AREdu 2021 – Immersive technology today

Svitlana H. Lytvynova¹, Serhiy O. Semerikov^{1,2,3,4}, Andrii M. Striuk³, Mykola I. Striuk³, Larisa S. Kolgatina⁵, Vladyslav Ye. Velychko⁶, Iryna S. Mintii^{1,2}, Olga O. Kalinichenko² and Serhii M. Tukalo¹

¹Institute of Information Technologies and Learning Tools of the NAES of Ukraine, 9 M. Berlynskoho Str., Kyiv, 04060, Ukraine

²Kryvyi Rih State Pedagogical University, 54 Gagarin Ave., Kryvyi Rih, 50086, Ukraine

³Kryvyi Rih National University, 11 Vitalii Matusevych Str., Kryvyi Rih, 50027, Ukraine

⁴University of Educational Management, 52-A Sichovykh Striltsiv Str., Kyiv, 04053, Ukraine

⁵H. S. Skovoroda Kharkiv National Pedagogical University, 29 Alchevskyh Str., Kharkiv, 61002, Ukraine

⁶Donbas State Pedagogical University, 19 Henerala Batiuka Str., Sloviansk, 64122, Ukraine

Abstract

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

Keywords

virtualization of learning: principles, technologies, tools, augmented reality gamification, design and implementation of augmented reality learning environments, aspects of environmental augmented reality security and ethics, augmented reality in science education, augmented reality in professional training and retraining, augmented reality social and technical issues

AREdu 2021: 4th International Workshop on Augmented Reality in Education, May 11, 2021, Kryvyi Rih, Ukraine S.h.lytvynova@gmail.com (S.H. Lytvynova); semerikov@gmail.com (S.O. Semerikov);

(S.O. Semerikov); http://mpz.knu.edu.ua/pro-kafedru/vikladachi/224-andrii-striuk (A.M. Striuk);

andrey.n.stryuk@gmail.com (A. M. Striuk); stryukm@gmail.com (M. I. Striuk); larakl@ukr.net (L. S. Kolgatina); vladislav.velichko@gmail.com (V. Ye. Velychko); irina.mintiy@kdpu.edu.ua (I. S. Mintii);

olgakalinichenko6@gmail.com (O.O. Kalinichenko); serhii.tukalo@gmail.com (S.M. Tukalo)

https://iitlt.gov.ua/eng/structure/detail.php?ID=998 (S. H. Lytvynova); https://kdpu.edu.ua/semerikov

http://hnpu.edu.ua/uk/kolgatina-larysa-sergivivna (L.S. Kolgatina); https://ddpu.edu.ua/cc/velychko/

⁽V. Ye. Velychko); https://kdpu.edu.ua/personal/ismintii.html (I. S. Mintii);

https://kdpu.edu.ua/personal/ookalinichenko.html (O.O. Kalinichenko);

https://iitlt.gov.ua/eng/structure/departments/science/detail.php?ID=293 (S. M. Tukalo)

D 0000-0002-5450-6635 (S.H. Lytvynova); 0000-0003-0789-0272 (S.O. Semerikov); 0000-0001-9240-1976

⁽A. M. Striuk); 0000-0002-7456-3725 (M. I. Striuk); 0000-0003-2650-8921 (L. S. Kolgatina); 0000-0001-9752-0907 (V. Ye. Velychko); 0000-0003-3586-4311 (I. S. Mintii); 0000-0002-7057-2675 (O. O. Kalinichenko); 0000-0002-6268-1185 (S. M. Tukalo)

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1. Introduction

1.1. AREdu 2021 at a glance

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

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

- Virtualization of learning: principles, technologies, tools
- Augmented reality gamification
- · Design and implementation of augmented reality learning environments



- Augmented reality in science education
- Figure 1: AREdu 2021 logo · Augmented reality in professional training and retraining

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

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

1.2. AREdu 2021 program committee

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

Olga Bondarenko, born in 1979, in 2001 graduated with honors from the geographical faculty of Kryvyi Rih 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 PhD thesis at the Republican Higher Educational Institution "Crimean Humanities University" (Yalta) and received a PhD 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, Czech Republic; assistant at Department of Applied Informatics, Faculty of Economics, VŠB-Technical university of Ostrava, Czech Republic; visiting professor at WSG Bydgoszcz, Poland.

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 databases, information systems, operating system, MES system in production and www technologies 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

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

Irina GEORGESCU holds a PhD 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 fuzzy economics, computational intelligence and econometrics. She is the author of about 40 journal papers and 2 books published in Springer Verlag.



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

Dr. **Vita Hamaniuk**, Professor of German, Literature and Didactics, Department of German, Literature and Didactics, Kryvyi Rih State Pedadogical University, Kryvyi Rih, Ukraine.

