AREdu 2020 – How augmented reality helps during the coronavirus pandemic

Oleksandr Yu. Burov[1[0000-0003-0733-1120]], Arnold E. Kiv[2[0000-0002-0991-2343]], Serhiy O. Semerikov[1,3,4[0000-0003-0789-0272]], Andrii M. Striuk[4[0000-0001-9240-1976]], Mykola I. Striuk[4[0000-0002-7456-3725]], Larisa S. Kolgatina[5[0000-0003-2650-8921]] and Iryna V. Oliinyk[6[0000-0002-1749-1518]]

[1] Institute of Information Technologies and Learning Tools of the NAES of Ukraine, 9 M. Berlynskoho Str., Kyiv, 04060, Ukraine
burov.alexander@gmail.com
[2] Ben-Gurion University of the Negev, P.O.B. 653, Beer Sheva, 8410501, Israel
kiv.arnold20@gmail.com
[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, stryukm@gmail.com
[5] H. S. Skovoroda Kharkiv National Pedagogical University, 29 Alchevskyh Str., Kharkiv, 61002, Ukraine
larakl@ukr.net
[6] Alfred Nobel University, 18 Sicheslavska Naberezhna Str., Dnipro, 49000, Ukraine
iv_oliynik@ukr.net

Abstract. This is an introductory text to a collection of papers from the AREdu 2029: The 3rd International Workshop on Augmented Reality in Education, which was held in Kryvyi Rih, Ukraine, on the May 13, 2020. 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 2020 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 since 2018 [20; 21]:

- 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 3rd International Workshop on Augmented Reality in Education (AREdu 2020), held in Kryvyi Rih, Ukraine, in May 13, 2020. It comprises 23 contributed papers that were carefully peer-reviewed and selected from 41 submissions. Each submission was reviewed by at least 3, and on the average 3.2, 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.

2 AREdu 2020 program committee

2.1 Core members

Dr. **Oleksandr Burov**, Dr.Sc., Leading Researcher, Institute of Information Technology and Learning Tools, National Academy of Pedagogic Science of Ukraine

Oleksandr Burov, born in 1953. Educational Background: Dr.Sc. (Eng.), 2007, science field “Ergonomics”. Ph.D., 1990, science field “Control in biological and medical systems”. National Technical University (Kyiv), Applied Mathematic Department, M.Sc. diploma, 1977. Area of professional interests: Cognitive work, intelligence, human factors/ergonomics, psychophysiology of mental activity. Professional expertise: Psychophysiological assessment of human performance, functional state and prediction of operators’ fitness for duty and performance (power industry, space, aviation). Field of application: Space, aviation, power industry, education and talent development.

E-mail: ayb@iitltl.gov.ua

Ing. **Helena Fidlerová**, Ph.D., a senior researcher at the Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava, Institute of Industrial Engineering and Management

Ing. Helena Fidlerová, Ph.D. received her Ph.D. degree in the field of Industrial Management in 2006. Her research aims at issues of education, STEM education, digital competences, Industry 4.0, Education 4.0, logistics, industrial engineering, and the application of statistical methods. She is author of several monographs and chapters of monographs, over 87 research papers in journals and proceedings. Since her study has extensive experience in domestic research projects VEGA, KEGA, and international projects e.g. ALTECS - Knowledge exchange in the framework of alternative economic systems for the promotion of sustainable regional development; International Visegrad Fund No. 21310155: Festival of Science as a Platform for Intensifying Cooperation between V4 Region Universities; and International Visegrad Fund No. -21810100: Academic Research Consortium integrating databases, robotics, and language technologies. She is a member of the Slovak Statistical and Demographic Society (SDSS) and the foreign organization International Association of Engineers (IAENG).

WWWL https://orcid.org/0000-0002-3426-5803
E-mail: helena.fidlerova@stuba.sk

Dr. **Irina Georgescu**, Lecturer of Computational Intelligence, Department of Economic Informatics and Cybernetics, Bucharest University of Economics, Bucharest, Romania

Irina Georgescu holds a Ph.D. in Economics from Turku Centre for Computer Science, Turku, Finland. Currently she is a lecturer at the Department of Economic Informatics and Cybernetics, Bucharest Academy of Economic Studies. Her research interests lie in the areas of econometrics, computational intelligence and risk theory. She is the author of about 50 journal papers and several books.

E-mail: irina.georgescu@csie.ase.ro

Dr. **Filip Górski**, Assistant Professor, Faculty of Mechanical Engineering and Management, Poznan University of Technology, Poland

E-mail: filip.gorski@put.poznan.pl

Dr. **Dragoș Daniel Iordache**, Researcher ICI Bucharest, Romania

Dragoș Daniel IORDACHE is a scientific researcher 2nd degree in the "Systems and Applications for Society" department of ICI Bucharest and university lecturer at the Faculty of Psychology and Educational Sciences from University of Bucharest. He received the PhD degree in Science of Education from the University of Bucharest in 2012. His research interests include: virtual learning environments, augmented reality, usability and pedagogical evaluation of e-Learning systems, user testing and heuristic evaluation of interactive systems.

https://www.researchgate.net/profile/Dragos_Iordache
E-mail: dragos.iordache@ici.ro

Prof. **M.-Carmen Juan** has a Ph.D. in Computer Science (2000) from the Universitat Politècnica de València (UPV). She has been a professor at the UPV since 1996 and a Full Professor since 2014. Her areas of interest include: computer graphics, virtual and augmented reality, advanced user interfaces and their applications to psychology, medicine, and education-entertainment.

WWW: http://personales.upv.es/mjuanli/
http://www.upv.es/ficha-personal/mjuanli
E-mail: mcarmen@dsic.upv.es

Dr. **Gábor Kiss**, PhD, Associate Professor at Department of Informatics, J. Selye University, Slovakia

E-mail: kissga@ujs.sk

Prof. **Arnold Kiv**, Ben-Gurion University of the Negev, Beer Sheva, Israel

Arnold Kiv received the D. Sc. (Dr. Hab.) degree in solid state physics from Tartu Institute of Physics, in 1978. From 1964 to 1982, he was a Senior Researcher and a Head of the Laboratory of Radiation Effects, Institute of Nuclear Physics, Academy of Sciences, Uzbekistan. From 1983 to 1998, he was a Head of the Department of Theoretical Physics, South-Ukrainian National

Pedagogical University. In 1997 he was an Invited Professor, Western Ontario University, Canada. From 1999 to the present, he is a Professor-Researcher in the Department of Materials Engineering, Ben-Gurion University of the Negev, Israel. In 1996 and 2011 he was co-Director of NATO Advanced research Workshops and an Editor of two NATO Series books. He has about 300 publications, three monographs and three Invention Certificates in the field of radiation effects in solid state electronics. His research interests include mechanisms of formation of radiation defects in solids, radiation methods in microelectronics, computer simulation in natural and humanitarian sciences.

WWW: https://www.researchgate.net/profile/Arik_Kiv

Prof. **Hennadiy Kravtsov**, PhD, Head of Department, Associate Professor of Chair of Informatics, Software Engineering and Economic Cybernetics, Kherson State University, Ukraine

WWW: http://www.kspu.edu/About/Faculty/FPhysMathemInformatics/ChairInformatics/Staff/Kravtsov.aspx?lang=en

Dr. **Lukáš Pichl**, Senior Associate Professor of Information Science, Department of Natural Sciences, International Christian University, Mitaka, Tokyo, Japan

Lukáš Pichl, born in 1974, received his Ph.D. from the Graduate University of Advanced Studies in 2000. Since 2001 he taught computer science in the University of Aizu, before joining the International Christian University in 2005. His current field of specialization is time series analysis and machine learning algorithms for the analysis of economic data including cryptocurrencies. Dr. Pichl has published a number of papers in international journals; he is a member of ACM and IEEE Computer Society, and currently serves as an associate editor of the Journal of Economic Interaction and Coordination (Springer).

E-mail: lukas@icu.ac.jp

Dr. **Nina Rizun**, PhD, assistant professor at the Faculty of Management and Economics, Gdańsk University of Technology, Poland

In October 1999 she obtained a PhD degree in technical sciences in the Faculty of Enterprise Economy and Production Organization, National Mining Academy, Dnipropetrovsk, Ukraine. PhD thesis title: Development of Complex Subsystem of the Organization and Planning of Mining and Transport Processes. In the years 1993-2000 she worked at the Department of Computer Science in the Metallurgical Academy, Dnipro, Ukraine. In the years 2000-2016 - at the Department of Economic Cybernetics and Mathematical Methods at the Alfred Nobel University, Dnipro, Ukraine. Since 2016, she has been working at the Department of Informatics in Management at the Faculty of Management and Economics of the Gdańsk University of Technology. Research Interests: Semantic analysis of the text in the natural language, Structuring and classification of web content, Decision-making logic modelling.

WWW: http://pg.edu.pl/ninrizun
E-mail: ninrizun@pg.edu.pl

Dr. **Mariya Shyshkina**, Head of Department of Cloud-based Systems for Education Informatization of the Institute of Information Technologies and Learning Tools of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine

Mariya Shyshkina, born in 1969, received a Candidate of Philosophical Sciences degree (PhD, Philosophy) from the Institute of Philosophy of the National Academy of Sciences of Ukraine, Kyiv, Ukraine, 1999, and a Doctor of Educational Sciences degree (Dr. habil.) from the Institute of Information Technologies and Learning Tools of the National Academy of Educational Sciences of Ukraine, 2016, Kyiv, Ukraine. Since 1999, she has been working in the field of information and communication technologies for education at the Institute of Information Technologies and Learning Tools of NAES of Ukraine where she is currently a chief of a department. Her research interests include philosophy of education, ICT for learning and research. She has published a number of papers in international journals and volumes in book series, is a member of editorial board of Information Technologies and Learning Tools Journal.

WWW: http://iitlt.gov.ua/eng/structure/departments/cloud/detail.php?ID=269
E-mail: shyshkina@iitlt.gov.ua

Dr. **Kateryna Vlasenko**, Professor of Mathematics, Head of the Mathematics and Modeling Department, Donbas State Engineering Academy, Kramatorsk, Ukraine

Kateryna Vlasenko, born in 1966, received a Candidate of Pedagogical Sciences degree (PhD) from the National Pedagogical Dragomanov University, Ukraine, in 2004, and a Doctor of Pedagogical Sciences degree (D.Sc. in Educational Science) from the Bohdan Khmelnytsky National University of Cherkasy, in 2011. Since 2008, she has been working in the field of mathematical and pedagogical modeling at Donbas State Engineering Academy, where she is currently head of the Mathematics and Modeling Department. Her research interests include the issues of mathematics education. She has published a number of papers in international journals and volumes in book series, is a member of editorial boards of Innovative Solutions in Modern Science, Topical Issues of Natural and Mathematical Education Sumy State Pedagogical University named after A. Makarenko.

WWW: http://formathematics.com/
E-mail: vlasenkokv@ukr.net

2.2 Additional reviewers

Dr. **Olga Bondarenko**, Candidate of Pedagogical Sciences, Associate Professor, Department of Economic and Social Geography and Methods of Teaching, Kryvyi Rih State Pedagogical University, Kryvyi Rih, Ukraine

Olga Bondarenko, born in 1979, in 2001 graduated with honors from the geographical faculty of Krivoy Rog State Pedagogical University, majoring in “Pedagogy and Methodology of Secondary Education. Geography and Biology”, acquired Bachelor Degree. In 2002 she received a Master Degree with honors in the major “Pedagogy and Methodology of Secondary Education. Geography”, qualified as a teacher of geography. In 2009, she successfully defended her Ph.D. thesis at the Republican Higher Educational Institution “Crimean Humanities University” (Yalta) and received a Ph.D. in Pedagogical Sciences. Since 2005 he has been working at Kryvyi Rih State Pedagogical University. Author of a number of scientific publications on vocational education, training of future teachers for pedagogical activity. Her research interests include

teacher training, the use of ICTs and GIS technologies in the educational process.

WWW: https://kdpu.edu.ua/personal/ovbondarenko.html
E-mail: bondarenko.olga@kdpu.edu.ua

Dr. **Roman Danel**, researcher at Department of Mechanical Engineering, Faculty of Technology, Institute of Technology and Businesses (VŠTE) in České Budějovice, Czechia and assistant at Department of Applied Informatics, Faculty of Economics, VŠB-Technical university of Ostrava, Czechia.

Roman Danel, born in 1967, spent 18 years in commercial practice in the field of IT / ICT, where he worked as an analyst, senior programmer, database and system administrator, project manager in information systems development, branch manager and for 4 years ran his own company specializing in SW supplies for industrial systems. He has been working at the university since 2009, in 2012-2017 he was the head of the automation department at the Faculty of Mining and Geology, VŠB-Technical university of Ostrava. Since 2012, he has also been lecturing at University of Economy Bydgoszcz (WSG), Poland. His research interests include information systems and automatic control in industry, databases, software engineering and business information systems.

E-mail: danel@rdanel.cz

Prof. **Vita Hamaniuk**, Doctor of science (pedagogical sciences), professor of the Department of German, Literature and Didactics, Kryvyi Rih State Pedagogical University, Kryvyi Rih, Ukraine

Vita Hamaniuk, born in 1965, Education – Dnipropetrovsk State University (1988), received a Candidate of Pedagogical Sciences degree (Ph.D.) from the Charkiv National Pedagogical Skovoroda University, Kryvyi Rih, Ukraine, in 1995, a Doctor of Sciences degree from East-Ukrainian National Wolodymyr Dahl University, Lugansk, Ukraine, in 2013. Since 2002 has been working at the Department of German, Literature and didactics at the Kryvyi Rih State Pedagogical University where she is currently professor. Her research interests include foreign languages teaching and learning, didactics of multilingualism, e-learning, blended learning, comparative researches in Education. She has published a number of papers in Ukrainian and

international journals, actively participates in international conferences and projects.

WWW: https://kdpu.edu.ua/personal/vagamanuk.html
E-mail: vitana65@gmail.com

Hamraz Javaheri, M.Sc., German Research Center for Artificial Intelligence (DFKI), Germany

Research interests: Augmented reality, Artificial Intelligence, General surgery, Education, Wearables

WWW: https://www.dfki.de/en/web/about-us/employee/person/haja01/
E-mail: Hamraz.Javaheri@dfki.de

Dr. **Christos Kaltsidis**, ICT Teacher, PhD Candidate at Democritus University of Thrace, Greece.

He is an ICT teacher in secondary education since 2003. He has studied Computer Science at the TEI of Thessaloniki and has a master's degree in Adult Education from the Hellenic Open University. He is a PhD candidate at the Department of Molecular Biology and Genetics of the Democritus University of Thrace and his research interests include the adaption of virtual reality in education, university pedagogy, and distance education. He actively participates in actions for Safer Internet usage by students and parents and he is passionate about developing online applications.

