immersive technology today

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Abstract

This is an introductory text to a collection of papers from the AREdu 2021: The 4th International Workshop on Augmented Reality in Education, which was held in Kryvyi Rih, Ukraine, on the May 11, 2021. It consists of short introduction, papers' review and some observations about the event and its future.

Keywords

virtualization of learning: principles, technologies, tools, augmented reality gamification, design and implementation of augmented reality learning environments, 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

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1. Introduction

1.1. AREdu 2021 at a glance

Augmented **R**eality in **Edu**cation (AREdu) is a peer-reviewed international Computer Science workshop focusing on research advances, applications of virtual, augmented and mixed reality in education.

AREdu topics of interest since 2018 [1, 2, 3]:

- Virtualization of learning: principles, technologies, tools
- Augmented reality gamification
- Design and implementation of augmented reality learning environments
- Augmented reality in science education
- Augmented reality in professional training and retraining

Figure 1: AREdu 2021 logo

This volume represents the proceedings of the 4th International Workshop on Augmented Reality in Education (AREdu 2021), held in Kryvyi Rih, Ukraine, on May 11, 2021. It comprises 18 contributed papers that were carefully peer-reviewed and selected from 25 submissions (https://notso.easyscience.education/aredu/2021/). Each submission was reviewed by at least 3, and on the average 3.1, program committee members. The accepted papers present the state-of-the-art overview of successful cases and provides guidelines for future research.

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

1.2. AREdu 2021 program committee

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2. Articles overview

2.1. Session 1: Virtualization of learning: principles, technologies, tools

Iryna S. Mintii (figure 2), Tetiana A. Vakaliuk, Svitlana M. Ivanova, Oksana A. Chernysh, Svitlana M. Hryshchenko and Serhiy O. Semerikov in the article "Current state and prospects of distance learning development in Ukraine" [4] presents a thorough literature review and highlights the

main stages in the development of distance learning in Ukraine. Moreover, the paper suggests the periodization of distance learning. Research data on distance learning peculiarities in Ukraine during and before the pandemic make it possible to outline the main problems faced by higher education institutions' (HEIs) teachers and students. Therefore, the study emphasizes common problems, namely hardware/software issues, poor Internet connectivity, lack of students' self-discipline and self-organization, absence of live communication, insufficient digital literacy skills etc. The paper analyzes the benefits of MOOCs that aim at digital competence development. It presents the results of students' survey on qualitative changes in distance learning organization in 2020–2021 academic year compared to 2019–2020 academic year. The results prove that in current academic year, distance learning is better organized due to a sufficient structure of distance learning courses, the use of one platform for the whole educational institution, higher teachers' digital competence, the use of various resources etc.

This article highlights further research by the authors, begun in [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38].

Figure 2: Presentation of paper [4].

The technologies of the augmented and virtual reality have a special role in medical education as an additional tool for training professional skills in pre-clinical practice. In the paper "The virtual reality simulator development for dental students training: a pilot study" [39], Yulia Yu. Dyulicheva, Daniil A. Gaponov (figure 3), Raša Mladenović and Yekaterina A. Kosova describe the development of a virtual reality simulator with immersion in VR scene for dentist office and simulation of tooth drilling. Such kinds of simulators would contribute to evolving capacities of motor skills and hand-eye coordination. The VR simulator for dental students training is developed for Oculus Quest 2 VR headset with six degrees of freedom. The Marching Cubes algorithm is chosen as an optimal decision for autonomous VR headsets, the computational power of which is much lower than PCs. The main stages of the development of tooth drilling simulation are considered. They include voxelization, marching cubes algorithm, collision detection, and detection of penetration depth of the dental drill. The experience of VR scene using

for dental students training has been piloted at the Faculty of Dentistry at the V. I. Vernadsky Crimean Federal University. To evaluate the pilot study we used a satisfaction questionnaire, which evaluated the realism of tooth 3D model drilling and the realism of VR scene for the creation of a dentist's office atmosphere.

This article highlights further research by the authors, begun in [40].

Figure 3: Presentation of paper [39].

Progress of modern digital technologies enlarged the quantity of researches about implementation and usage of VR technologies in education process of higher educational establishments. The article "Application of VR technologies in building future maritime specialists' professional competences" [41] by Serhii A. Voloshynov, Felix M. Zhuravlev, Ivan M. Riabukha, Vitaliy V. Smolets and Halyna V. Popova (figure 4) provides analysis of best practices of simulation technologies application in maritime education. Absence of national research experience, evidence base for efficiency of new VR simulators operation leaves this issue open to be investigated in terms of researches on their performance effectiveness. The article proposes overview of advantages of VR technologies implementation aimed at building and shaping of future maritime specialists' professional competences. Authors investigate potential application possibilities of interactive and representative potential of immersion digital technologies during education process at maritime educational establishments. Problem of VR technologies integration into education and training of future seafarers is highlighted, as well as possibility to use virtual courses in the process of future maritime specialists' training. The article reveals prognostic validity of VR simulators used for building of professional competences.

This article highlights further research by the authors, begun in [42, 43, 44].

Figure 4: Presentation of paper [41].

The article 'Selection of online tools for creating math tests'" [37] by Oksana V. Zaika, Tetiana A. Vakaliuk (figure 5), Andrii V. Riabko, Roman P. Kukharchuk, Iryna S. Mintii and Serhiy O. Semerikov considers online tools for creating tests, which should be used when teaching mathematics in both higher education and general secondary education. Among the variety of online means of creating tests by the method of expert evaluation, three were identified, which allow conducting various tests both in the classroom and remotely, which are free and do not require special conditions for their use and which work on smartphones. The advantages and disadvantages of three online tools for creating tests Kahoot!, Quizizz, Classtime are analyzed, and a comparative description of the selected tools is given. Criteria for the selection of such tools were identified – functional-didactic and organizational. The following indicators belong to the functional-didactic: the presence of different types of questions, including open-ended; use of formulas, both in questions and in answers; use of pictures, both in questions and in answers; no restrictions on the length of questions and answers; instant receipt of results by the teacher, their evaluation and analysis; instant receipt of results by the respondent; to the organizational: the availability of a free version; no need to install the program; ease of use – characterizes the convenience and clarity of the interface for creating tests and their use; possibility of testing in online and offline mode; time limits, both for a single question and the whole test; random order of questions/answer options; instant demonstration of the correct answer to the respondent. With the help of expert evaluation, it was found that according to these criteria, Quizizz is the most appropriate for testing.