Vita Hamaniuk, born in 1965, 1995 received a Candidate of Pedagogical Sciences degree (Dr. ped.) from the Kharkiv State Pedagogical H. Scovoroda University, in 2013 – a Doctor of Pedagogical Sciences degree (Dr. habil.) from the East-Ukrainian National Volodymyr Dahl University. In 2001 she received his habilitation as the Docent (Assoc. Prof.) at the Department of Foreign Languages of Kryvyi Rih State Pedagogical University.

In 2015 she received his habilitation as the Professor (Full Prof.) at the Department of German, Literature and Didactics of Kryvyi Rih State Pedagogical University. From September 1995 until now Vita Hamaniuk worked as a head of Department of Foreign Languages, as an Associate Professor, Head of Department, Full Professor of Department of German, Literature and Didactics. From April 2017, she works as vice-rector for research at Kryvyi Rih State Ped-



agogical University. 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

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

WWW: https://www.dfki.de/en/web/about-us/ employee/person/haja01/

E-mail: hamraz.javaheri@dfki.de

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

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 Informatics, Department of Information Systems, Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine.

Oleksandr Kolgatin, born in 1966, received a Candidate of Technical Sciences degree (Dr. phil.) from the Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, in 1995, the field of scientific interests was computational modeling of the heat and mass transfer processes. Since 1990, he worked in the field of teaching informatics and using information technologies in education and received a Doctor of Pedagogical Sciences degree (Dr. habil.) from the Institute of Information technologies and Learning Tools of the National Academy of Pedagogical Sciences of Ukraine, in 2011. His research interests include computational modeling, pedagogical diagnostics, information systems and 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 Journal of Information Technologies in Education and associate editor of Information Technologies and Learning Tools.

WWW: http://www.is.hneu.edu.ua/?q=node/294 E-mail: kolgatin@ukr.net

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://www.scopus.com/authid/detail.uri?authorId=56925498100, https://orcid.org/ 0000-0002-7924-3878, https://scholar.google.com/citations?user=-GCy09MAAAAJ

E-mail: yaroslav.krainyk@chmnu.edu.ua

Dr. **Hennadiy Kravtsov**, Kherson State University, Ukraine.

WWW: http://www.kspu.edu/About/Faculty/ FPhysMathemInformatics/ChairInformatics/Staff/Kravtsov. aspx

E-mail: kgmkherson@gmail.com

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 Cryophisics 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**, Deputy Director for Research, Institute of Information Technologies and Learning Tools of NAES of Ukraine, Kyiv, Ukraine.

Svitlana Lytvynova, born in 1964, received a Candidate of Pedagogical Sciences degree (Dr. phil.) from the Institute of Information Technologies and Learning Tools of the National Academy of Pedagogical Sciences of Ukraine in 2011, 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 2016. Since



2004, he has been working on the problems on the implementation of ICT, cloud, mobile, AR & VR technologies, computer modeling in the educational process of educational institutions. She has published a number of papers in international journal and volumes in book series, is a member of editorial boards of leading Ukrainian magazines from problem ICT in education and professional development of teachers.

WWW: https://iitlt.gov.ua/eng/ E-mail: s.h.lytvynova@gmail.com

Ph. D. **Iryna Mintii**, associate professor of Computer Science, Department of Computer Science and Applied Mathematics, vice dean of Faculty of Physics and Mathematics, Kryvyi Rih State Pedagogical University, Kryvyi Rih, Ukraine.

Iryna Mintii received a Candidate of Pedagogical Sciences degree (Ph. D.) from the National Pedagogical Dragomanov University, Kyiv, 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

Andrii Morozov, Candidate of Technical Sciences (PhD), 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

Pavlo Nechypurenko, Associate 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

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.

Yuliia Nosenko, born in 1984, received a Candidate of Pedagogical Sciences degree (Ph.D.) 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 80 scientific papers, including ar-



ticles 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-y@ukr.net

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 (In-



stitute 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://tnpu.edu.ua/faculty/fizmat/oleksyuk-vasil-petrovich.php

E-mail: oleksyuk@fizmat.tnpu.edu.ua

DSc **Kateryna Osadcha**, Associate professor, Department of Computer Science and Cybernetics, Bogdan Khmelnitsky Melitopol state pedagogical university, Melitopol, Ukraine.

Kateryna Osadcha, born in 1977, received a Candidate of Pedagogical Sciences (PhD in Education) from the Vinnytsia State Pedagogical University named after Mykhailo Kotsiubynsky, Ukraine, in 2010 and received a Doctor of Pedagogical Sciences (PhD in Education) from the Classic Private University (Zaporizhzhia), Ukraine, in 2020. Since 2011, she has been working as an Associate professor of the Department of Computer Science and Cybernetics at the Bogdan Khmelnitsky Melitopol state pedagogical univer-



sity. 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), "Computing Conference 2021" (United Kingdom).

WWW: http://osadcha.mdpu.org.ua 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 sys-



tems, 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), "Computing Conference" (formerly called "Science and Information (SAI) Conference") (UK), Intelligent Systems Conference (IntelliSys) (The Netherlands), "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", "Mathematical and statistical methods of sociological information's analysis") 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

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. 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 she work in the Institute of Information Technologies and Learning Tools of the NAES of Ukraine.