WWW: http://utopia.duth.gr/ckaltsid
E-mail: ckaltsid@mbg.duth.gr

Dr. **Oleksandr Kolgatin**, Professor of Information System Chair, Department of Economic Informatics, Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine

Oleksandr Kolgatin received a Candidate of Technical Sciences degree (Ph.D.) from the Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine in 1995 and a Doctor of Pedagogical Sciences degree from the Institute of Information Technologies and Learning Tools of the National Academy of Educational Sciences of Ukraine in 2011. His research interests include computational modelling, information and communication technologies in education, and

pedagogical diagnostics. He has published a number of papers in Ukrainian and international journals, is a member of editorial boards of Journal of Information Technologies in Education and an associate editor of Information Technologies and Learning Tools.

WWW: https://orcid.org/0000-0001-8423-2359

Assoc. Prof. **Yaroslav Krainyk**, Head of Computer Engineering Department, Petro Mohyla Black Sea National University, Mykolaiv, Ukraine

Yaroslav Krainyk, born in 1990, received a Ph.D. degree in Computer Systems and Components from Petro Mohyla Black Sea State University, Ukraine, in 2016. His research interests include computer systems and their applications, embedded systems, reconfigurable computing, FPGA. Since 2016, he has been a member of Computer Engineering Department as a senior lecturer, doctoral student, and associate professor. In 2019, he became a head of Computer Engineering Department. He has participated in the reviewing of papers published by Elsevier, IEEE, and Springer. He is a section editor in Computer Science & Engineering Journal (https://cse-journal.com/index.php/journal).

WWW: https://orcid.org/0000-0002-7924-3878
E-mail: yaroslav.krainyk@chmnu.edu.ua

Dr. **Volodymyr Kukharenko**, Professor of Technical Cryophisics Department, National Technical University “Kharkiv Polytechnic Institute”, Kharkiv, Ukraine

Volodymyr Kukharenko, born in 1947, received a Candidate of Technical Sciences degree from Physical Technic Institute of Low Temperature National Academy of Sciences of Ukraine. Since 1976, he has been working in the field of low temperature at the National Technical University “Kharkiv Polytechnic Institute”, where he is professor of Technical Cryophysics Department and academician of International Academy of Refrigeration UD. His research interests include distance learning. He has published a number of papers in international journals and six books from creating distance courses, about tutor, blended learning.

WWW: https://dl.khpi.edu.ua

E-mail: kukharenkovn@gmail.com

Dr. **Svitlana Lytvynova**, Head of the Open Learning Environment Technology Department, Institute of Information Technologies and Learning Tools of the National Academy of Education Sciences of Ukraine, Kiev, Ukraine

Svitlana Lytvynova, born in 1964, in 2011 received a degree of Candidate of Pedagogical Sciences (Ph.D.) at the Institute of Information Technologies and Learning Tools of the National Academy of Education Sciences of Ukraine. In 2017, received a degree of Doctorate of Pedagogical Sciences at the Institute of Information Technologies and Learning Tools of the National Academy of Education Sciences of Ukraine. Since 2004, she has been working on the development, implementation and use of information and communication technologies in educational practice. Her research interests include improving the quality of the educational environment of educational institutions and the continuous development of educators. She is a MIE Expert Microsoft Education. She has published a number of articles in international scientific journals and book series volumes, is a member of the editorial boards of the journal “Information Technologies and Teaching Tools” (Web of Science) and the professional publication “Computer at School and Family”.

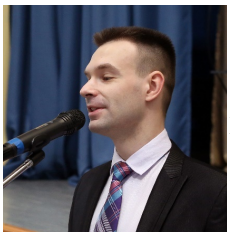
WWW: https://www.facebook.com/slytvynova
E-mail: s.h.lytvynova@gmail.com

Ph. D. **Iryna Mintii**, Associate Professor of Computer Science, Department of Computer Science and Applied Mathematics, Kryvyi Rih State Pedadogical University, Kryvyi Rih, Ukraine.

Iryna Mintii, born in 1983, received a Candidate of Pedagogical Sciences degree (Ph. D.) from the National Pedagogical Dragomanov University, Kiev, Ukraine, in 2013. Her research interests include ICT in education. She has published a number of papers in international journals.

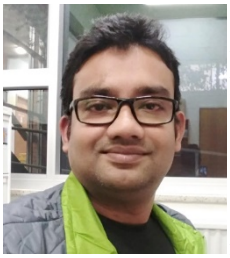
WWW: https://kdpu.edu.ua/personal/ismintii.html
E-mail: irina.mintiy@kdpu.edu.ua

Dr. **Andrii Morozov**, Candidate of Technical Sciences (Ph.D.), Associate Professor, Department of Computer Science, Zhytomyr Polytechnic State University, Zhytomyr, Ukraine



Andrii Morozov, born in 1985, received a Candidate of Technical Sciences degree (Dr. phil.). From 2006 he works at the Zhytomyr Polytechnic State University as an assistant, associate professor, head of department, dean of the faculty, vice-rector for scientific and pedagogical work. His research interests include transport logistics, discrete optimization, information and communication technologies in education. He has published a number of papers in international journals and volumes in book series, is a member of editorial boards of scientific professional edition of Ukraine “Technical Engineering”.

WWW: https://www.facebook.com/morozov.andriy
E-mail: morozov@ztu.edu.ua



Ranesh Kumar Naha, is a casual academic staff member at the University of Tasmania, Australia. He is currently pursuing his Ph.D. studies on reliable resource allocation and scheduling in the Fog computing environment with the same university.

Ranesh Kumar Naha has been awarded a Tasmania Graduate Research Scholarship (TGRS) to support his Ph.D. studies. He received his Master of Science (M.Sc.) degree from Universiti Putra Malaysia, in 2015. He has been awarded a prestigious Commonwealth Scholarship provided by the Ministry of Higher Education, Malaysia. His research interests include wired and wireless networks, parallel and distributed computing, security, Blockchain, Cloud computing, Internet of Things (IoT) and Fog/Edge computing.

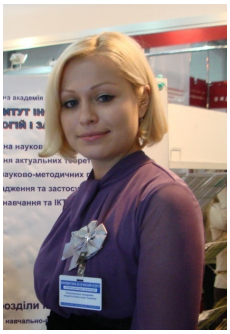
E-mail: raneshkumar.naha@utas.edu.au

Dr. **Pavlo Nechypurenko**, Assistant Professor of Department of Chemistry and Methods of its Teaching, Kryvyi Rih State Pedagogical University, Kryvyi Rih, Ukraine

Pavlo Nechypurenko, born in 1981, received a Magister of Teaching of Chemistry from Kryvyi Rih State Pedagogical University, Ukraine, in 2004, and a Candidate of Pedagogical Sciences degree (Dr. phil.) from the Luhansk Taras Shevchenko National University, Ukraine, in 2017. Since 2004, he has been working in the field of analytical chemistry and method of solving chemical problems at the Kryvyi Rih State Pedagogical University. His research interests include using of ICT on Chemistry education, Analytical Chemistry, Technique of

chemical experiment. He has published a number of papers in Ukrainian and international journals and developed a series of virtual laboratory work to teaching chemistry.

E-mail: acinonyxleo@gmail.com, acinonyxleo@kdpu.edu.ua



Dr. **Yulia Nosenko**, Leading Researcher, Department of Cloud-Oriented Systems of Education Informatization, Institute of Information Technologies and Learning Tools of NAES of Ukraine, Kyiv, Ukraine

Yulia Nosenko, born in 1984, received a Candidate of Pedagogical Sciences degree (Dr. phil.) in 2011. In 2010-2015 worked at Taras Shevchenko National University of Kiev (part time). Since 2010 has been working at the Institute of Information Technologies and Learning Tools of National Academy of Educational Sciences of Ukraine, where she is currently leading researcher. Her research interests relates to implementation and use of cloud services in education, formation and development of educators' digital competence, use of ICT as a tool for supporting inclusive learning. She has published over 70 scientific papers, including articles in international journals, is a member of editorial board of peer-reviewed e-journal "Information Technologies and Learning Tools".

WWW: http://iitlt.gov.ua/structure/departments/cloud/detail.php?ID=48
E-mail: nosenko@iitlt.gov.ua

Dr. **Vasyl Oleksiuk**, PhD (pedagogical sciences), associate professor of the Department of Computer Science and Teaching Techniques, Ternopil Volodymyr Hnatiuk National Pedagogical University, Ternopil, Ukraine

Vasyl Oleksiuk, born in 1980, received a Candidate of Pedagogical Sciences degree (Dr. phil.) from the National Pedagogical University, Kyiv, Ukraine, in 2007. Since 2003, he has been working Department of Computer Science and Teaching Techniques at Ternopil Volodymyr Hnatiuk National Pedagogical University, where he is currently associate professor. His research interests include computer networks, cloud computing, e-learning, electronic libraries. He has published a number of papers in Ukrainian and international journals, is a member of editorial boards of the journals Information Technologies and Learning Tools (Institute of

Information Technologies and Learning Tools of NAES of Ukraine) and The Scientific Issues of Ternopil Volodymyr Hnatiuk National Pedagogical University (Series: pedagogy).

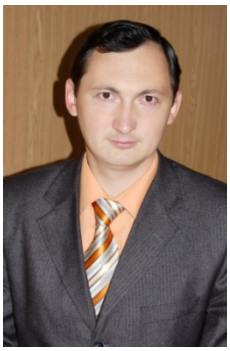
WWW: http://kafinf.tnpu.edu.ua/en/teachers/oleksuk_v-p/#
E-mail: oleksyuk@fizmat.tnpu.edu.ua

Dr. **Kateryna Osadcha**, Full Professor, Department of Computer Science and Cybernetics, Bogdan Khmelnitsky Melitopol state pedagogical university, Melitopol, Ukraine

Kateryna Osadcha, born in 1977, received a Doctor of Pedagogical Sciences (DSc in Education) from the Classic Private University, Ukraine, in 2020. Since 2011, she has been working as an professor of the Department of Computer Science and Cybernetics at the Bogdan Khmelnitsky Melitopol state pedagogical university.

Her research interests include: computer science, network technology, programming, ICT, e-learning, engineering education, educational technology, tutoring. She is author of about a hundred scientific works, including textbooks, monographs, author's certificates. She is a member of editorial boards of “Ukrainian Journal of Educational Studies and Information Technology” (Ukraine), “International Conference on Higher Education Advances” (Spain), “Transactions of Kremenchuk Mykhailo Ostrohradskyi National University” (Ukraine), “Professional Education: Methodology, Theory and Technologies” (Ukraine).

WWW: https://www.facebook.com/kosadca
E-mail: okp@mdpu.org.ua



Dr. **Viacheslav Osadchyi**, Professor of Department of Computer Science and Cybernetics, Bogdan Khmelnitsky Melitopol state pedagogical university, Melitopol, Ukraine

Viacheslav Osadchyi, born in 1975, received a Candidate of Pedagogical Sciences (PhD in Education) from the Vinnytsia State Pedagogical University named after Mykhailo Kotsiubynsky, Ukraine, in 2006, and a Doctor of Pedagogical Sciences from the Vinnytsia State Pedagogical University named after Mykhailo Kotsiubynsky, Ukraine, in 2013.

Since 1999, he has been working in the field of information technology and vocational education at the Bogdan Khmelnitsky

Melitopol state pedagogical university. Now – Head of the Department of Computer Science.

His research interests include: computer science, information networks, ICT, programming, software development, information systems, data science. He has published a number of papers in international journals.

He is a member of editorial boards of “Ukrainian Journal of Educational Studies and Information Technology” (Ukraine), “International Conference on Higher Education Advances” (Spain), “Transactions of Kremenchuk Mykhailo Ostrohradskyi National University” (Ukraine), “Information Technologies and Learning Tools” (Ukraine), “Scientific papers of Berdyansk State Pedagogical University Series: Pedagogical sciences” (Ukraine).

WWW: http://osadchyi.mdpu.org.ua/
E-mail: poliform55@gmail.com

Dr. **Liubov Panchenko**, Professor at the Department of Sociology, National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, Kyiv, Ukraine

Liubov Panchenko was awarded a Candidate of Pedagogical Sciences degree (Dr. phil.) from H. S. Skovoroda Kharkiv National Pedagogical University, Kharkiv, Ukraine, in 1995, and a Doctor of Pedagogical Sciences degree (Dr. habil.) from the Luhansk Taras Shevchenko National University, in 2012. Since 1993, she has been working in the field of information and communication technology in education. Since 2016 she has been a Professor at the Department of Sociology, National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”. Her research interests include information and communication technology in education, university’s educational environment, MOOCs, data analysis and multivariate methods in scientific research, digital storytelling, adult education. She has published a number of papers and text books (“Computer data analysis”, “Data analysis practicum”) and is an editorial board member of the Ukrainian journals “Information Technologies and Learning Tools” (associated editor), “e-Environment of Modern University”, and “Humanization of the educational process”.

WWW: http://www.sociology.kpi.ua/en/faculty-2
E-mail: lubov.felixovna@gmail.com

Dr. **Olga Pinchuk**, Deputy Director for Scientific Experimental Work, Leading Researcher. PhD (in Pedagogics), Senior Researcher in the field of information and communication technologies in education, Institute of Information Technologies and Learning Tools of the NAES of Ukraine

Education: M.P. Drahomanov Kyiv State Pedagogical Institute in specialties of Mathematics, Computer Science and Computer Engineering teacher. Currently the experience in teaching is 25 years. Since 2005 I work in the Institute of Information Technologies and Learning Tools of the NAES of Ukraine. I worked on the implementation of the tasks of the scientific research works "Scientific and methodological foundations use of computer oriented tools in teaching natural and mathematical subjects in profile School", "Scientific and methodological principles of organization of distance learning environment in secondary schools", "Methodology of design network resource centers of distance education of secondary schools", "Formation of information and educational environment for learning high school students through technology electronic social networks" (Head of Scientific Research). I have more than 80 published scientific works, the author of collective monographs, manuals. I also obtain the post of co-editors-in-chief of "Information Technologies and Learning Tools", a bimonthly peer-reviewed e-journal in educational sphere, publishing full-text articles online with immediate open-access.