This article highlights further research by the authors, begun in [45].

Figure 5: Presentation of paper [37].

2.2. Session 2: Augmented reality gamification

Use of visual methods plays a significant role in learning. ICT allow us to create electronic educational resources in a new format and with new opportunities. The study of their didactic possibilities, forms and methods of their application is a topical issue. Simulation, virtualization, gamification requires new knowledge about their application, and therefore, the problem of training future teachers to use them is an urgent and important part of training. In the article "Gamification when studying logical operators on the Minecraft EDU platform" [46] by Elena G. Fedorenko, Nataliia V. Kaidan, Vladyslav Ye. Velychko (figure 6) and Vladimir N. Soloviev the modern achievements in the use of serious games in education were investigated and analyzed, the possibilities of using virtual worlds in education were considered, the recommendations for the practical training of future teachers to use them were developed. In practice, the effectiveness of the use of virtual tools in education has been tested. A pedagogical experiment has been launched to identify the effectiveness of gamification in the realities of education in Ukraine.

This article highlights further research by the authors, begun in [47, 48, 49, 50, 51, 52, 53].

2.3. Session 3: Design and implementation of augmented reality learning environments

The article "Analysis of tools for the development of augmented reality technologies" [54] by Tetiana A. Vakaliuk (figure 7) and Svitlana I. Pochtoviuk considers cross-platform products that should be used to develop augmented reality technologies: Unreal Development, Kit, Unity, Godot, Engine, Cocos2D, MonoGame, Unreal Engine, Marmalade, and others. Also, the

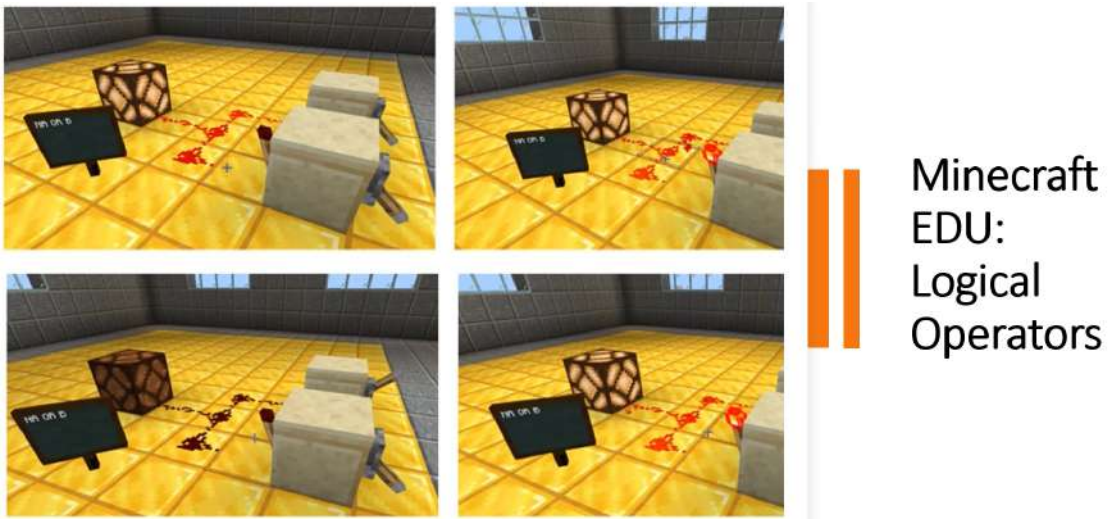

Figure 6: Presentation of paper [46].

possibilities of known SDKs for the development of augmented reality applications (Wikitude, Vuforia, Kudan, Maxst, Xzimg, NyARToolkit, Metaio SDK) are given. It is established that for the development of augmented reality technologies can be used not only cross-platform engines but also sets of development tools. Such kits allow you to speed up and simplify the process of developing any program with elements of augmented reality. These advantages and disadvantages will help beginners to choose the most convenient tool for developing augmented reality technologies. In addition, the article attempts to identify criteria and indicators for the selection of such environments, as well as their expert evaluation.

This article highlights further research by the authors, begun in [55, 56, 57, 58, 59].

In the paper "Using augmented reality for architecture artifacts visualizations" [60] Zarema S. Seidametova, Zinnur S. Abduramanov and Girey S. Seydametov (figure 8) compared the main SDKs for the development of a marker-based AR apps and 3D modeling freeware computer programs used for developing 3D-objects. We presented a concept, design and development of AR application "Art-Heritage'' with historical monuments and buildings of Crimean Tatars architecture (XIII-XX centuries). It uses a smartphone or tablet to alter the existing picture, via an app. Using "Art-Heritage'' users stand in front of an area where the monuments used to be and hold up mobile device in order to see an altered version of reality.

The article "Augmented reality while studying radiochemistry for the upcoming chemistry teachers" [61] by Liliia Ya. Midak (figure 9), Ivan V. Kravets, Olga V. Kuzyshyn, Tetiana V. Kostiuk, Khrystyna V. Buzhdyhan, Victor M. Lutsyshyn, Ivanna O. Hladkoskok, Arnold E. Kiv and Mariya P. Shyshkina is describe the mobile application (on Android) designed to visualize the basic definitions of the discipline "Radiochemistry and radioecology" in 3D. Studying the education material of this discipline (phenomena of radionuclide, radioisotope, the nucleus, the fundamental particle etc and their specifics) requires a more sophisticated explanation from the teacher and dynamic dimensional image from the student. Decent detailed visualization

Figure 7: Presentation of paper [54].

of the study material makes this process easier. So applying the augmented reality is rational for the purpose of visualizing the study material, applying it allows demonstrate 3D-models of the nucleus, the fundamental particles, the nature of radioactive decay, nuclear fission, the specifics of managing the nuclear weapon and the NPS. Involving this instrument of the up-to-date information and communication technologies while studying the new material gives the opportunity to develop and boost the spatial imagination of the students, "to see" the invisible and to understand the received material in a better way, which improves its better memorizing. As far as the augmented reality is one of the most recent new-age education trends, all the teachers are required to have the ability to use it. In this reason the upcoming teachers, the students of the "General Education (Chemistry)" specialty, must be trained with this technology. Within the study process the students have the opportunity to review the positive moments of applying AR from a student's stand of point and to understand, how to apply similar education tools in the future pedagogic work.

This article highlights further research by the authors, begun in [62, 63, 64, 65, 66, 67, 68, 69, 70, 71].