She 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), "System of computer modeling of cognitive tasks for the formation of competencies of students in natural and mathematical subjects". She have more than 80 published scientific works, the author of collective monographs, manuals. She also obtain the post of co-editors-in-chief of "Information Technologies and Learning Tools ", a 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. **Serhiy Semerikov**, Professor of Computer Science and Educational technology, Kryvyi Rih State Pedagogical University, Ukraine.

Serhiy Semerikov is professor of Department of Computer Science and Applied Mathematics at Kryvyi Rih State Pedagogical University. He got both PhD and DSc in education (informatics) from the National Pedagogical Dragomanov University in 2001 and 2009, respectively. The main directions of Dr. Semerikov' research is methods of learning and educational technology.

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



Dr. **Yevhenii Shapovalov**, Chief specialist in Ministry of Digital Transformation of Ukraine and Researcher in National Center "Junior Academy of Science of Ukraine".

Yevhenii Shapovalov was born in 1992, received Ph.D. in 2020 from the National University of Life and Environmental Sciences of Ukraine in biotechnology. He worked in the field of digitalization of chemistry education in the National Center "Junior Academy of Science of Ukraine" from 2014 to 2020 and then start to work in the Ministry of Digital transformation. He has studied the anaerobic digestion of high nitrogen content in biotechnology and modern approaches in the digitalization of education, such as using AR, smart tools, and ontologies to structure education content. He is a board member of NGO "European Studies' Platform for Sustainable Development" and has experience in international educational projects (Erasmus+).



WWW: http://www.nas.gov.ua/UA/PersonalSite/Pages/default.aspx?PersonID=0000026333

E-mail: sjb@man.gov.ua, shapovalov@thedigital.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, 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**, PhD of Physics and Mathematic Sciences, DSc of Educational Sciences, Department of Informatics, Software Engineering and Economic Cybernetics, Kherson State University, Kherson, Ukraine.

Nataliia Valko, in 2006 earned a PhD degree of Physics and Mathematic Sciences in specialty "Mathematical modeling and numerical methods". She 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

Nataliia Veretennikova, PhD, 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 PhD 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 a lot of 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.

WWW: http://wiki.lp.edu.ua/wiki/%D0%92%D0%B5%D1%80%D0%B5%D1%82%D0%B5%D0% BD%D0%BD%D1%96%D0%BA%D0%BE%D0%B2%D0%B0_%D0%9D%D0%B0%D1%82%D0%B0% D0%BB%D1%96%D1%8F_%D0%92%D1%8F%D1%87%D0%B5%D1%81%D0%BB%D0%B0%D0%B2% D1%96%D0%B2%D0%BD%D0%B0 E-mail: nataver19@gmail.com

Dr. **Kateryna Vlasenko**, Professor of Maths, Department of Mathematics, National University of "Kyiv Mohyla Academy", Kyiv, 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. 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/tutors/kateryna-vlasenko/ E-mail: vlasenkokv@ukr.net

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



2. Articles overview

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

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

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

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



Figure 2: Presentation of paper [4].

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

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





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

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



Figure 4: Presentation of paper [41].

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

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



Figure 5: Presentation of paper [37].

2.2. Session 2: Augmented reality gamification

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

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

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

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



Figure 6: Presentation of paper [46].

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

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

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

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



Figure 7: Presentation of paper [54].

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

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

2.4. Session 4: Augmented reality in science education

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



Figure 8: Presentation of paper [60].

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

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

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





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

Homework example (6th week)



Figure 10: Presentation of paper [72].

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

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

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

This article highlights further research by the authors, begun in [80, 81, 82, 83, 84, 85, 86?]. The article 'Using Blippar to create augmented reality in chemistry education'" [87] by Yuliya



Figure 11: Presentation of paper [76].

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

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

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



Figure 12: Presentation of paper [79].

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



Figure 13: Presentation of paper [87].

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

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

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



Figure 14: Presentation of paper [88].

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

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



Figure 15: Presentation of paper [90].

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

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

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



Figure 16: Presentation of paper [71].

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

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

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

Level B - "Synergistic movements" (Virtual model - VM)



Figure 3. Space: your body and the immediate surrounding space

Figure 17: Presentation of paper [70].

Movement: base walking and dancing (rhythmic), maintaining balance and balancing

Characteristic of movement: movements without taking into account the spatial structure of the environment, economical, balancing, stereotic, equilibrium, "pulsating", rhythmic, repetitive, smooth and precise, partially automatic, the basis of walking

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

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



Figure 18: Presentation of paper [100].

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

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

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

ACTIVATION OF COLORING PAGES WITH AUGMENTED REALITY LIVE COLORING



Figure 19: Presentation of paper [101].

3. Conclusion

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We are looking forward to excellent presentations and fruitful discussions, which will broaden our professional horizons. We hope all participants enjoy this workshop and meet again in more friendly, hilarious, and happiness of further AREdu 2022.

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