WWW: http://iitlt.gov.ua/
E-mail: opinchuk@iitlt.gov.ua

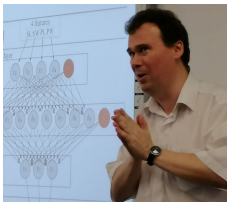
Dr. **Oleg Pursky**, Professor of Computer Science and Information Systems, Head of Department of Computer Science and Information Systems, Kyiv National University of Trade and Economics, Kyiv, Ukraine

Oleg Pursky, born in 1967, received a Candidate of Sciences in Physics and Mathematics degree (Dr. phil.) from the Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, in 2001, and a Doctor of Sciences in Physics and Mathematics degree (Dr. habil.) from the Taras Shevchenko National University of Kyiv, Ukraine, in 2010. His research interests include informational systems development, computer simulation and modeling of socio-economic systems. He has published a number of papers in

international journals, monographs and volumes in book series, is a member of editorial board of International Journal of Economic Theory and Application, reviewer of scientific journals International Journal of Modern Physics (B) and Heat Transfer and certified Data Science & Machine Learning specialist. He is a member of Scientific Council section of Ukrainian Ministry of Education and Science on the specialty "Informatics and Cybernetics". Currently, he is working as a Head of Department of Computer Science and Information Systems, Kyiv National University of Trade and Economics.

WWW: https://knute.edu.ua/blog/read/?pid=12695&uk
E-mail: Pursky_O@ukr.net

Dr. **Natalya Rashevska**, PhD, Kryvyi Rih National University, Ukraine



Dr. **Serhiy Semerikov**, Professor of Computer Science and Educational technology, Kryvyi Rih State Pedagogical University, Ukraine

Serhiy Semerikov had studied Mathematics and Computer Science at Kryvyi Rih State Pedagogical University, Ukraine in 1993-1998. He has obtained an MA Diploma in Mathematics and Computer Science and MS Diploma in Mathematics at Kryvyi Rih State Pedagogical University in 1998 (cum laude). In 2001 he was awarded a PhD degree in Computer Science Education at Dragomanov National Pedagogical University, Ukraine. In 2002 he received his habilitation as the Docent (Assoc. Prof.) at the Department of Computer Science and Applied Mathematics of Kryvyi Rih State Pedagogical University. In 2009 he was awarded a DrSc degree in Computer Science Education at Dragomanov National Pedagogical University, Ukraine. In 2011 he received his habilitation as the Professor (Full Prof.) at the Department of Fundamental Disciplines of National Metallurgical Academy of Ukraine.

From July till September 1998 Mr. Semerikov worked as a head of Research Laboratory of Department of Computer Science and Applied Mathematics at Kryviy Rih State Pedagogical University. From September 1999 till now he works at Kryviy Rih State Pedagogical University at various positions: Assistant Professor, Associate Professor, Head of Department, Full Professor. In 2010-2016 he was affiliated as a visiting professor at National Metallurgical Academy of Ukraine and Kryviy Rih National University.

Since 1997 he took and is taking part as a researcher, senior researcher, principal researcher in many research and RTD projects funded by Ukrainian Ministry of Education and Science, International Renaissance Foundation, Kryviy Rih National University. Since 2010 he works at the Institute of Information Technologies and Learning Tools of the NAES of Ukraine, Ukraine at the research positions.

Since 1999 Dr. Semerikov teaches undergraduate and graduate courses in Computer Modelling, Operating Systems, Architectures of Computer Systems, System Programming, Econometry, Data Compression Techniques, Programming Theory, Artificial Intelligence, the Machine Learning and Pattern Recognition, Quantum Programming, ICT in Education, Advances in ICT, the Software Engineering and Programming Technologies, Functional Programming. He supervised over 100 successfully accomplished master theses and 11 PhDs. He has also been the member of about 50 PhD Committees.

Dr. Semerikov has published over 300 papers as journal articles, book chapters, refereed conference and workshop contributions. He also co-edited or (co-)authored several proceedings volumes and textbooks. He serves as a member of Editorial Advisory Boards, Editorial Review Boards of international journals, a program committee member of many international conferences and workshops.

Dr. Semerikov is the founder and the co-head of the Joint Laboratory on Cloud Technologies in Education (CTE) at Kryvyi Rih National University.

WWW: https://kdpu.edu.ua/semerikov/
E-mail: semerikov@gmail.com

Dr. **Yevhenii Shapovalov**, a researcher at Junior Academy of Science of Ukraine, Chief Specialist at Ministry of Digital Transformation of Ukraine

Yevhenii Shapovalov was born in 1992. He defended Ph.D. in 2019 in the field of Biotechnology at the National University of life and environmental sciences of Ukraine. Since 2014 worked in the National Academy of Science of Ukraine where he provided chemical laboratory, work in science in the field of computer sciences. Science 2020 starts working at the Ministry of Digital Transformation of Ukraine. He was a participant of 3 international Jean Monnet projects related to implementing European standards in Educational programs on Environmental Sciences and Sustainable development.

WWW: http://www.nas.gov.ua/UA/PersonalSite/Pages/default.aspx?PersonID=0000026333
E-mail: sjb@man.gov.ua

Dr. **Andrii Striuk**, Ph.D., Head of Simulation and Software Engineering department of Kryvyi Rih National University, Kryvyi Rih, Ukraine

Andrii Striuk, born in 1979. In 2000 he graduated from the Kryvyi Rih Technical University with a degree in Automated Systems Software. In 2001, he received a master's degree in computer science. Has been working at the Department of Modeling and Software of Kryvyi Rih National University since 2000. Combines educational activities with practical, developing and implementing educational software products. In 2011 he defended his Ph.D. thesis. From 2014 to 2017 he is studying at the doctoral program in Institute of Information Technologies and Learning Tools of the NAES of Ukraine (Kyiv, Ukraine). In 2017, he was awarded the Prize of the President of Ukraine for young scientists. Heads the Simulation and Software Engineering department of Kryvyi Rih National University since 2018. Field of scientific interest: professional training of software engineers, mobile learning technologies, the use of augmented reality technologies in education.

WWW: http://mpz.knu.edu.ua/pro-kafedru/vikladachi/224-andrii-striuk
E-mail: andrii.striuk@knu.edu.ua

Dr. **Tetiana Vakaliuk**, professor of the department of Software Engineering, Zhytomyr Polytechnic State University, Zhytomyr, Ukraine

Tetiana Vakaliuk, born in 1983, received a Candidate of Pedagogical Sciences degree from the National Pedagogical Dragomanov University, Ukraine, in 2013, and a Doctor of Pedagogical Sciences degree from the Institute of Information Technologies and Learning Tools of the National Academy of Sciences of Ukraine, in 2019. Since 2019, she has been working in the field of information technologies at the Zhytomyr Polytechnic State University. Her research interests include information technologies, ICT in Education, Cloud technologies. She has published a number of papers in international journals, is a member of editorial boards of Information Technologies and Learning Tools, Zhytomyr Ivan Franko State University Journal: Pedagogical Sciences, Collection of Scientific Papers of Uman State Pedagogical University.

www: https://sites.google.com/view/neota
e-mail: tetianavakaliuk@gmail.com

Dr. **Nataliia Valko**, Ph.D. of Physics and Mathematic Sciences, D.Sc. in Education, Department of Informatics, Software Engineering and Economic Cybernetics, Kherson State University, Kherson, Ukraine

Nataliia Valko has extensive experience in teachers' education via modern teaching technologies, blended learning, STEM-education. Her teaching experience in University is over 20 years. She is one of the organizers of the STEM school of KSU. She has management skills in the field of teacher training, planning educational activities, creating distance learning courses on the Moodle platform. She manages students design work to create models of robotic systems. Effectively applies innovative teaching methods for future teachers of natural-mathematical disciplines using robotics and their preparation for using STEM-technologies in teaching. She actively studies innovative teaching methods, methods of project activity. She has published a number of papers of different kinds (including books, articles in scientific international journals, conference proceedings etc.), is a member of editorial boards of Journal of Information Technologies in Education (ITE).

WWW: http://www.kspu.edu/About/Faculty/FPhysMathemInformatics/ChairInformatics/Staff/NValko.aspx
E-mail: valko@ksu.ks.ua

Dr. **Nataliia Veretennikova**, Ph.D., candidate of social communication, assistant of the Department of Information Systems and Networks, Lviv Polytechnic National University, Lviv, Ukraine

Nataliia Veretennikova, born in 1990, received Ph.D. degree from Vernadsky National Library of Ukraine in 2017. She is a winner of the President's Award for Young Scientists in 2019 and a winner of the Regional Prize for Young Scientists and Researchers for Scientific Achievements that Contribute to Social and Economic Transformation in the Region and Affirm the High Authority of Lviv Region Scholars in Ukraine and in the World. Her scientific research relates to the field of electronic science, linguistic support and social communications.

She is an author of several papers in domestic and international journals as well as volumes. She is a member of editorial boards and joins in Programme and Organizing committees of international conferences or workshops.

E-mail: nataver19@gmail.com

Dr. **Yuliia Yechkalo**, Associate professor, Department of Physics, Kryvyi Rih National University, Ukraine

Yuliia Yechkalo, born in 1981, received a Candidate of Pedagogical Sciences degree from the Kirovograd State Vladimira Vinnichenka Pedagogical University, Ukraine, in 2013. Since 2005, she has been working at the National Metallurgical Academy of Ukraine. She has been working at the Kryvyi Rih National University since 2012. Her research interests include theory and methods of education (physics) and information and communication technologies in education.

E-mail: uliaechk@gmail.com

3 Session 1: Augmented reality in science education

Elena V. Komarova and Arnold E. Kiv in the article “Alternatives in biological education as a way to implement an ethical approach to the formation of subject and professional competence of future teachers” [24] (fig. 1) analyzes the experience of using alternative means of teaching biological disciplines, the purpose of which is to partially or completely replace biological objects in educational practice with their visualized copies. The quantitative results obtained make it possible to judge the effect of the applied alternatives on the degree of formation of subject competence of students.

Assessing students' understanding of the ethics of alternative means used, their importance in the formation of elements of teacher's professional competence lies in the area of further development of the topic, begun in [23] and [25].

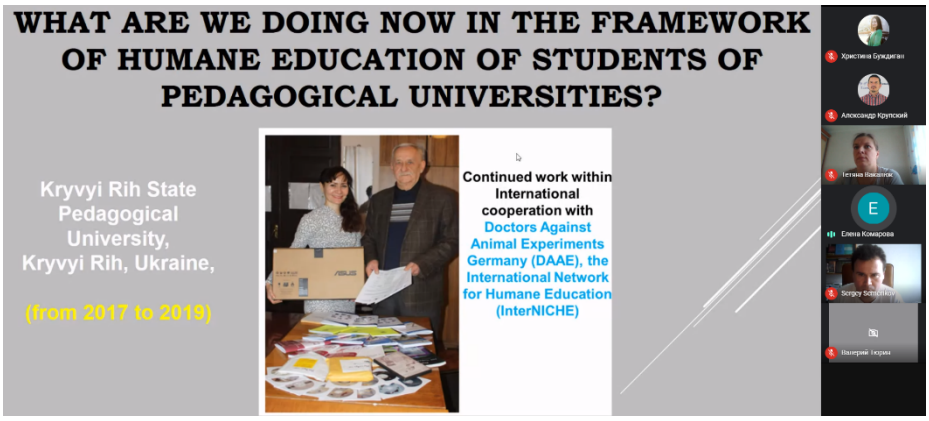


Fig. 1. Presentation of paper [24].

Zhanna I. Bilyk, Yevhenii B. Shapovalov, Viktor B. Shapovalov, Anna P. Megalinska, Fabian Andruszkiewicz and Agnieszka Dołhańczuk-Śródka in the article "Assessment of mobile phone applications feasibility on plant recognition: comparison with Google Lens" [4] (fig. 2) highlights further research, begun in [61], [62] and [63]. The article is devoted to systemizing all mobile applications used during the STEM-classes and can be used to identify plants. There are 10 mobile applications that are plant identifiers worldwide. These applications can be divided into three groups, such as plant identifiers that can analyze photos, plant classification provides the possibility to identify plants manually, plants-care apps that remind water of the plant, or change the soil. In this work, mobile apps such as Flora Incognita, PlantNet, PlantSnap, PictureThis, LeafSnap, Seek, PlantNet were analyzed for usability parameters and accuracy of identification. To provide usability analysis, a survey of experts of digital education on installation simplicity, level of friendliness of the interface, and correctness of picture processing. It is proved that Flora Incognita and PlantNet are the most usable and the most informative interface from plant identification apps. However, they were characterized by significantly lower accuracy compared to Google Lens results. Further comparison of the usability of applications that have been tested in the article with Google Lens, proves that Google Lens characterize by better usability and therefore, Google Lens is the most recommended app to use to provide plant identification during biology classes.

Natalya V. Rashevska, Serhiy O. Semerikov, Natalya O. Zinonos, Viktoriia V. Tkachuk and Mariya P. Shyshkina in the article "Using augmented reality tools in the teaching of two-dimensional plane geometry" [57] (fig. 3) highlights further research, begun in [58], [64], [68], [75], [79] and [81]. This study aimed to analyze mobile tools that can be used to visualize teaching geometry. The use of augmented reality tools in the geometry lessons creates precisely such conditions for positive emotional

interaction between the student and the teacher. It also provided support to reduce fear and anxiety attitudes towards geometry classes. The emotional component of learning creates the conditions for better memorization of the educational material, promotes their mathematical interest, realizes their creative potential, creates the conditions for finding different ways of solving geometric problems.

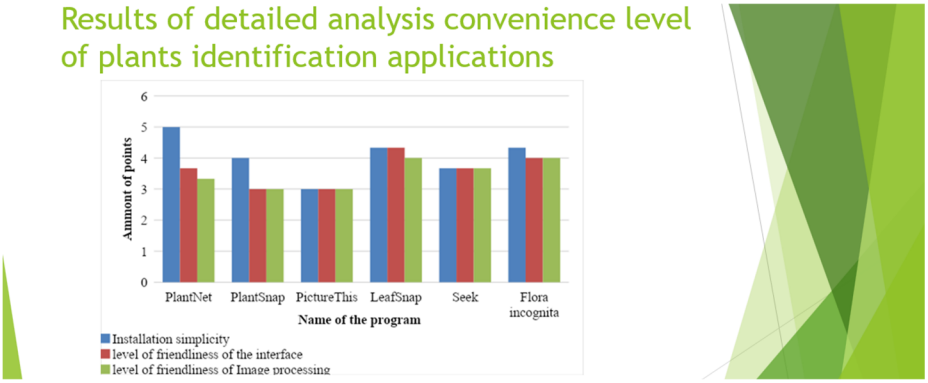


Fig. 2. Presentation of paper [4].