2.4. Session 4: Augmented reality in science education

The article "Review of the course "Development of Virtual and Augmented Reality Software" for STEM teachers: implementation results and improvement potentials" [72] by Serhiy O. Semerikov, Mykhailo M. Mintii (figure 10) and Iryna S. Mintii provides a review of applying the

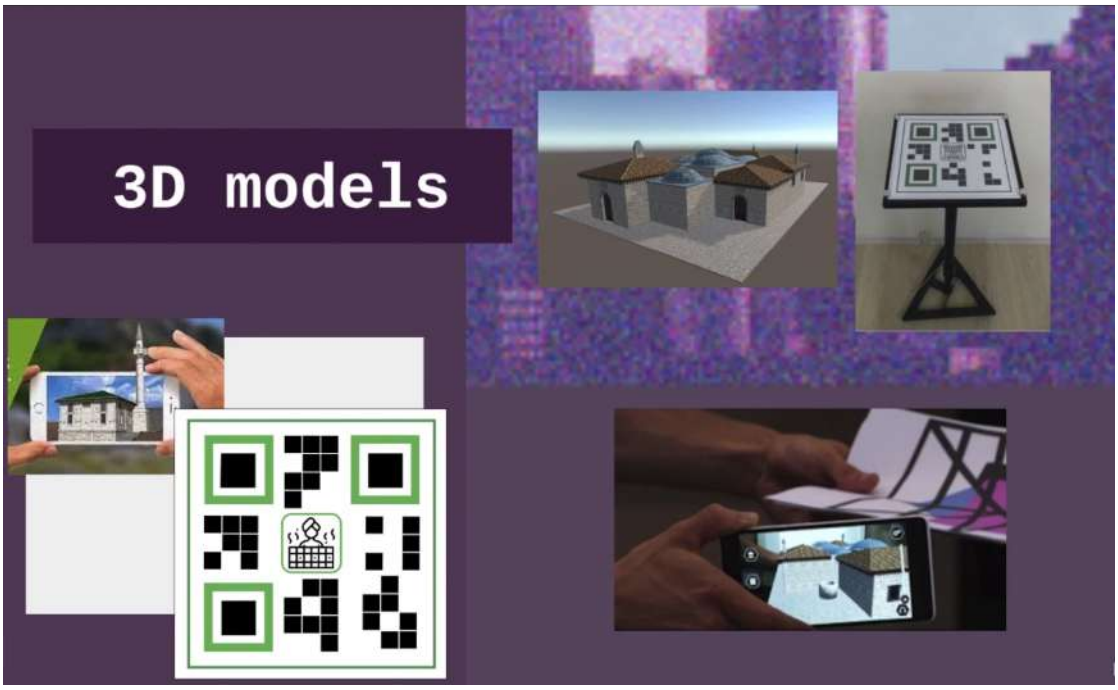

Figure 8: Presentation of paper [60].

virtual and augmented reality technology to education. There are analysed VR and AR tools applied to the course "Development of VR and AR software" for STEM teachers and specified efficiency of mutual application of the environment Unity to visual design, the programming environment (e.g. Visual Studio) and the VR and AR platforms (e.g. Vuforia). JavaScript language and the A-Frame, AR.js, Three.js, ARToolKit and 8th Wall libraries are selected as programming tools. The designed course includes the following modules: development of VR tools (VR and Game Engines; physical interactions and camera; 3D interface and positioning; 3D user interaction; VR navigation and introduction) and development of AR tools (set up AR tools in Unity 3D; development of a project for a photograph; development of training materials with Vuforia; development for promising devices). The course lasts 16 weeks and contains the task content and patterns of performance. It is ascertained that the course enhances development of competences of designing and using innovative learning tools. There are provided the survey of the course participants concerning their expectations and the course results. Reduced amounts of independent work, increased classroom hours, detailed methodological recommendations and increased number of practical problems associated with STEM subjects are mentioned as the course potentials to be implemented.

This article highlights further research by the authors, begun in [73, 74, 66, 58, 38, 75].

High-quality professional training of a future mathematics teacher who is able to meet the challenges that permeate all sides, the realities of the globalizing information society, pre-

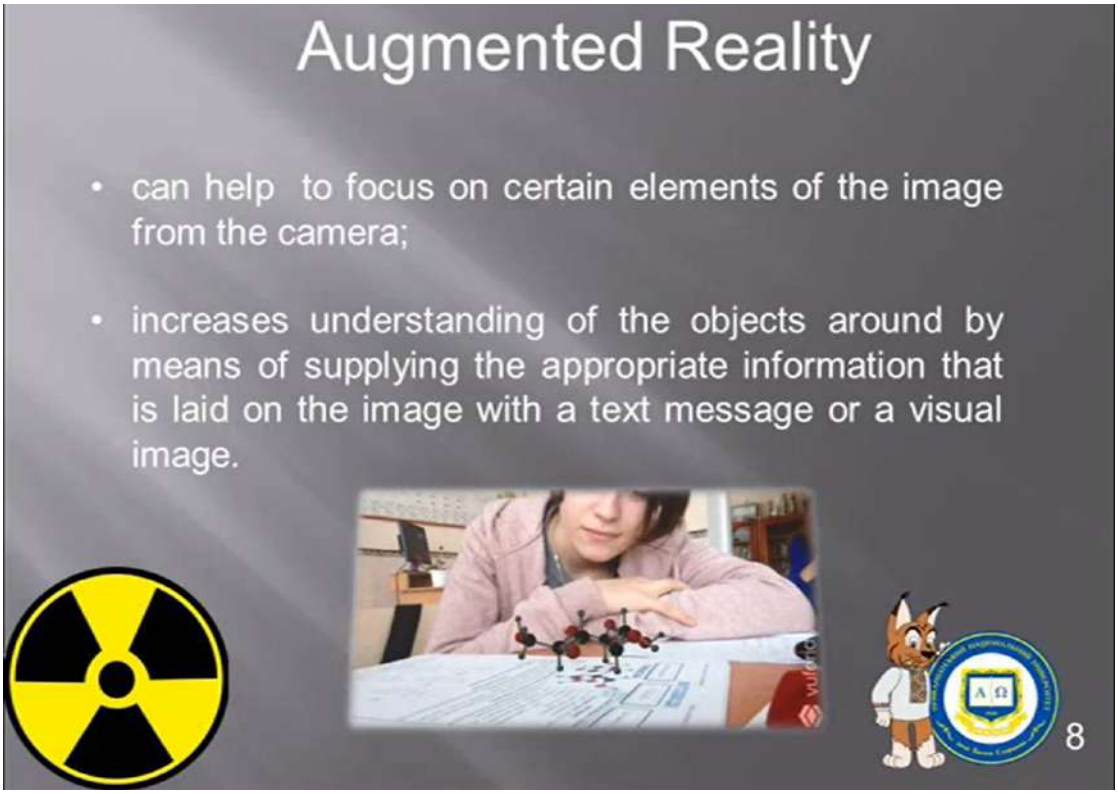

Figure 9: Presentation of paper [61].