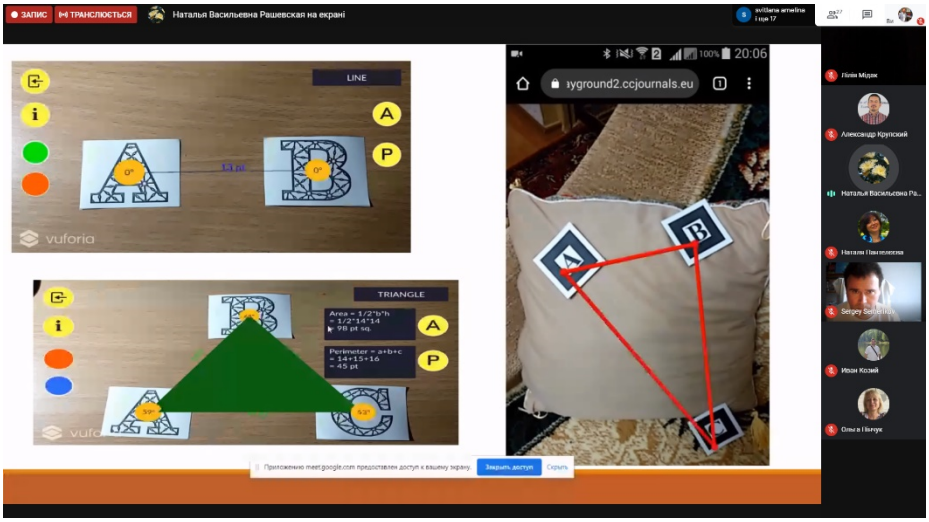


Fig. 3. Presentation of paper [57].

Vasyl P. Oleksiuk and Olesia R. Oleksiuk in the article "Exploring the potential of augmented reality for teaching school computer science" [43] (fig. 4) explored the possibilities of using augmented reality in education. They identified means of augmented reality for teaching computer science at school. Such programs and services allow students to observe the operation of computer systems when changing their parameters. Students can also modify computer hardware for augmented reality objects

and visualize algorithms and data processes. The article describes the content of author training for practicing teachers. At this event, some applications for training in AR technology were considered. The possibilities of working with augmented reality objects in computer science training are singled out. It is shown that the use of augmented reality provides an opportunity to increase the realism of research; provides emotional and cognitive experience. This all contributes to engaging students in systematic learning; creates new opportunities for collaborative learning, develops new representations of real objects.

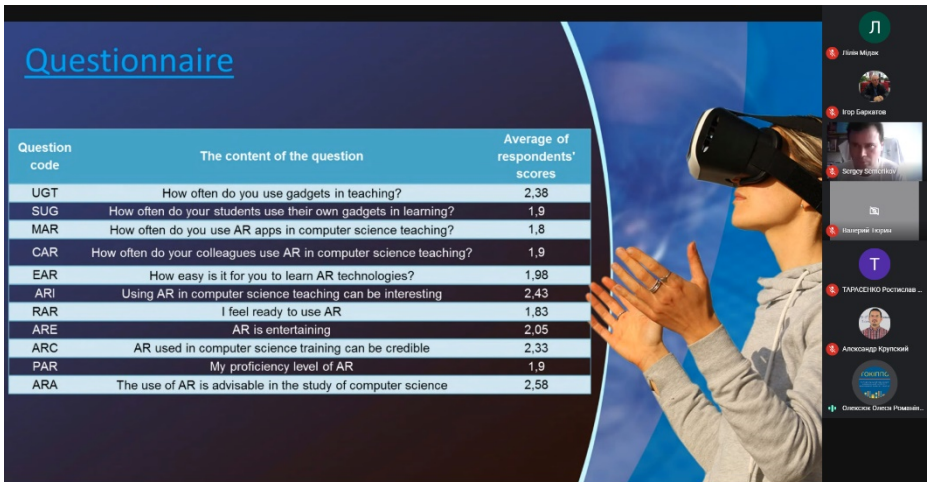


Fig. 4. Presentation of paper [43].

4 Session 2: Augmented reality in professional training and retraining

The article “Methodological aspects of using augmented reality for improvement of the health preserving competence of a Physical Education teacher” [22] (fig. 5) of Oksana V. Klochko, Vasyl M. Fedorets, Aleksandr D. Uchitel and Vitaliy V. Hnatyuk deals with the results of the research aimed at the improvement of methodology of use of augmented reality for the development of health preserving competence of a Physical Education teacher under conditions of post-graduate education. From the point of Umwelt phenomenology, augmented reality is characterized by correspondence to nature, its cognitive, metaphoric, diverse, interactive, anthropomorphic nature. The article analyzes the vectors of using augmented reality in the professional activity of a Physical Education teacher, particularly the one that is aimed at health preservation. The software that may be used with this purpose has been described. The attitude of Physical Education teachers to the use of the augmented reality for preserving their students’ health and development of their motion skills, intellect and creativity was determined in the research. The results of the survey show that the majority of teachers positively react to the idea of using augmented reality in their professional activity.

However, in some cases, not a fully formed understanding of this issue was observed. The ways of solving the stated problem could be the inclusion of augmented technologies' techniques into the process of post-graduate education, taking into consideration the anthropological, ethical, cultural contexts as well as teacher involvement in the stated process.

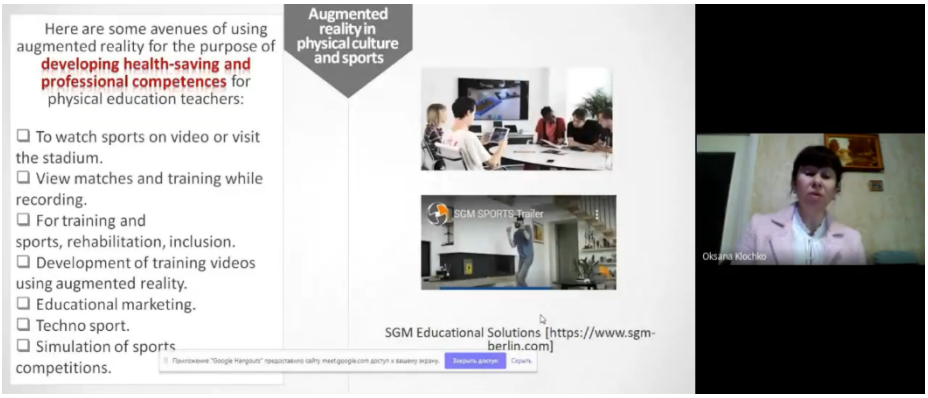


Fig. 5. Presentation of paper [22].

Rostyslav O. Tarasenko, Svitlana M. Amelina, Yuliya M. Kazhan and Olga V. Bondarenko in the article "The use of AR elements in the study of foreign languages at the university" [74] (fig. 6) highlights further research by the authors, begun in [1], [15], [70], [71], [72] and [73]. The article deals with the analysis of the impact of the using AR technology in the study of a foreign language by university students. It is stated out that AR technology can be a good tool for learning a foreign language. The use of elements of AR in the course of studying a foreign language, in particular in the form of virtual excursions, is proposed. Advantages of using AR technology in the study of the German language are identified, namely: the possibility of involvement of different channels of information perception, the integrity of the representation of the studied object, the faster and better memorization of new vocabulary, the development of communicative foreign language skills. The ease and accessibility of using QR codes to obtain information about the object of study from open Internet sources is shown. The results of a survey of students after virtual tours are presented. A reorientation of methodological support for the study of a foreign language at universities is proposed. Attention is drawn to the use of AR elements in order to support students with different learning styles (audio, visual, kinesthetic).

The article "Methodology of using mobile apps with augmented reality in students' vocational preparation process for transport industry" [32] (fig. 7) highlights further research by Olena O. Lavrentieva, Ihor O. Arkhypov, Oleksandr P. Krupskyi, Denys O. Velykodnyi and Sergiy V. Filatov, begun in [14], [33] and [51]. In the article the current state and trends of use AR technologies in transport industry and in a future specialists' vocational training process have been reviewed and analyzed. The essence and content of the AR technologies relevant to transport industry have been clarified. The main directions of the AR introduction for the various spheres of transport industry

including design and tuning, mechanical and automotive engineering, marketing and advertising, maintenance and operation, diagnostics and repair of cars have been determined. The AR mobile apps market and the features of the mobile apps with AR have been outlined. The pedagogical terms of effective organizing the students' cognitive activity for transport industry via AR technologies have been determined and researched, namely: to provide each student with the position of an active actor of study and cognitive activity, to switch the study information in a mode of the project activity, the educational content professionalization and to teach students to use the modern ICT purposefully, to manage students' cognitive process by means of ICT. The methodology of using mobile apps with AR in students' vocational preparation process for transport industry has been presented. It covers the system of educational tasks, updated content of lectures, practical and laboratory classes for specialized disciplines.

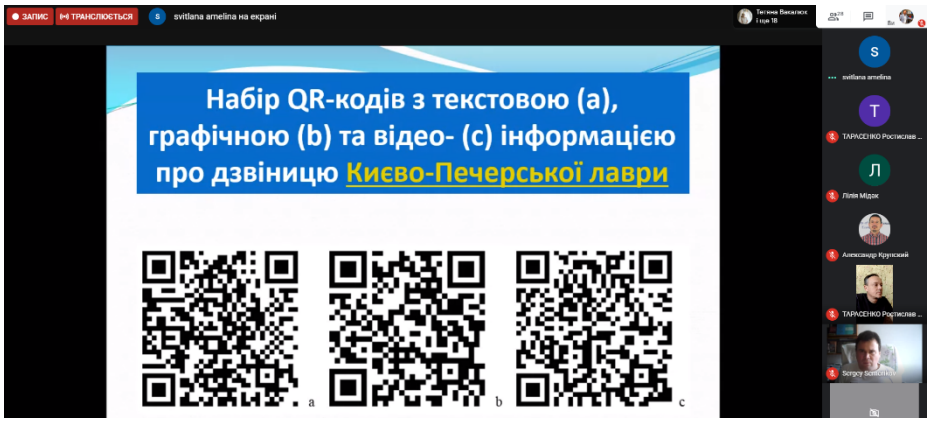


Fig. 6. Presentation of paper [74].

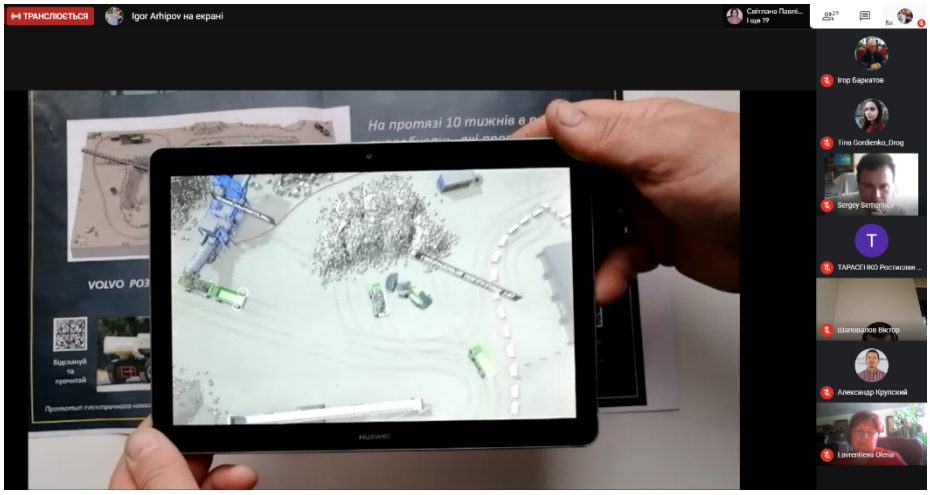


Fig. 7. Presentation of paper [32].

5 Session 3: Design and implementation of augmented reality learning environments

The article “New effective aid for teaching technology subjects: 3D spherical panoramas joined with virtual reality” [2] (fig. 8) highlights further research by Igor V. Barkatov, Volodymyr S. Farafonov, Valeriy O. Tiurin, Serhiy S. Honcharuk, Vitaliy I. Barkatov and Hennadiy M. Kravtsov, begun in [13] and [29]. The article raises the problem of extending the range of available teaching aids for vehicle-related subjects. Benefiting from the modern information and visualization technologies, authors present a new teaching aid that constitutes a spherical (360° or 3D) photographic panorama and a Virtual Reality (VR) device. The nature of the aid, its potential applications, limitations and benefits in comparison to the common aids are discussed. The proposed aid is shown to be cost-effective and is proved to increase efficiency of training, according to the results of a teaching experiment that was carried out. A series of panoramas, which are already available, and its planned expansions are presented. The authors conclude that the proposed aid may significantly improve the cost-efficiency balance of teaching a range of technology subjects.

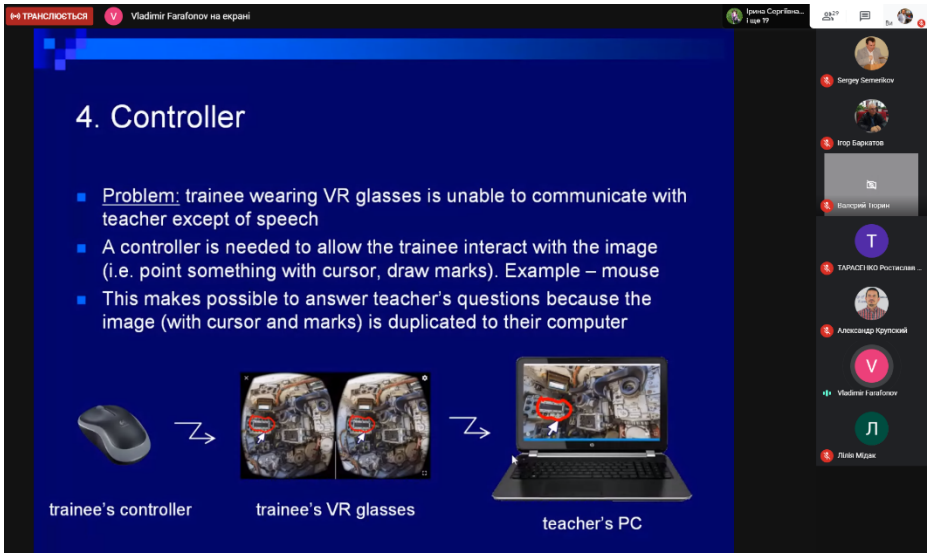


Fig. 8. Presentation of paper [2].

Edgar Iván De la Cruz Vaca, Edgar Roberto Salazar Achig, Jonathan Alexis Romero López, Adriana Estefanía Tigselema Benavides and Jacson Javier Rodriguez Conde in the article “Numerical methods for handling robotic arms using augmented reality” [9] (fig. 9) presents an augmented reality application for mobile devices, as a contribution to education through a technological learning tool that allows the management of industrial robotic arms, implementing advanced control algorithms, which allows the simulation of several selected desired trajectories by the user; and the incorporation of

animations that allow to know its operation and to verify the follow-up of the proposed trajectory, as well as the visualization of control errors in each trajectory taken. The application is oriented to the simulation of industrial robotic arms within an intuitive and friendly augmented reality environment, which allows users a great interaction with the robot's structure, providing simulation programs with new immersion technologies, in the educational field. Tests in the augmented reality application demonstrate ease of use and user intuition, providing a better understanding of the operation and structure of programmable manipulators.