supposes reliance on a highly effective learning environment. The purpose of the research "Improving the learning environment for future mathematics teachers with the use application of the dynamic mathematics system GeoGebra AR" [76] by Nataliia V. Osypova (figure 11) and Volodimir I. Tatochenko is to transform the traditional educational environment for training future mathematics teachers with the use of the GeoGebra AR dynamic mathematics system, the introduction of cloud technologies into the educational process. The educational potential of GeoGebra AR in the system of professional training of future mathematics teachers is analyzed in the paper. Effective and practical tools for teaching mathematics based on GeoGebra AR using interactive models and videos for mixed and distance learning of students are provided. The advantages of the GeoGebra AR dynamic mathematics system are highlighted. The use of new technologies for the creation of didactic innovative resources that improve the process of teaching and learning mathematics is presented on the example of an educational and methodological task, the purpose of which is to create didactic material on the topic "Sections of polyhedra". While solving it, future teachers of mathematics should develop the following constituent elements: video materials; test tasks for self-control; dynamic models of sections of polyhedra; video instructions for constructing sections of polyhedra and for solving basic problems in the GeoGebra AR system. The article highlights the main characteristics of the

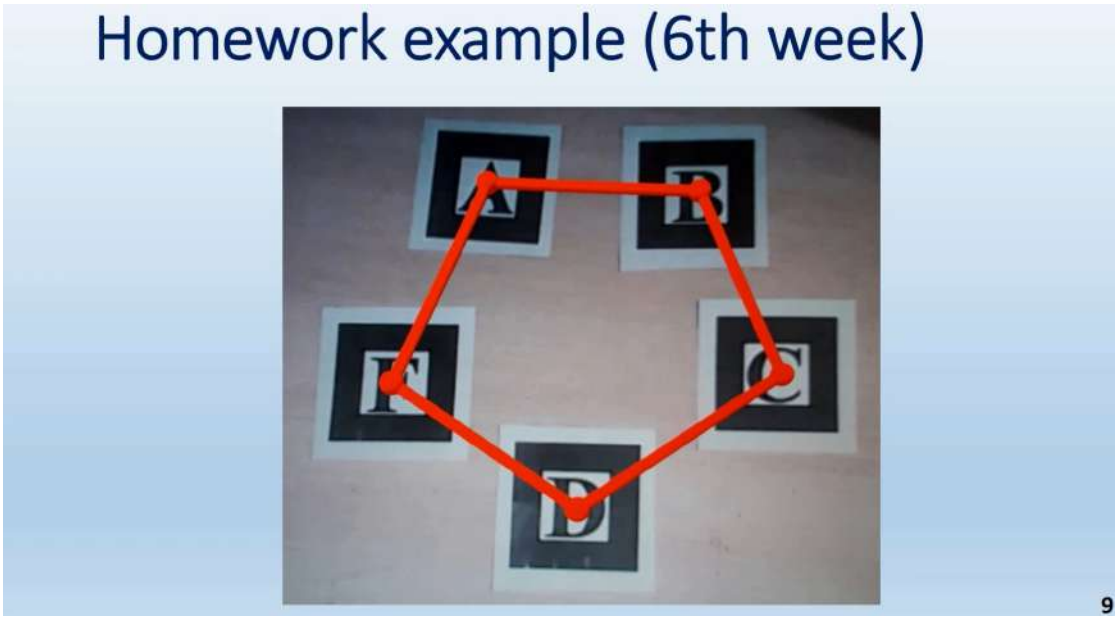

Figure 10: Presentation of paper [72].

proposed educational environment for training future mathematics teachers using the GeoGebra AR dynamic mathematics system: interdisciplinarity, polyprofessionalism, dynamism, multicomponent.

This article highlights further research by the authors, begun in [77, 78].

The article "The development and use of mobile app AR Physics in physics teaching at the university" [79] by Arnold E. Kiv, Vladyslav V. Bilous, Dmytro M. Bodnenko, Dmytro V. Horbatovskyi, Oksana S. Lytvyn and Volodymyr V. Proshkin (figure 12) outlines the importance of using Augmented Reality in physics education at the university as a valuable tool for visualization and increasing the attention and motivation of students to study, solving educational problems related to future professional activities, improving the interaction of teachers and students. Provided an analysis of the types of AR technology and software for developing AR apps. The sequences of actions for developing the mobile application AR Physics in the study of topics: "Direct electronic current", "Fundamentals of the theory of electronic circuits". The software tools for mobile application development (Android Studio, SDK, NDK, Google Sceneform, 3Ds MAX, Core Animation, Asset Media Recorder, Ashampoo Music Studio, Google Translate Plugin) are described. The bank of 3D models of elements of electrical circuits (sources of current, consumers, measuring devices, conductors) is created. Because of the students' and teachers' surveys, the advantages and disadvantages of using AR in the teaching process are discussed. Mann-Whitney U-test proved the effectiveness of the use of AR for laboratory works in physics by students majoring in "Mathematics", "Computer Science", and "Cybersecurity".

This article highlights further research by the authors, begun in [80, 81, 82, 83, 84, 85, 86**?**].

The article 'Using Blippar to create augmented reality in chemistry education'" [87] by Yuliya

Figure 11: Presentation of paper [76].

V. Kharchenko, Olena M. Babenko and Arnold E. Kiv (figure 13) presents an analysis of the possibilities and advantages of augmented reality technologies and their implementation in training of future Chemistry and Biology teachers. The study revealed that the use of augmented reality technologies in education creates a number of advantages, such as: visualization of educational material; interesting and attractive learning process; increasing student motivation to study and others. Several augmented reality applications were analyzed. The Blippar app has been determined to have great benefits: it's free; the interface is simple and user-friendly; the possibility of using different file types; the possibility of combining a large amount of information and logically structuring it; loading different types of information: video, images, 3D models, links to sites, etc. Thus, convenient interactive projects were developed using the Blippar application, which were called study guide with AR elements, and implemented in teaching chemical disciplines such as Laboratory Chemical Practice and Organic Chemistry. Using such study guide with AR elements during classes in a real chemical laboratory is safe and does not require expensive glassware. The student interviews revealed that the use of the Blippar application facilitated new material understanding, saved time needed to learn material, and was an effective addition to real-life learning.

2.5. Session 5: Augmented reality in professional training and retraining

Training and professional development of nuclear power plant personnel are essential components of the atomic energy industry's successful performance. The rapid growth of virtual reality (VR) and augmented reality (AR) technologies allowed to expand their scope and caused

Figure 12: Presentation of paper [79].

the need for various studies and experiments in terms of their application and effectiveness. Therefore, the article "Immersive technology for training and professional development of nuclear power plants personnel" [88] by Oleksandr O. Popov, Anna V. Iatsyshyn (figure 14), Andrii V. Iatsyshyn, Valeriia O. Kovach, Volodymyr O. Artemchuk, Viktor O. Gurieiev, Yulii G. Kutsan, Iryna S. Zinovieva, Olena V. Alieksieieva, Valentyna V. Kovalenko and Arnold E. Kiv studies the peculiarities of the application of VR and AR technologies for the training and professional development of personnel of nuclear power plants. The research and experiments on various aspects of VR and AR applications for specialists' training in multiple fields have recently started. The analysis of international experience regarding the technologies application has shown that powerful companies and large companies have long used VR and AR in the industries they function. The paper analyzes the examples and trends of the application of VR technologies for nuclear power plants. It is determined that VR and AR's economic efficiency for atomic power plants is achieved by eliminating design errors before starting the construction phase; reducing the cost and time expenditures for staff travel and staff training; increasing industrial safety, and increasing management efficiency. VR and AR technologies for nuclear power plants are successfully used in the following areas: modeling various atomic energy processes; construction of nuclear power plants; staff training and development; operation, repair, and maintenance of nuclear power plant equipment; presentation of activities and equipment. Peculiarities of application of VR and AR technologies for training of future specialists and advanced training of nuclear power plant personnel are analyzed. Staff training and professional development using VR and AR technologies take place in close to real-world conditions that are safe for participants and equipment. Applying VR and AR at nuclear power plants can increase efficiency: to work out the order of actions in the emergency mode; to optimize the temporary cost of urgent repairs; to test of dismantling/installation of elements of the equipment; to

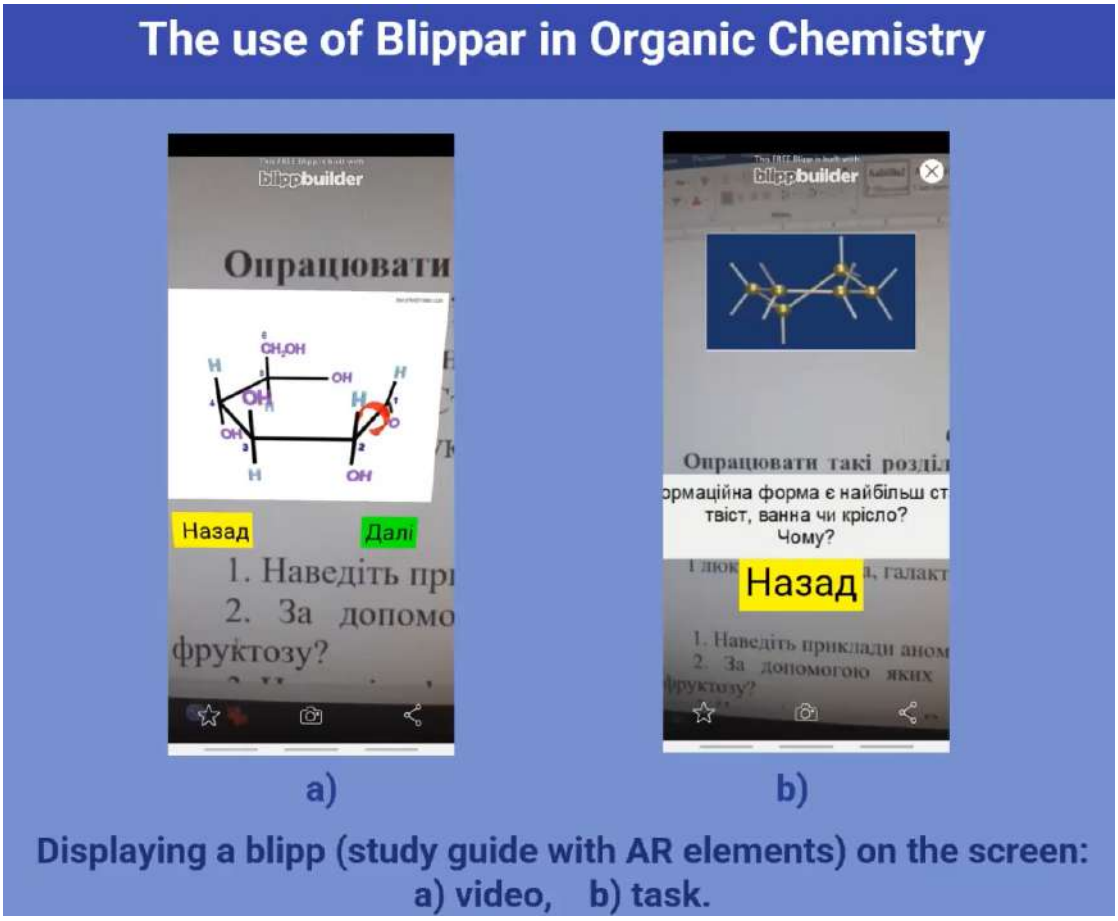

Figure 13: Presentation of paper [87].

identify weaknesses in the work of individual pieces of equipment and the working complex as a whole. The trends in the application of VR and AR technologies for the popularization of professions in nuclear energy among children and youth are outlined. Due to VR and AR technologies, the issues of "nuclear energy safety" have gained new importance both for the personnel of nuclear power plants and for the training of future specialists in the energy sector. Using VR and AR to acquaint children and young people with atomic energy in a playful way, it becomes possible to inform about the peculiarities of the nuclear industry's functioning and increase industry professions' prestige.

This article highlights further research by the authors, begun in [89, 63].