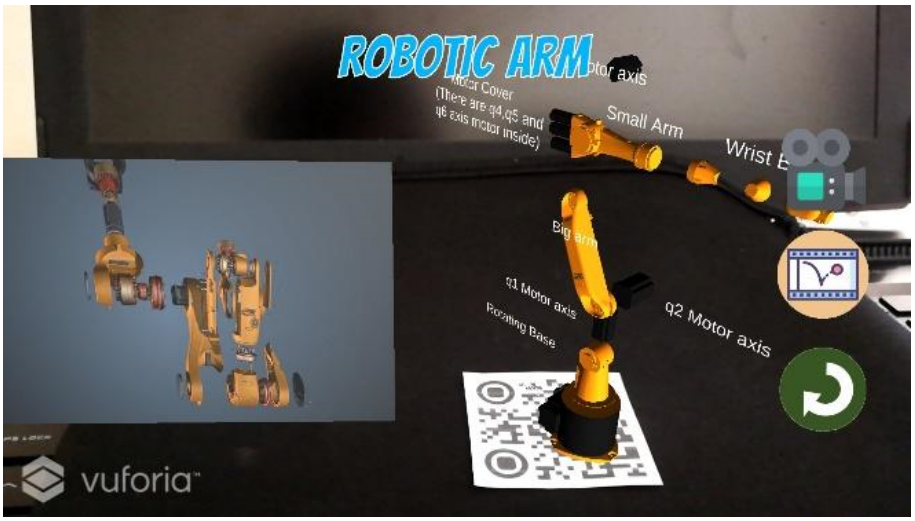


Fig. 9. Presentation of paper [9].

The article “Using a web application to realize the effect of AR in assessing the environmental impact of emissions source” [80] (fig. 10) of Tetyana I. Zhylenko, Ivan S. Koziy, Vladyslav S. Bozhenko and Irina A. Shuda describes a software that helps to show visually how the emissions of a chemical plant are spreading to the surrounding city. The harmfulness to the city of the cloud into which emissions are converted can also be calculated by the program. Authors have implemented a number of functions responsible for emission modeling, taking into account different conditions.

The article “Development of AR-applications as a promising area of research for students” [3] (fig. 11) of Vladyslav V. Bilous, Volodymyr V. Proshkin and Oksana S. Lytvyn substantiates the importance of using augmented reality in the educational process, in particular, in the study of natural and mathematical disciplines. The essence of AR, characteristics of AR hardware and software, directions and advantages of using AR in the educational process are outlined. It has proven that AR is a unique tool that allows educators to teach the new digital generation in a readable, comprehensible, memorable and memorable format, which is the basis for developing a strong interest in learning. Presented the results of the international study on the quality of education PISA (Programme for International Student Assessment) which stimulated the development of the problem of using AR in mathematics teaching. Within the limits of

realization of research work of students of the Borys Grinchenko Kyiv University the AR-application on mathematics is developed. To create it used tools: Android Studio, SDK, ARCore, QR Generator, Math pattern. A number of markers of mathematical objects have been developed that correspond to the school mathematics course (topic: “Polyhedra and Functions, their properties and graphs”). The developed AR tools were introduced into the process of teaching students of the specialty “Mathematics”. Prospects of research in development of a technique of training of separate mathematics themes with use of AR have been defined.

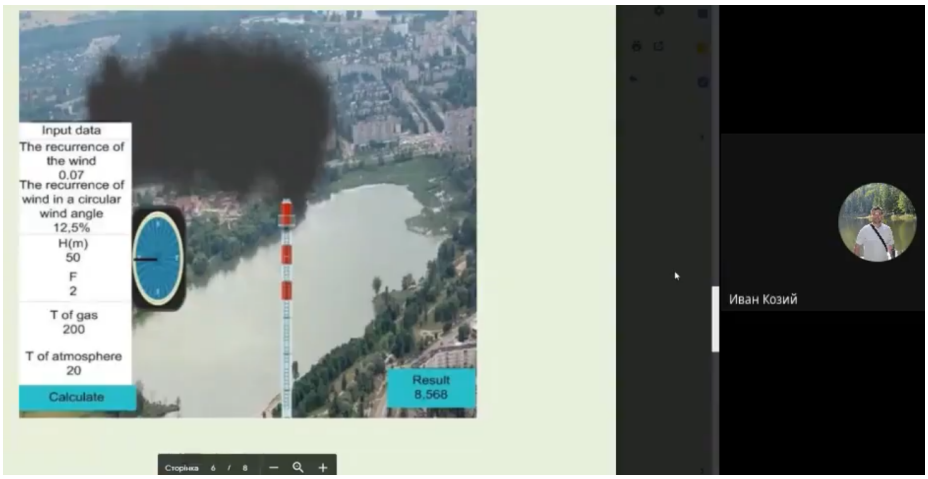


Fig. 10. Presentation of paper [80].

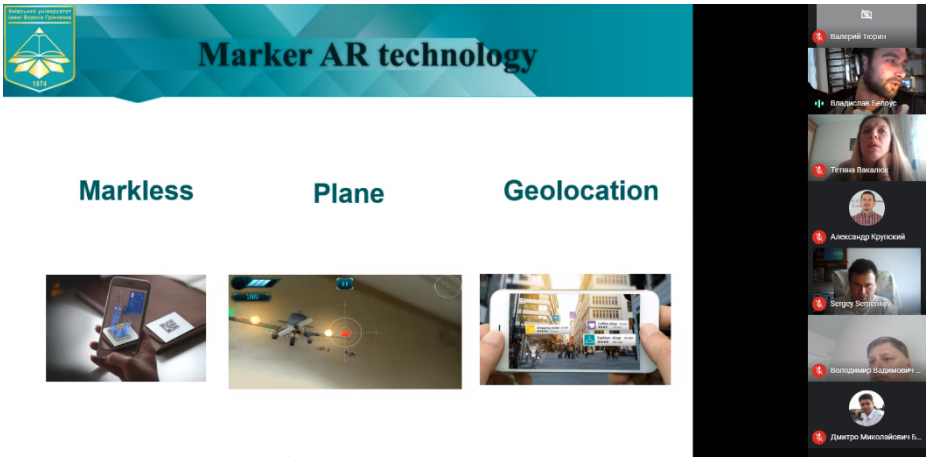


Fig. 11. Presentation of paper [3].

The article “Development of a model of the solar system in AR and 3D” [12] (fig. 12) of Valentyna V. Hordiienko, Galyna V. Marchuk, Tetiana A. Vakaliuk and Andrey V. Pikilnyak highlights further research by the authors, begun in [13], [39], [53] and [81].

In this article, the possibilities of using augmented reality technology are analyzed and the software model of the solar system model is created. The analysis of the available software products modeling the solar system is carried out. The developed software application demonstrates the behavior of solar system objects in detail with augmented reality technology. In addition to the interactive 3D model, you can explore each planet visually as well as informatively – by reading the description of each object, its main characteristics, and interesting facts. The model has two main views: Augmented Reality and 3D. Real-world object parameters were used to create the 3D models, using the basic ones – the correct proportions in the size and velocity of the objects and the shapes and distances between the orbits of the celestial bodies.

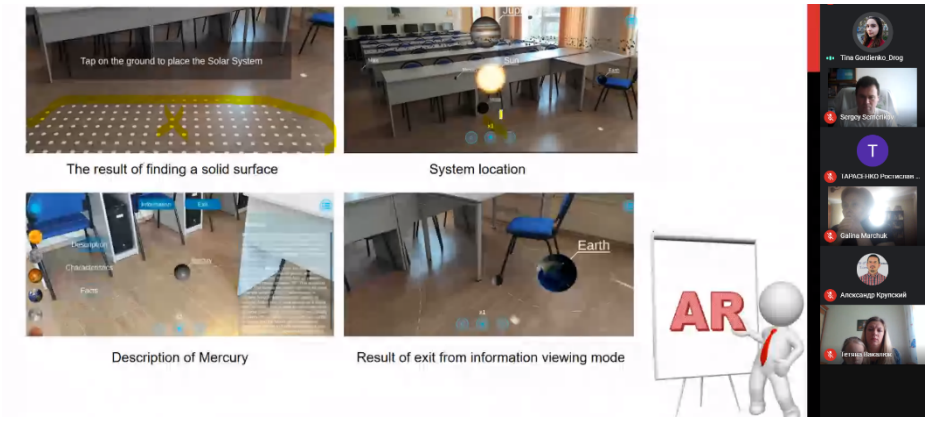


Fig. 12. Presentation of paper [12].

The article “Augmented reality in process of studying astronomic concepts in primary school” [37] of Liliia Ya. Midak, Ivan V. Kravets, Olga V. Kuzyshyn, Khrystyna V. Berladyniuk, Khrystyna V. Buzhdyhan, Liliia V. Baziuk and Aleksandr D. Uchitel (fig. 13) highlights further research by the authors, begun in [38] and [40]. The objective of the research is development a mobile application (on the Android platform) designed for visualization of the Solar System with the AR technology and the alphabet study, applying the astronomic definitions, which can be used by the teacher and the students for an effective training for studying the subjects of the astronomic cycle in primary school. AR cards with the images of the Solar System planets and other celestial bodies were developed, as well as the “Space alphabet” was created. In the developed alphabet every letter of the alphabet becomes a certain celestial body or a different astronomic definition. AR gives the opportunity to visualize images of the Solar System as much as possible, in other words to convert 2D images into 3D, as well as “make them alive”. Applying this tool of ICT while studying new data gives the ability to develop and improve the pupils’ spatial thinking, “to see” the invisible and to understand the perceived information in a deeper way, which will be beneficial for its better memorizing and development of computer skills. Studying the alphabet in the offered mobile app will definitely help nail the achieved knowledge and get interesting information about celestial bodies that are invisible and superior for kids; to make a

journey into the space, prepare a project on “The Space Mysteries” subject; to stimulate the development of curiosity, cognitive motivation and learning activity; the development of imagination, creative initiative, including speaking out.

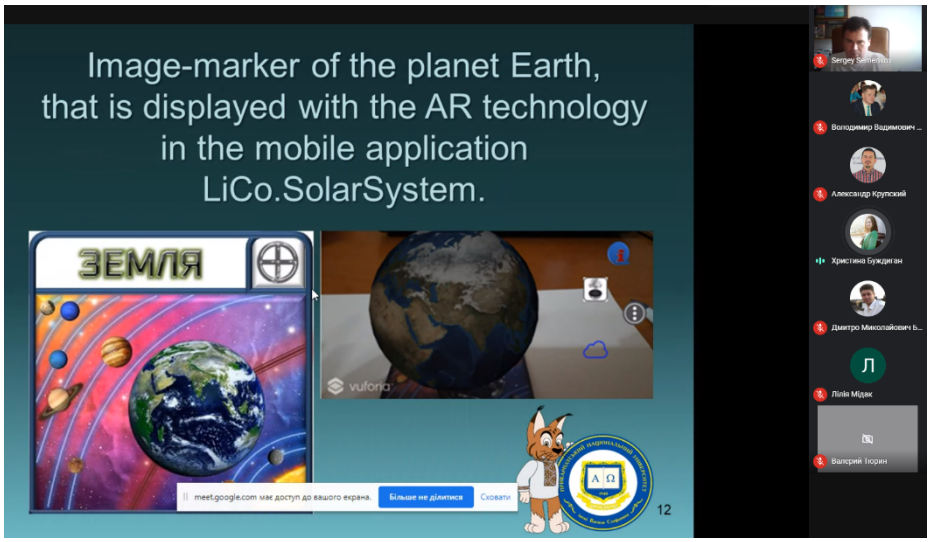


Fig. 13. Presentation of paper [37].

Yulia Yu. Dyulicheva, Yekaterina A. Kosova and Aleksandr D. Uchitel in the article “The augmented reality portal and hints usage for assisting individuals with autism spectrum disorder, anxiety and cognitive disorders” [10] (fig. 14) propose to apply the augmented reality portal as a special tool for the teachers to interact with people at the moment when a panic attack or anxiety happens in education process. It is expected that applying the augmented reality portal in education will help students with ASD, ADHD and anxiety disorder to feel safe at discomfort moment and teachers can interact with them. Authors’ application with the augmented reality portal has three modes: for teachers, parents, and users. It gives the ability to organize personalized content for students with special needs. Authors developed the augmented reality application aimed at people with cognitive disorders to enrich them with communication skills through associations understanding. Applying the augmented reality application and the portal discovers new perspectives for learning children with special needs. The AR portal creates illusion of transition to another environment. It is very important property for children with ADHD because they need in breaks at the learning process to change activity (for example, such children can interact with different 3D models in the augmented reality modes) or environment. The developed AR portal has been tested by a volunteer with ASD (male, 21 years old), who confirmed that the AR portal helps him to reduce anxiety, to feel calm down and relaxed, to switch attention from a problem situation.

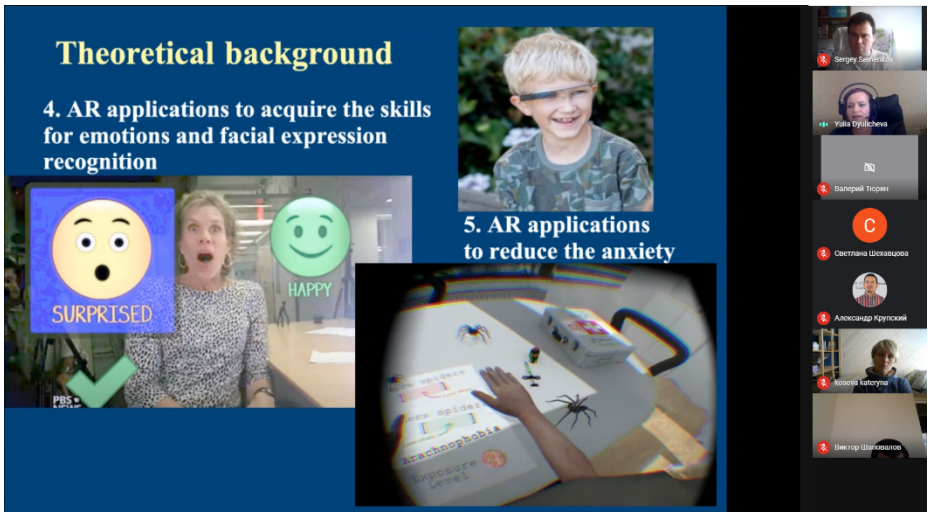


Fig. 14. Presentation of paper [10].