The article "Using augmented reality in university education for future IT specialists: educational process and student research work" [90] by Vladyslav V. Babkin, Viktor V. Sharavara, Volodymyr V. Sharavara, Vladyslav V. Bilous (figure 15), Andrei V. Voznyak and Serhiy Ya. Kharchenko substantiates the feature of using augmented reality (AR) in university training of future IT specialists in the learning process and in the research work of students. The survey of

Figure 14: Presentation of paper [88].

university teachers analyzed the most popular AR applications for training future IT specialists (AR Ruler, AR Physics, Nicola Tesla, Arloon Geometry, AR Geometry, GeoGebra 3D Graphing Calculator, etc.), disclose the main advantages of the applications. The methodological basis for the implementation of future IT specialists research activities towards the development and use of AR applications is substantiated. The content of the activities of the student's scientific club "Informatics studios" of Borys Grinchenko Kyiv University is developed. Students as part of the scientific club activity updated the mobile application, and the model bank corresponding to the topics: "Polyhedrons" for 11th grade, as well as "Functions, their properties and graphs" for 10th grade. The expediency of using software tools to develop a mobile application (Android Studio, SDK, NDK, QR Generator, FTDS Dev, Google Sceneform, Poly) is substantiated. The content of the stages of development of a mobile application is presented. As a result of a survey of students and pupils the positive impact of AR on the learning process is established.

In modern conditions, innovative augmented reality technologies are actively developing, which are widespread in many areas of human activity. Introduction of advanced developments in the process of professional training of future specialists of socionomic professions in the conditions of adaptive training, contributes to the implementation of the principles of a personalized approach and increase the overall level of competitiveness. The article "The use of augmented reality technologies in the development of emotional intelligence of future specialists of socionomic professions under the conditions of adaptive learning" [71] by Viacheslav V. Osadchyi, Hanna B. Varina (figure 16), Kateryna P. Osadcha, Olha V. Kovalova, Valentyna V. Voloshyna, Oleksii V. Sysoiev and Mariya P. Shyshkina is devoted to the theoretical and empirical analysis of the features of the implementation of augmented reality technologies in the construct of traditional psychological and pedagogical support aimed at the development of

Figure 15: Presentation of paper [90].

emotional intelligence of the future specialist. The interdisciplinary approach was used while carrying out the research work at the expense of the general fund of the state budget: "Adaptive system for individualization and personalization of professional training of future specialists in the conditions of blended learning". A comprehensive study of the implementation of traditional psychological-pedagogical and innovative augmented reality technologies was conducted in the framework of scientific cooperation of STEAM-Laboratory, Laboratory of Psychophysiological Research and Laboratory of Psychology of Health in Bogdan Khmelnitsky Melitopol State Pedagogical University. The theoretical analysis considers the structural model of emotional intelligence of the future specialist of socionomic professions, which is represented by two structural components: intrapersonal construct of emotional intelligence and interpersonal construct of emotional intelligence. Each component mediates the inherent emotional intelligence of interpretive, regulatory, adaptive, stress-protective and activating functions. The algorithm of the empirical block of research is presented by two stages: ascertaining and forming research. According to the results of the statement, low indicators were found on most scales, reflecting the general level of emotional intelligence development of future specialists, actualizing the need to find and implement effective measures for the development of emotional intelligence components in modern higher education and taking into account information development and digitalization. As part of the formative stage of the research implementation, a comprehensive program "Development of emotional intelligence of future professionals" was tested, which integrated traditional psychological and pedagogical technologies and innovative augmented reality technologies. This program is designed for 24 hours, 6 thematic classes of 4 hours. According to the results of a comprehensive ascertaining and shaping research, the effectiveness of the influence of augmented reality technologies on the general index of emotional intelligence is proved. The step-by-step model of integration of augmented reality components influencing the ability to analyze, understand and regulate emotional states into a complex program of emotional intelligence development is demonstrated. According to the results of the formative study, there is a dominance of high indicators of the following components: intrapersonal (50%), interpersonal (53.3%). Thus, we can say that intrapersonal and interpersonal emotional

intelligence together involve the actualization of various cognitive processes and skills, and are related to each other. Empirical data were obtained as a result of conducting a psychodiagnostic study on an innovative computer complex HC-psychotest.

This article highlights further research by the authors, begun in [91, 84, 85, 92, 93, 94, 95, 96, 97, 58].

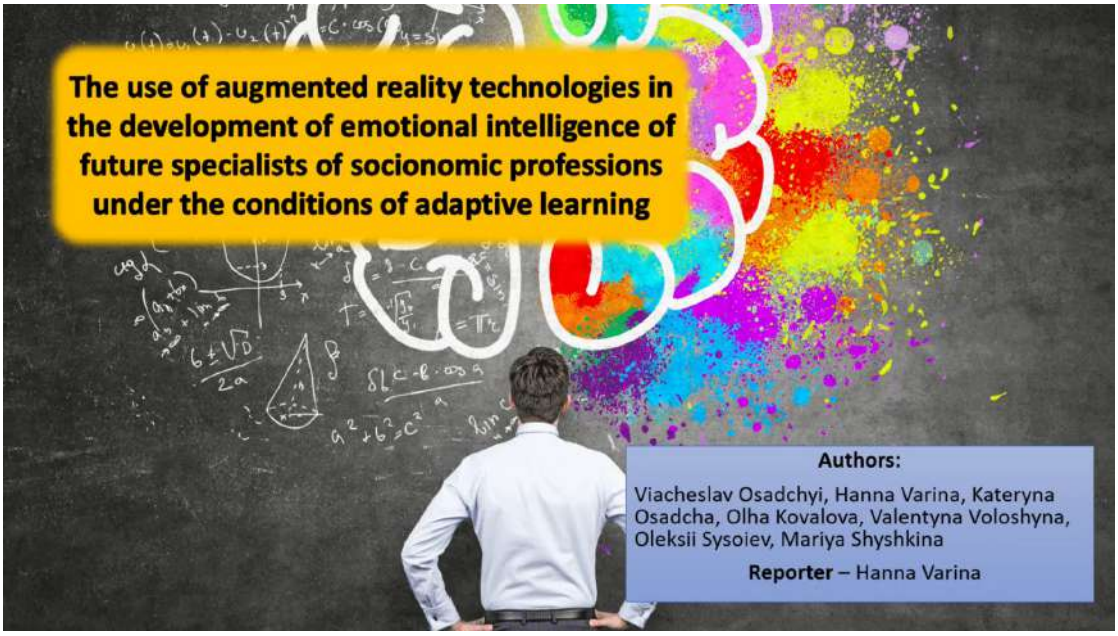

Figure 16: Presentation of paper [71].