6 Session 4: Augmented gamification

The article “Features of implementation of modern AR technologies in the process of psychological and pedagogical support of children with autism spectrum disorders” [46] (fig. 15) highlights further research by Viacheslav V. Osadchyi, Hanna B. Varina, Kateryna P. Osadcha, Olesia O. Prokofieva, Olha V. Kovalova and Arnold E. Kiv, begun in [67] and [76]. The article deals with the actual issue of the specificity and algorithm of the introduction of innovative AR technologies in the process of psychological and pedagogical support of children with autism spectrum disorders (ASD). An innovative element of theoretical and methodological analysis of the problem and empirical research is the detection of vectors of a constructive combination of traditional psycho-correctional and psycho-diagnostic approaches with modern AR technologies. The analysis of publications on the role and possibilities of using AR technologies in the process of support children with ASD (autism spectrum disorder) and inclusive environment was generally conducted by surfing on the Internet platforms containing the theoretical bases for data publications of scientific journals and patents. The article also analyzes the priorities and potential outcomes of using AR technologies in psycho-correction and educational work with autistic children. According to the results of the analysis of scientific researches, Unified clinical protocol of primary, secondary (specialized), tertiary (highly specialized) medical care and medical rehabilitation “Autism spectrum disorders (disorders of general development)”, approaches for correction, development and education of children with ASD, AR technologies were selected for further implementation in a comprehensive program of psychological and pedagogical support for children with ASD. The purpose of the empirical study is the search, analysis and implementation of multifunctional AR technologies in the psycho-correctional construct of psychological and pedagogical

support of children with ASD. According to the results of the pilot study, the priorities and effectiveness of using AR technologies in the development of communicative, cognitive, emotional-volitional, mnemonic abilities of children and actualization of adaptive potential and adaptive, socially accepted behaviors are made. The possibilities and perspectives of using AR technologies as an element of inclusive environment, with regard to nosology and phenomenology, need further investigation.

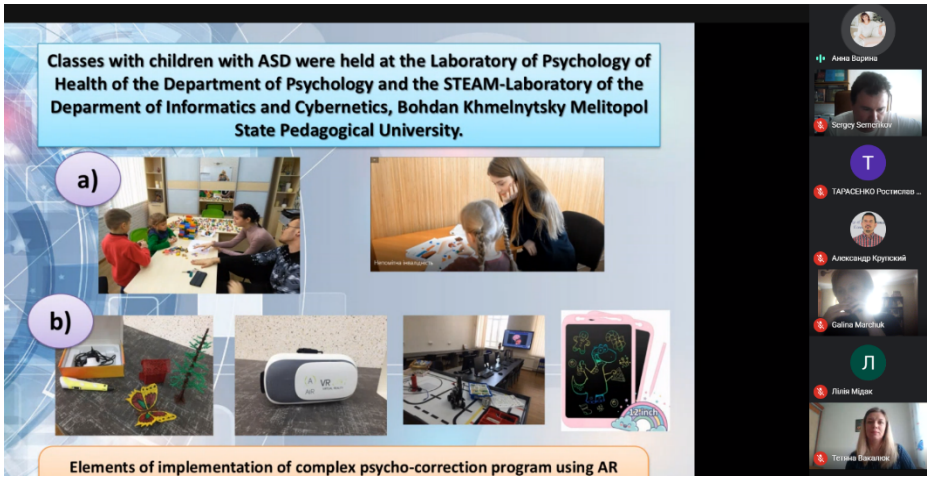


Fig. 15. Presentation of paper [46].

The article "Augmented reality books: concepts, typology, tools" [49] (fig. 16) highlights further research by Liubov F. Panchenko, Tetiana A. Vakaliuk and Kateryna V. Vlasenko, begun in [47] and [48]. In the article the facet classification for augmented books is proposed; the main facets are: reality-virtuality continuum, type of augmented materials, device types, type of interaction, spatial space of book, book's category. Content for a module of a specialty course about augmented reality books for the system of professional training and retraining for educators in postgraduate education is discussed. Some samples of tasks for educators are presented: audio augmented book about world's books monuments; analysis augmented reality examples in the textbook of the New Ukrainian school (subject name, topic, didactic tasks, quality of implementation, directions of expansion etc.), search and analysis augmented books according to the professional interests of the educators; discussion how augmented reality can help to improve student motivation with accent to attention, relevance, confidence and satisfaction; group work about design and creation a fragment of own textbook with augmented reality.

Liudmyla L. Nezhyva, Svitlana P. Palamar and Oksana S. Lytvyn in the article "Perspectives on the use of augmented reality within the linguistic and literary field of primary education" [41] (fig. 17) analyzes the scientific sources on the problem of augmented reality in the educational field. There is a fragmentary rationale for new technology in primary school, to a greater extent the experience of scientists and practitioners relate to the integrated course "I am exploring the world". The

peculiarities of Ukrainian and foreign writers' works with AR applications, which are appropriate to use during the classes of literary reading, are analyzed. The authors substantiated the prospect of augmented reality technology for mastering the artistic image of the world of literary work, the relevance of use of AR to modern educational challenges, and also demonstrated the possibility of immersion into the space of artistic creation and activation of students' imagination with the help of AR applications. The article demonstrates the possibilities of use AR-technology for the development of emotional intelligence and creative thinking, solving educational tasks by setting up an active dialogue with literary heroes. The basic stages of the application of AR technologies in the literary reading lessons in accordance with the opportunities of the electronic resource are described: involvement; interaction; listening, reading and audition; research; creative work; evaluation. It is confirmed that in the process of using augmented reality technology during the reading lessons, the qualitative changes in the process of formation of the reader's culture of the students of experimental classes appears, as well as the increase of motivation, development of emotional intelligence and creative thinking.

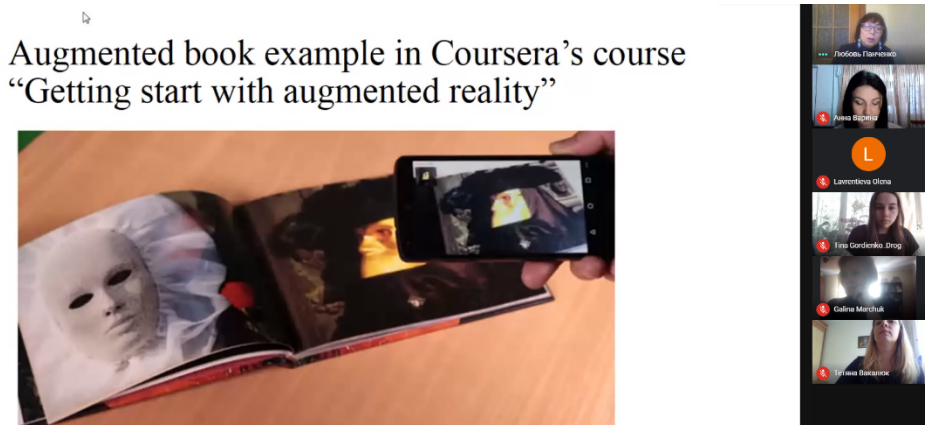


Fig. 16. Presentation of paper [49].

The article "Developing a 3D quest game for career guidance to estimate students' digital competences" [56] highlights further research by Oleksandr V. Prokhorov, Vladyslav O. Lisovichenko, Mariia S. Mazorchuk and Olena H. Kuzminska, begun in [30], [31], [50] and [55]. This article reveals the process of creating a career guidance 3D quest game for applicants who aim to apply for IT departments. The game bases on 3D model of computer science and information technologies department in the National Aerospace University "Kharkiv Aviation Institute". The quest challenges aim to assess the digital competency level of the applicants and first-year students. The paper features leveraged software tools, development stages, implementation challenges, and the gaming application scenario. The game scenario provides for a virtual tour around a department of the 3D university. As far as the game replicates the real-life objects, applicants can see the department's equipment and class-rooms. For the gaming application development team utilized C# and C++, Unity 3D, and Source Engine. For

object modeling, we leveraged Hammer Editor, Agisoft PhotoScan Pro, and the photogrammetry technology, that allowed for realistic gameplay. Players are offered various formats of assessment of digital competencies: test task, puzzle, assembling a computer and setting up an IT-specialist workplace. The experiment conducted at the open house day proved the 3D quest game efficiency. The results of digital competence evaluation do not depend on the testing format. The applicants mostly preferred to take a 3D quest, as more up-to-date and attractive engagement.

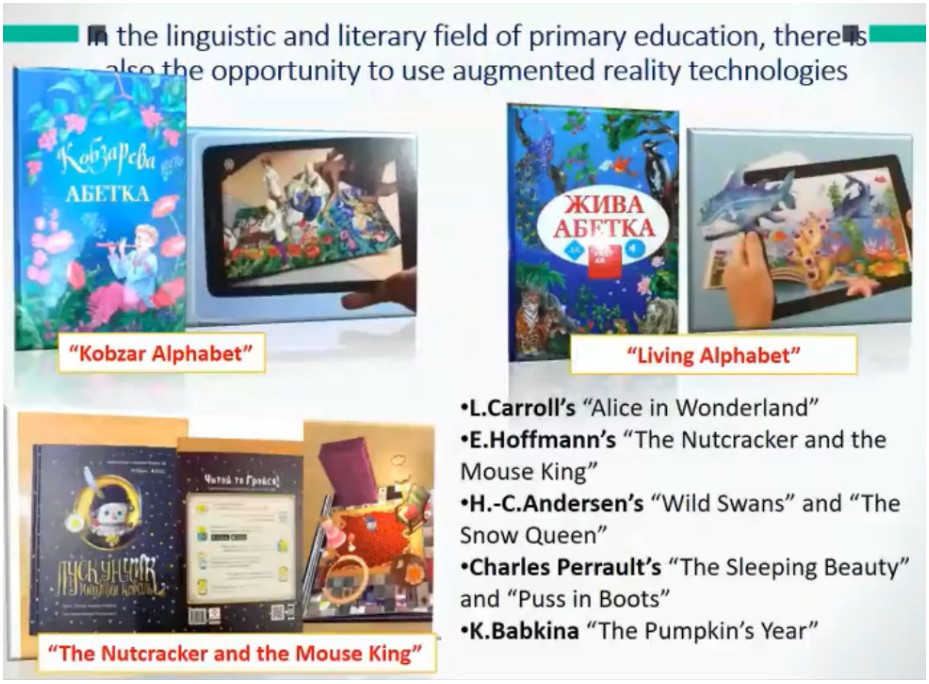


Fig. 17. Presentation of paper [41].

7 Session 5: Virtualization of learning: principles, technologies, tools

The article "Conceptual model of learning based on the combined capabilities of augmented and virtual reality technologies with adaptive learning systems" [45] (fig. 19) highlights further research by Viacheslav V. Osadchyi, Hanna Y. Chemerys, Kateryna P. Osadcha, Vladyslav S. Kruhlyk, Serhii L. Koniukhov, Arnold E. Kiv, begun in [26], [27] and [44]. The article is devoted to actual problem of using modern ICT tools to increase the level of efficiency of the educational process. The current state and relevance of the use of AR and VR technologies as an appropriate means of improving the educational process are considered. In particular, attention is paid to the potential of the combined capabilities of AR and VR technologies with adaptive learning systems. Insufficient elaboration of cross-use opportunities for achieving of

efficiency of the educational process in state-of-the-art research has been identified. Based on analysis of latest publications and experience of using of augmented and virtual reality technologies, as well as the concept of adaptive learning, conceptual model of learning based on the combined capabilities of AR and VR technologies with adaptive learning systems has been designed. The use of VR and AR technologies as a special information environment is justified, which is applied in accordance with the identified dominant type of students' thinking. The prospects of using the proposed model in training process at educational institutions for the implementation and support of new teaching and learning strategies, as well as improving learning outcomes are determined by the example of such courses as “Algorithms and data structures”, “Computer graphics and three-dimensional modeling”, “Circuit Engineering”, “Computer Architecture”.

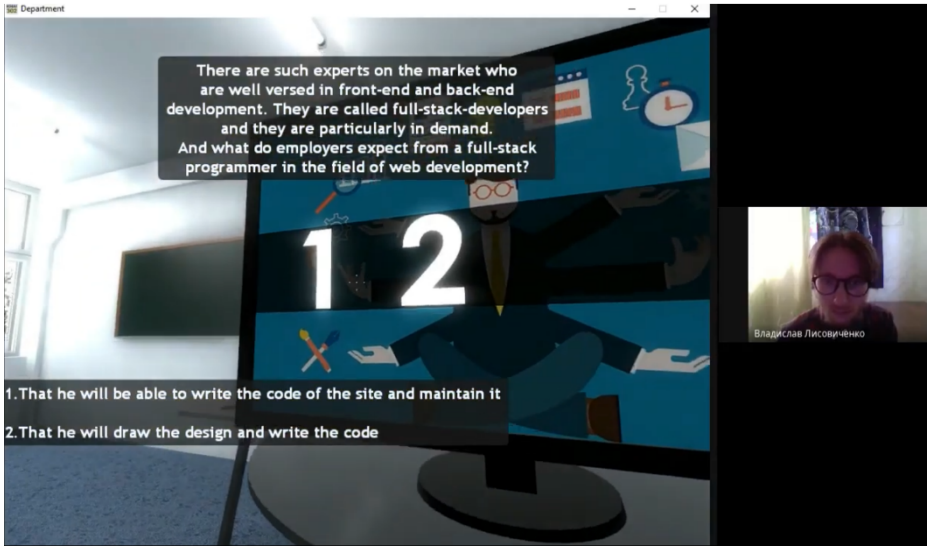


Fig. 18. Presentation of paper [56].

The article “Personalization of learning using adaptive technologies and augmented reality” [35] (fig. 20) highlights further research by Maiia V. Marienko, Yulia H. Nosenko and Mariya P. Shyshkina, begun in [34], [42], [52], [54], [65] and [66]. The research is aimed at developing the recommendations for educators on using adaptive technologies and augmented reality in personalized learning implementation. The latest educational technologies related to learning personalization and the adaptation of its content to the individual needs of students and group work are considered. The current state of research is described, the trends of development are determined. Due to a detailed analysis of scientific works, a retrospective of the development of adaptive and, in particular, cloud-oriented systems is shown. The preconditions of their appearance and development, the main scientific ideas that contributed to this are analyzed. The analysis showed that the scientists point to four possible types of semantic interaction of augmented reality and adaptive technologies. The adaptive

cloud-based educational systems design is considered as the promising trend of research. It was determined that adaptability can be manifested in one or a combination of several aspects: content, evaluation and consistency. The cloud technology is taken as a platform for integrating adaptive learning with augmented reality as the effective modern tools to personalize learning. The prospects of the adaptive cloud-based systems design in the context of teachers training are evaluated. The essence and place of assistive technologies in adaptive learning systems design are defined. It is shown that augmented reality can be successfully applied in inclusive education. The ways of combining adaptive systems and augmented reality tools to support the process of teachers training are considered. The recommendations on the use of adaptive cloud-based systems in teacher education are given.

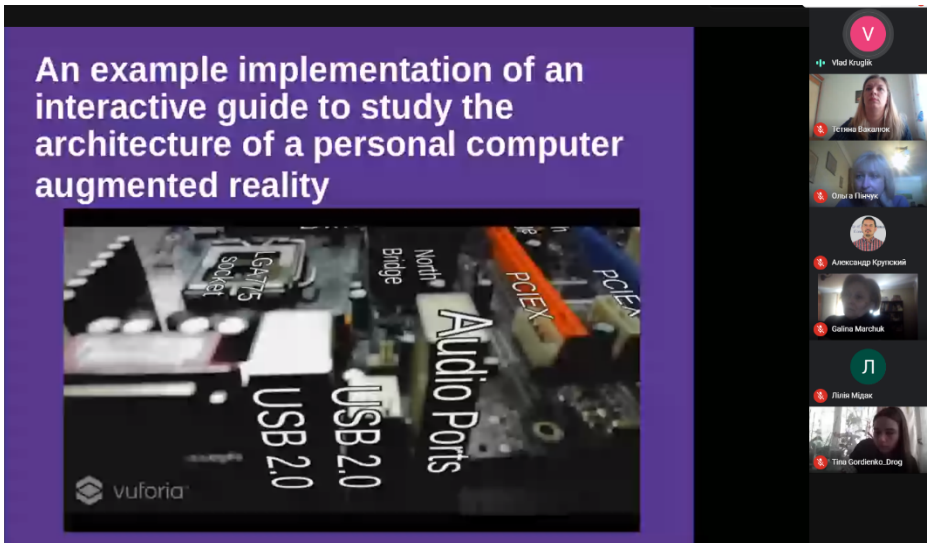


Fig. 19. Presentation of paper [45].

The article “Using a virtual digital board to organize student’s cooperative learning” [5] (fig. 21) highlights further research by Dmytro M. Bodnenko, Halyna A. Kuchakovska, Volodymyr V. Proshkin and Oksana S. Lytvyn, begun in [11] and [60]. The article substantiates the importance of using a virtual digital board to organize student’s cooperative learning in the conditions of distance education, incl. social distance (for the quarantine period 2020). The main advantages of using a virtual digital board are outlined and their functions for the organization of cooperative education are compared. An analysis of the benefits of using virtual digital boards and a survey of experts made it possible to identify the most popular virtual digital boards: Wiki-Wall, Glogster, PadLet, Linoit, Twidla, Trello, Realtimeboard (Miro), Rizzoma. The comparison of the functions of virtual digital boards outlines their ability to organize students’ cooperative learning. The structure of the module E-Learning “Creating education content with tools of virtual digital board Padlet” is presented in the system LMS Moodle. The results of the experiment are presented, which show the

effectiveness of the use of instruments of the virtual digital board to organize student's cooperative learning. Perspectives of researches in developing methods of using a virtual digital board by students of natural-mathematical specialties are determined.

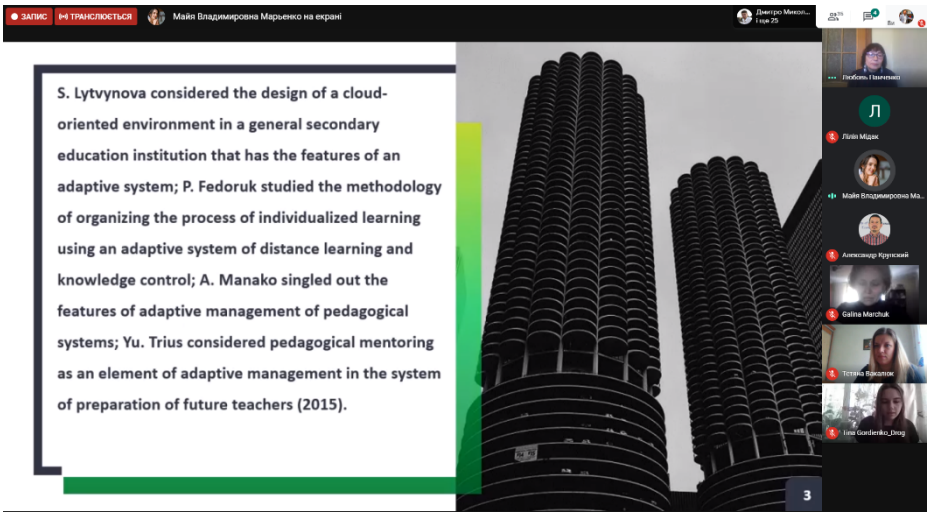


Fig. 20. Presentation of paper [35].

Fig. 21. Presentation of paper [5].

The article "Distance learning as innovation technology of school geographical education" [69] (fig. 22) highlights further research by Myroslav J. Syvyi, Ordenbek B. Mazbayev, Olga M. Varakuta, Natalia B. Panteleeva and Olga V. Bondarenko, begun in [6], [7], [8], [16], [17], [18], [19] and [36]. The article substantiates the necessity of using innovative technologies in the process of studying and teaching geographical disciplines at secondary schools. Particular attention is paid to distance learning as a

pedagogical innovation, its theoretical aspects and the ways of its introduction into the educational process. The relevance of using distance learning at the New Ukrainian School is proved. Its advantages and disadvantages are revealed. The examples of some forms of distance learning that will contribute to geographical competence development according to European requirements are provided. The article particularly focuses on the Massive Open Online Courses, modern websites, virtual portals of individual teachers, LearningApps.org portal, and Moodle.

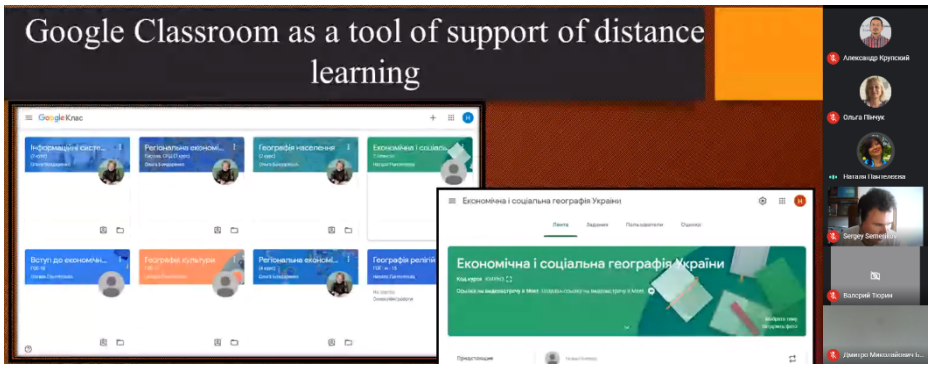


Fig. 22. Presentation of paper [69].

The article “The development of students' critical thinking in the context of information security” [59] (fig. 23) highlights further research by the Sergii V. Savchenko, Svitlana O. Shekhavtsova and Vladimir I. Zaselskiy, begun in [77] and [78]. The purpose of the given research is to introduce theoretical substantiation and experimental approbation of students’ critical thinking development in the context of information security. The skills of critical thinking help students to cope with the bulk of information they daily receive. However, there is still no conventional methodology for critical thinking development in university students. In our study we suggest possible ways to develop critical thinking in university students via introducing some special courses into the curriculum, and consider the results of the experimental study conducted on the basis of two Ukrainian leading universities. In order to improve the students’ skills of critical thinking the author suggested implementing the special course “The specifics of students’ critical thinking in the context of information security”, and an optional distance course on optimization of students’ critical thinking on the background of information and communication technologies. After the implementation of the suggested courses the indicators of students’ critical thinking development showed positive changes and proved the efficiency of the special courses as well as the general hypothesis of the study.

8 Conclusion

The third instalment of AREdu was organised by Kryvyi Rih National University, Ukraine (with support of the rector Prof. Mykola Stupnik), in collaboration with Kryvyi

Rih State Pedagogical University, Ukraine (with support of the rector Prof. Yaroslav Shramko), Institute of Information Technologies and Learning Tools of the NAES of Ukraine (with support of the director Prof. Valeriy Bykov) and Ben-Gurion University of the Negev, Israel (with support of the rector Prof. Chaim Hames).

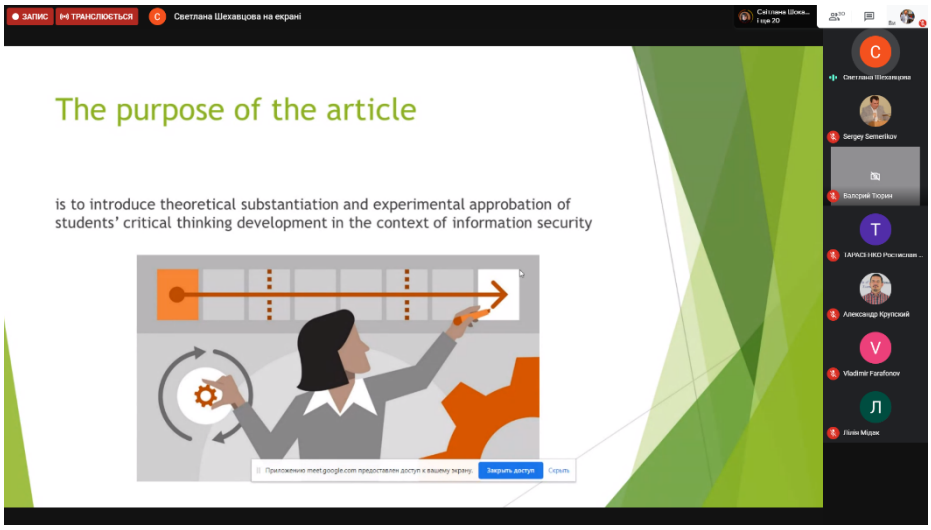


Fig. 23. Presentation of paper [59].

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 of HotCRP, 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 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 2021.

References

1. Amelina, S.M., Tarasenko, R.O., Azaryan, A.A.: Information and technology case as an indicator of information competence level of the translator. CEUR Workshop Proceedings **2433**, 266–278 (2019)

2. Barkatov, I.V., Farafonov, V.S., Tiurin, V.O., Honcharuk, S.S., Barkatov, V.I., Kravtsov, H.M.: New effective aid for teaching technology subjects: 3D spherical panoramas joined with virtual reality. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
3. Bilous, V.V., Proshkin, V.V., Lytvyn, O.S.: Development of AR-applications as a promising area of research for students. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
4. Bilyk, Zh.I., Shapovalov, Ye.B., Shapovalov, V.B., Megalinska, A.P., Dołhańczuk-Śródka, A.: Assessment of mobile phone applications feasibility on plant recognition: comparison with Google Lens AR-app. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
5. Bodnenko, D.M., Kuchakovska, H.A., Proshkin, V.V., Lytvyn, O.S.: Using a virtual digital board to organize student's cooperative learning. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
6. Bondarenko, O.V., Mantulenko, S.V., Pikilnyak, A.V.: Google Classroom as a Tool of Support of Blended Learning for Geography Students. CEUR Workshop Proceedings **2257**, 182–191 (2018)
7. Bondarenko, O.V., Pakhomova, O.V., Lewoniewski, W.: The didactic potential of virtual information educational environment as a tool of geography students training. CEUR Workshop Proceedings **2547**, 13–23 (2020)
8. Bondarenko, O.V., Pakhomova, O.V., Zaselskiy, V.I.: The use of cloud technologies when studying geography by higher school students. CEUR Workshop Proceedings **2433**, 377–390 (2019)
9. De la Cruz Vaca, E.I., Salazar Achig, E.R., Romero López, J.A., Tigselema Benavides, A.E., Rodriguez Conde, J.J.: Numerical methods for handling robotic arms using augmented reality. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
10. Dyulicheva, Yu.Yu., Kosova, Ye.A., Uchitel, A.D.: The augmented reality portal and hints usage for assisting individuals with autism spectrum disorder, anxiety and cognitive disorders. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
11. Hlushak, O.M., Proshkin, V.V., Lytvyn, O.S.: Using the e-learning course "Analytic Geometry" in the process of training students majoring in Computer Science and Information Technology. CEUR Workshop Proceedings **2433**, 472–485 (2019)
12. Hordiienko, V.V., Marchuk, G.V., Vakaliuk, T.A., Pikilnyak, A.V.: Development of a model of the solar system in AR and 3D. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
13. Hruntova, T.V., Yechkalo, Yu.V., Striuk, A.M., Pikilnyak, A.V.: Augmented Reality Tools in Physics Training at Higher Technical Educational Institutions. CEUR Workshop Proceedings **2257**, 33–40 (2018)

14. Ivanova, H.I., Lavrentieva, O.O., Eivas, L.F., Zenkovych, Iu.O., Uchitel, A.D.: The students' brainwork intensification via the computer visualization of study materials. CEUR Workshop Proceedings **2643**, 185–209 (2020)
15. Kazhan, Yu.M., Hamaniuk, V.A., Amelina, S.M., Tarasenko, R.O., Tolmachev, S.T.: The use of mobile applications and Web 2.0 interactive tools for students' German-language lexical competence improvement. CEUR Workshop Proceedings **2643**, 392–415 (2020)
16. Kholoshyn, I., Burman, L., Nazarenko, T., Mantulenko, S., Panteleeva, N.: Geographic particulars of the world's population food ration. In: Semerikov, S., Chukharev, S., Sakhno, S., Striuk, A., Osadchyi, V., Solovieva, V., Vakaliuk, T., Nechypurenko, P., Bondarenko, O., Danylchuk, H. (eds.) The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020). Kryvyi Rih, Ukraine, May 20-22, 2020. E3S Web of Conferences **166**, 13007 (2020). doi:10.1051/e3sconf/202016613007
17. Kholoshyn, I.V., Bondarenko, O.V., Hanchuk, O.V., Shmeltser, E.O.: Cloud ArcGIS Online as an innovative tool for developing geoinformation competence with future geography teachers. CEUR Workshop Proceedings **2433**, 403–412 (2019)
18. Kholoshyn, I.V., Bondarenko, O.V., Hanchuk, O.V., Varfolomyeyeva, I.M.: Cloud technologies as a tool of creating Earth Remote Sensing educational resources. CEUR Workshop Proceedings **2643**, 474–486 (2020)
19. Kholoshyn, I.V., Varfolomyeyeva, I.M., Hanchuk, O.V., Bondarenko, O.V., Pikilnyak, A.V.: Pedagogical techniques of Earth remote sensing data application into modern school practice. CEUR Workshop Proceedings **2433**, 391–402 (2019)
20. Kiv, A.E., Shyshkina, M.P., Semerikov, S.O., Striuk, A.M., Yechkalo, Yu.V.: AREdu 2019 – How augmented reality transforms to augmented learning. CEUR Workshop Proceedings **2547**, 1–12 (2020)
21. Kiv, A.E., Soloviev, V.N.: Preface. CEUR Workshop Proceedings **2257** (2018)
22. Klochko, O.V., Fedorets, V.M., Uchitel, A.D., Hnatyuk, V.V.: Methodological aspects of using augmented reality for improvement of the health preserving competence of a Physical Education teacher. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
23. Komarova, E., Starova, T.: Majority values of school biological education in the context of education for sustainable development. In: Semerikov, S., Chukharev, S., Sakhno, S., Striuk, A., Osadchyi, V., Solovieva, V., Vakaliuk, T., Nechypurenko, P., Bondarenko, O., Danylchuk, H. (eds.) The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020). Kryvyi Rih, Ukraine, May 20-22, 2020. E3S Web of Conferences **166**, 10029 (2020). doi:10.1051/e3sconf/202016610029
24. Komarova, E.V., Kiv, A.E.: Alternatives in biological education as a way to implement an ethical approach to the formation of subject and professional competence of future teachers. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
25. Komarova, O.V., Azaryan, A.A.: Computer Simulation of Biological Processes at the High School. CEUR Workshop Proceedings **2257**, 24–32 (2018)
26. Kompaniets, A., Chemerys, H., Krasheninnik, I.: Using 3D modelling in design training simulator with augmented reality. CEUR Workshop Proceedings **2546**, 213–223 (2019)
27. Koniukhov, S., Osadcha, K.: Implementation of education for sustainable development principles in the training of future software engineers. In: Semerikov, S., Chukharev, S., Sakhno, S., Striuk, A., Osadchyi, V., Solovieva, V., Vakaliuk, T., Nechypurenko, P.,