The article "Development of the health-preserving competence of a physical education teacher on the basis of N. Bernstein's theory of movements construction using virtual reality technologies" [70] by Mykola B. Yevtuch, Vasyl M. Fedorets, Oksana V. Klochko (figure 17), Mariya P. Shyshkina and Alla V. Dobryden studies the results of the research aimed at the improvement of the methodology of development of the health-preserving competence of a Physical Education teacher in conditions of post-graduate education on the basis of Nikolai Bernstein's theory of movement construction using virtual reality technologies. Based on the use of AR/VR technologies a software application "Virtual Model Illustrating Nikolai Bernstein's Theory of Movement Construction" was developed. The stated model is one of the tools of the "Methodology of development of the health preserving competence of a Physical Education teacher on the basis of Nikolai Bernstein's theory of the levels of movement construction". The experimental study determines that the application of the virtual model within the stated methodology is an effective tool for the development of the health preserving competence of a Physical Education teacher. The application of the virtual model allows the actualization of the health preserving, conceptual, gnoseological, biomechanical, inclusive, corrective potentials of Nikolai Bernstein's theory of movement construction. The use of the virtual model presents the ways of targeted and meaningful use of Nikolai Bernstein's theory of the levels of movement

construction by a Physical Education teacher and the improvement of physical and recreational technologies and concrete physical exercises and movement modes. Due to the application of virtual reality tools, health-preserving, preventative, corrective and developmental strategies are being formed among which the significant ones are: “Application of synergistic movements to adaptation to movement activity, and recreation”, “Application of spatial movements for actualization of the orientation and search activities and development of spatial thinking”, “Use of movements with a complicated algorithm for intellect development”.

This article highlights further research by the authors, begun in [98, 99].

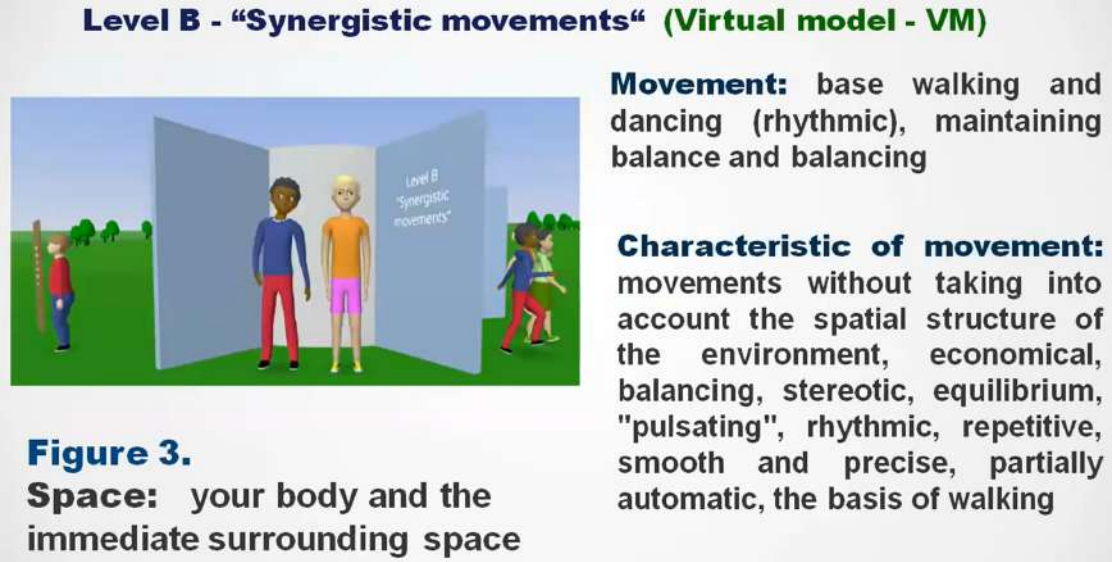

Figure 17: Presentation of paper [70].

The article “The usage of augmented reality technologies in professional training of future teachers of Ukrainian language and literature” [100] by Olha B. Petrovych, Alla P. Vinnichuk, Viktor P. Krupka, Iryna A. Zelenenka and Andrei V. Voznyak (figure 18) deals with the peculiarities of creation and practical application of augmented reality technologies for the organization of students-philologists’ individual and group work in studying the discipline “Methodic of teaching literature”. The relevance of the introduction of AR technologies for the future teachers-philologists’ readiness formation to the professional activity is substantiated. Analysis of the scientific sources suggested that the professional training process requires the modernization of teaching methods, and the usage of information and communication technologies (ICT) in education, in particular AR technologies, allows to make the learning process interesting and exciting. The domestic and foreign experience of AR technologies application into current educational practices is generalized. A step-by-step algorithm for creating the AR in the mobile application Unite and its subsequent content filling for professional training of future teachers of Ukrainian language and literature is described. The visualization of the educational content of the lepbook “Incredible Lesya Ukrainka”, made by students-philologists at the Mykhailo Stelmakh Faculty of Philology and Journalism of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical

University during the studying the discipline “Methodic of teaching literature”, is detailed. It is specified that the educational process is based on the creation AR with the visualization of interactive learning materials with animation, instructions, links, video content, illustrations etc. according to the rubrics of the lepbook. It is emphasized that the implementation of AR technologies provides the increasing of motivation for systematic mastering of practical skills, enhances students’ concentration and attention, increases their cognitive experience, promotes the development of their creative abilities, produces the opportunities of using the visualized content for students’ research work, stimulates them to self-expression, motivates them to self-development, trains them to the skillful use of the Internet, modern gadgets and mobile applications, etc. Prospects for studying the possibilities of using AR technologies in lessons of Ukrainian literature at secondary school are determined.

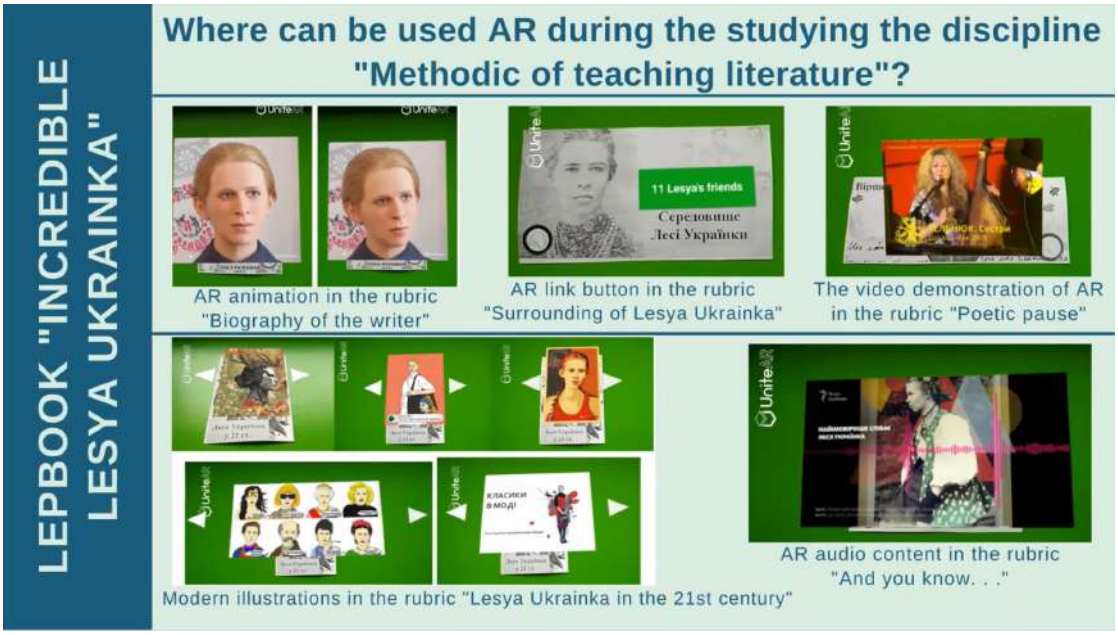

Figure 18: Presentation of paper [100].

The article ‘Formation of readiness of future teachers to use augmented reality in the educational process of preschool and primary education‘” [101] by Svitlana P. Palamar (figure 19), Ganna V. Bielienka, Tatyana O. Ponomarenko, Liudmyla V. Kozak, Liudmyla L. Nezhyva and Andrei V. Voznyak substantiates the importance of training future teachers to use AR technologies in the educational process of preschool and primary education. Scientific sources on the problem of AR application in education are analyzed. Possibilities of using AR in work with preschoolers and junior schoolchildren are considered. Aspects of research of the problem of introduction of AR in education carried out by modern foreign and domestic scientists are defined, namely: use of AR-applications in education; introduction of 3D technologies, virtual and augmented reality in the educational process of preschool and primary school; 3D, virtual and augmented reality technologies in higher education; increase of the efficiency of learning and motivating students

through the use of AR-applications on smartphones; formation of reading culture by means of augmented reality technology; prospects for the use of augmented reality within the linguistic and literary field of preschool and primary education. The authors analyzed the specifics of toys with AR-applications, interactive alphabets, coloring books, encyclopedias and art books of Ukrainian and foreign writers, which should be used in working with children of preschool and primary school age; the possibilities of books for preschool children created with the help of augmented reality technologies are demonstrated. The relevance of the use of AR for the effective education and development of preschoolers and primary school children is determined. Problems in the application of AR in the educational process of modern domestic preschool education institutions are outlined. A method of diagnostic research of the level and features of readiness of future teachers to use AR in the educational process of preschool and primary education has been developed. Criteria, indicators are defined, the levels of development of the main components of the studied readiness (motivational, cognitive, activity) are characterized. The insufficiency of its formation in future teachers in the field of preschool and primary education; inconsistency between the peculiarities of training future teachers to use AR in professional activities and modern requirements for the quality of the educational process; the need to develop and implement a holistic system of formation of the studied readiness of future teachers in the conditions of higher pedagogical education are proved. A model of forming the readiness of future teachers to use AR in the educational process of preschool and primary education has been developed.

This article highlights further research by the authors, begun in [102].

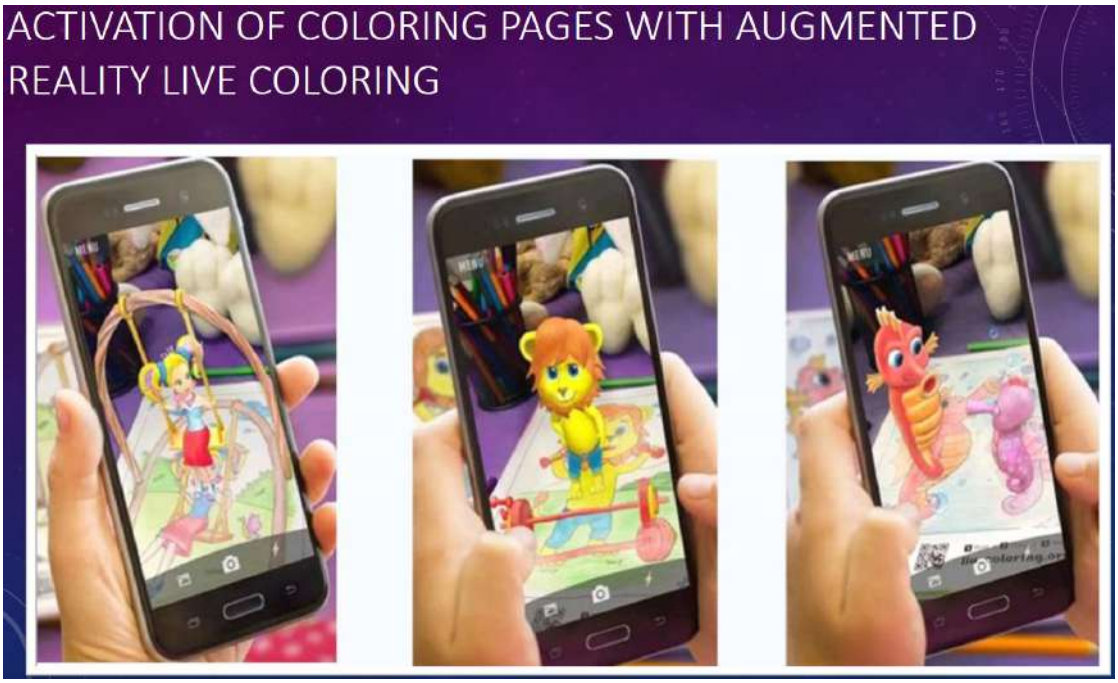

Figure 19: Presentation of paper [101].

3. Conclusion

The fourth installment of AREdu was organized by Kryvyi Rih National University (with support of the rector Mykola I. Stupnik) in collaboration with Kryvyi Rih State Pedagogical University (with support of the rector Yaroslav V. Shramko), Institute of Information Technologies and Learning Tools of the NAES of Ukraine (with support of the director Valeriy Yu. Bykov) and University of Educational Management (with support of the vice-rector for research and digitalization Oleg M. Spirin).

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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 2022.

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