Bondarenko, O., Danylchuk, H. (eds.) The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020). Kryvyi Rih, Ukraine, May 20-22, 2020. E3S Web of Conferences **166**, 10035 (2020). doi:10.1051/e3sconf/202016610035

28. Kozlovsky, E.O., Kravtsov, H.M.: Multimedia virtual laboratory for physics in the distance learning. CEUR Workshop Proceedings **2168**, 42–53 (2018)
29. Kravtsov, H., Pulinets, A.: Interactive Augmented Reality Technologies for Model Visualization in the School Textbook. CEUR-WS.org, online (2020, in press)
30. Kuzminska, O., Mazorchuk, M., Morze, N., Pavlenko, V., Prokhorov, A.: Study of Digital Competence of the Students and Teachers in Ukraine. Communications in Computer and Information Science **1007**, 148–169 (2019)
31. Kuzminska, O., Mazorchuk, M., Morze, N., Pavlenko, V., Prokhorov, A.: Digital competency of the students and teachers in Ukraine: Measurement, analysis, development prospects. CEUR Workshop Proceedings **2104**, 366–379 (2018)
32. Lavrentieva, O.O., Arkhypov, I.O., Krupskyi, O.P., Velykodnyi, D.O., Filatov, S.V.: Methodology of using mobile apps with augmented reality in students' vocational preparation process for transport industry. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
33. Lavrentieva, O.O., Arkhypov, I.O., Kuchma, O.I., Uchitel, A.D.: Use of simulators together with virtual and augmented reality in the system of welders' vocational training: past, present, and future. CEUR Workshop Proceedings **2547**, 201–216 (2020)
34. Marienko, M., Nosenko, Y., Sukhikh, A., Tataurov, V., Shyshkina, M.: Personalization of learning through adaptive technologies in the context of sustainable development of teachers' education. In: Semerikov, S., Chukharev, S., Sakhno, S., Striuk, A., Osadchyi, V., Solovieva, V., Vakaliuk, T., Nechypurenko, P., Bondarenko, O., Danylchuk, H. (eds.) The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020). Kryvyi Rih, Ukraine, May 20-22, 2020. E3S Web of Conferences **166**, 10015 (2020). doi:10.1051/e3sconf/202016610015
35. Marienko, M.V., Nosenko, Yu.H., Shyshkina, M.P.: Personalization of learning using adaptive technologies and augmented reality. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
36. Mazbayev, O., Alieva, L., Demeuov, A.: Problematic issues of geographical education in Kazakhstan. In: Semerikov, S., Chukharev, S., Sakhno, S., Striuk, A., Osadchyi, V., Solovieva, V., Vakaliuk, T., Nechypurenko, P., Bondarenko, O., Danylchuk, H. (eds.) The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020). Kryvyi Rih, Ukraine, May 20-22, 2020. E3S Web of Conferences **166**, 10032 (2020). doi:10.1051/e3sconf/202016610032
37. Midak, L.Ya., Kravets, I.V., Kuzyshyn, O.V., Berladyniuk, Kh.V., Buzhdyhan, Kh.V., Baziuk, L.V., Uchitel, A.D.: Augmented reality in process of studying astronomic concepts in primary school. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
38. Midak, L.Ya., Kravets, I.V., Kuzyshyn, O.V., Pahomov, J.D., Lutsyshyn, V.M., Uchitel, A.D.: Augmented reality technology within studying natural subjects in primary school. CEUR Workshop Proceedings **2547**, 251–261 (2020)

39. Morkun, V.S., Morkun, N.V., Pikilnyak, A.V.: Augmented reality as a tool for visualization of ultrasound propagation in heterogeneous media based on the k-space method. CEUR Workshop Proceedings **2547**, 81–91 (2020)
40. Nechypurenko, P.P., Starova, T.V., Selivanova, T.V., Tomilina, A.O., Uchitel, A.D.: Use of Augmented Reality in Chemistry Education. CEUR Workshop Proceedings **2257**, 15–23 (2018)
41. Nezhyva, L.L., Palamar, S.P., Lytvyn, O.S.: Perspectives on the use of augmented reality within the linguistic and literary field of primary education. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
42. Nosenko, Yu.H., Popel, M.V., Shyshkina, M.P.: The state of the art and perspectives of using adaptive cloud-based learning systems in higher education pedagogical institutions (the scope of Ukraine). CEUR Workshop Proceedings **2433**, 173–183 (2019)
43. Oleksiuk, V.P., Oleksiuk, O.R.: Exploring the potential of augmented reality for teaching school computer science. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
44. Osadcha, K., Osadchyi, V., Semerikov, S., Chemerys, H., Chorna, A.: The Review of the Adaptive Learning Systems for the Formation of Individual Educational Trajectory. CEUR-WS.org, online (2020, in press)
45. Osadchyi, V.V., Chemerys, H.Y., Osadcha, K.P., Kruhlyk, V.S., Koniukhov, S.L., Kiv, A.E.: Conceptual model of learning based on the combined capabilities of augmented and virtual reality technologies with adaptive learning systems. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
46. Osadchyi, V.V., Varina, H.B., Osadcha, K.P., Prokofieva, O.O., Kovalova, O.V., Kiv, A.E.: Features of implementation of modern AR technologies in the process of psychological and pedagogical support of children with autism spectrum disorders. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
47. Panchenko, L., Khomiak, A.: Education Statistics: Looking for a Case-study for Modelling. CEUR-WS.org, online (2020, in press)
48. Panchenko, L.F., Muzyka, I.O.: Analytical review of augmented reality MOOCs. CEUR Workshop Proceedings **2547** (2020)
49. Panchenko, L.F., Vakaliuk, T.A., Vlasenko, K.V.: Augmented reality books: concepts, typology, tools. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
50. Pavlenko, V., Prokhorov, A., Kuzminska, O., Mazorchuk, M.: Competence approach to modeling and control of students' learning pathways in the cloud service. CEUR Workshop Proceedings **1844**, 257–264 (2017)
51. Pererva, V.V., Lavrentieva, O.O., Lakomova, O.I., Zavalniuk, O.S., Tolmachev, S.T.: The technique of the use of Virtual Learning Environment in the process of organizing the future teachers' terminological work by specialty. CEUR Workshop Proceedings **2643**, 321–346 (2020)
52. Pinchuk, O.P., Sokolyuk, O.M., Burov, O.Yu., Shyshkina, M.P.: Digital transformation of learning environment: aspect of cognitive activity of students. CEUR Workshop Proceedings **2433**, 90–101 (2019)

53. Pochtoviuk, S.I., Vakaliuk, T.A., Pikilnyak, A.V.: Possibilities of application of augmented reality in different branches of education. CEUR Workshop Proceedings **2547**, 92–106 (2020)
54. Popel, M.V., Shyshkina, M.P.: The Cloud Technologies and Augmented Reality: the Prospects of Use. CEUR Workshop Proceedings **2257**, 232–236 (2018)
55. Prokhorov, A., Klymenko, I., Yashina, E., Morozova, O., Oleynick, S., Solyanyk, T.: SCADA systems and augmented reality as technologies for interactive and distance learning. CEUR Workshop Proceedings **1844**, 245–256 (2017)
56. Prokhorov, O.V., Lisovichenko, V.O., Mazorchuk, M.S., Kuzminska, O.H.: Developing a 3D quest game for career guidance to estimate students' digital competences. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
57. Rashevska, N.V., Semerikov, S.O., Zinonos, N.O., Tkachuk, V.V., Shyshkina, M.P.: Using augmented reality tools in the teaching of two-dimensional plane geometry. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
58. Rashevska, N.V., Soloviev, V.N.: Augmented Reality and the Prospects for Applying Its in the Training of Future Engineers. CEUR Workshop Proceedings **2257**, 192–197 (2018)
59. Savchenko, S.V., Shekhavtsova, S.O., Zaselskiy, V.I.: The development of students' critical thinking in the context of information security. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
60. Shamonia, V.H., Semenikhina, O.V., Proshkin, V.V., Lebid, O.V., Kharchenko, S.Ya., Lytvyn, O.S.: Using the Proteus virtual environment to train future IT professionals. CEUR Workshop Proceedings **2547**, 24–36 (2020)
61. Shapovalov, V.B., Atamas, A.I., Bilyk, Zh.I., Shapovalov, Ye.B., Uchitel, A.D.: Structuring Augmented Reality Information on the stemua.science. CEUR Workshop Proceedings **2257**, 75–86 (2018)
62. Shapovalov, V.B., Shapovalov, Ye.B., Bilyk, Zh.I., Megalinska, A.P., Muzyka, I.O.: The Google Lens analyzing quality: an analysis of the possibility to use in the educational process. CEUR Workshop Proceedings **2547**, 117–129 (2020)
63. Shapovalov, Ye.B., Bilyk, Zh.I., Atamas, A.I., Shapovalov, V.B., Uchitel, A.D.: The Potential of Using Google Expeditions and Google Lens Tools under STEM-education in Ukraine. CEUR Workshop Proceedings **2257**, 66–74 (2018)
64. Shepiliev, D.S., Semerikov, S.O., Yechkalo, Yu.V., Tkachuk, V.V., Markova, O.M., Modlo, Ye.O., Mintii, I.S., Mintii, M.M., Selivanova, T.V., Maksyshko, N.K., Vakaliuk, T.A., Osadchyi, V.V., Tarasenko, R.O., Amelina, S.M., Kiv, A.E.: Development of career guidance quests using WebAR. Journal of Physics: Conference Series (2020, in press)
65. Shyshkina, M.P., Marienko, M.V.: Augmented reality as a tool for open science platform by research collaboration in virtual teams. CEUR Workshop Proceedings **2547**, 107–116 (2020)
66. Shyshkina, M.P.: The Problems of Personnel Training for STEM Education in the Modern Innovative Learning and Research Environment. CEUR Workshop Proceedings **2257**, 61–65 (2018)
67. Symonenko, S.V., Zaitseva, N.V., Osadchyi, V.V., Osadcha, K.P., Shmeltser, E.O.: Virtual reality in foreign language training at higher educational institutions. CEUR Workshop Proceedings **2547**, 37–49 (2020)

68. Syrovatskyi, O.V., Semerikov, S.O., Modlo, Ye.O., Yechkalo, Yu.V., Zelinska, S.O.: Augmented reality software design for educational purposes. CEUR Workshop Proceedings **2292**, 193–225 (2018)
69. Syvyi, M.J., Mazbayev, O.B., Varakuta, O.M., Panteleeva, N.B., Bondarenko, O.V.: Distance learning as innovation technology of school geographical education. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
70. Tarasenko, R., Amelina, S.: A Unification of the Study of Terminological Resource Management in the Automated Translation Systems as an Innovative Element of Technological Training of Translators. CEUR-WS.org, online (2020, in press)
71. Tarasenko, R.O., Amelina, S.M., Azaryan, A.A.: Features of the use of cloud-based translation systems in the process of forming information competence of translators. CEUR Workshop Proceedings **2433**, 322–335 (2019)
72. Tarasenko, R.O., Amelina, S.M., Azaryan, A.A.: Improving the content of training future translators in the aspect of studying modern CAT tools. CEUR Workshop Proceedings **2643**, 360–375 (2020)
73. Tarasenko, R.O., Amelina, S.M., Azaryan, A.A.: Integrated testing system of information competence components of future translators. CEUR Workshop Proceedings **2643**, 376–391 (2020)
74. Tarasenko, R.O., Amelina, S.M., Kazhan, Yu.M., Bondarenko, O.V.: The use of AR elements in the study of foreign languages at the university. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
75. Tkachuk, V.V., Yechkalo, Yu.V., Markova, O.M.: Augmented reality in education of students with special educational needs. CEUR Workshop Proceedings **2168**, 66–71 (2018)
76. Valko, N.V., Kushnir, N.O., Osadchyi, V.V.: Cloud technologies for STEM education. CEUR Workshop Proceedings **2643**, 435–447 (2020)
77. Volikova, M.M., Armash, T.S., Yechkalo, Yu.V., Zaselskiy, V.I.: Practical use of cloud services for organization of future specialists professional training. CEUR Workshop Proceedings **2433**, 486–498 (2019)
78. Yahupov, V.V., Kyva, V.Yu., Zaselskiy, V.I.: The methodology of development of information and communication competence in teachers of the military education system applying the distance form of learning. CEUR Workshop Proceedings **2643**, 71–81 (2020)
79. Yechkalo, Yu.V., Tkachuk, V.V., Hruntova, T.V., Brovko, D.V., Tron, V.V.: Augmented Reality in Training Engineering Students: Teaching Techniques. CEUR Workshop Proceedings **2393**, 952–959 (2019)
80. Zhylenko, T.I., Koziy, I.S., Bozhenko, V.S., Shuda, I.A.: Using a web application to realize the effect of AR in assessing the environmental impact of emissions source. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
81. Zinonos, N.O., Vihrova, E.V., Pikilnyak, A.V.: Prospects of Using the Augmented Reality for Training Foreign Students at the Preparatory Departments of Universities in Ukraine. CEUR Workshop Proceedings **2257**, 87–92 (2018)