# Unlocking the power of synergy: the joint force of cloud technologies and augmented reality in education

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## Abstract

This is an introductory text to a collection of selected papers from the 10th Workshop on Cloud Technologies in Education (CTE 2021) and 5th International Workshop on Augmented Reality in Education (AREdu 2022) which were held in Kryvyi Rih, Ukraine, on May 23, 2022. It consists of information on events and short summaries of selected papers.

## Keywords

adaptive cloud learning platforms, blended learning, blockchain in education, cloud-based AI education applications, cloud-based e-learning platforms, tools and services, cloud-based learning environments, competency-based education platforms, digital transformation of education, educational data mining, emotion AI, immersive technology applications in education, mobile learning, smart campus technologies, social analytics in education, virtualization of learning: principles, technologies, tools, augmented reality gamification, design and implementation of augmented reality learning environments, augmented reality in science education, augmented reality in professional training and retraining

# 1. Introduction

## 1.1. CTE 2022: 10th Workshop on Cloud Technologies in Education

### 1.1.1. CTE 2022 at a glance

**C**loud **T**echnologies in **E**ducation (CTE) is a peer-reviewed international Computer Science workshop focusing on research advances, applications of cloud technology in education.

The Workshop occupies contributions in all aspects of educational technologies and cloud-based learning tools, platforms, paradigms and models, functioning programmes or papers relevant to modern engineering and technological decisions in the IT age.

CTE topics of interest since 2012 [1, 2, 3, 4, 5, 6, 7, 8, 9]:

- Adaptive Cloud Learning Platforms
- Blended Learning
- Blockchain in Education
- Cloud-based AI Education Applications
- Cloud-based E-learning Platforms, Tools and Services


Figure 1: CTE 2022 logo.

*CTE 2022: 10th Workshop on Cloud Technologies in Education,*
*AREdu 2022: 5th International Workshop on Augmented Reality in Education, May 23, 2022, Kryvyi Rih, Ukraine*
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https://ptpe.edc.uoc.gr/en/staff/32380/82 (S. Papadakis); https://ieeexplore.ieee.org/author/38339185000 (A. E. Kiv); http://www.kspu.edu/About/Faculty/FPhysMathemInformatics/ChairInformatics/Staff/Kravtsov.aspx (H. M. Kravtsov);
https://kubg.edu.ua/prouniversitet/vizytivka/rektorat/dyrektory/1175-osadchyi-viacheslav-volodymyrovych.html (V. V. Osadchyi); https://iitlt.gov.ua/eng/structure/departments/cloud/detail.php?ID=565 (M. V. Marienko);
https://iitlt.gov.ua/eng/structure/detail.php?ID=442 (O. P. Pinchuk);
https://iitlt.gov.ua/eng/structure/departments/cloud/detail.php?ID=269 (M. P. Shyshkina);
https://iitlt.gov.ua/eng/structure/detail.php?ID=1139 (O. M. Sokolyuk); https://acnsci.org/mintii (I. S. Mintii);
https://sites.google.com/view/neota/profile-vakaliuk-t (T. A. Vakaliuk); http://lazarova.vk.vntu.edu.ua/ (L. E. Azarova); http://hnpu.edu.ua/uk/kolgatina-larysa-sergiyivna (L. S. Kolgatina); https://nubip.edu.ua/node/6245 (S. M. Amelina); https://duan.edu.ua/abit/osvitni-prohramy/osvitni-prohramy-kafedry-innovatsiinykh-tekhnolohii-z-pedahohiky-psykholohii-ta-sotsialnoi-roboty-3.html#volkova_n (N. P. Volkova); https://ddpu.edu.ua/cc/velychko (V. Ye. Velychko);
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- Cloud-based Learning Environments
- Competency-Based Education Platforms
- Digital Transformation of Education
- Educational Data Mining
- Emotion AI
- Immersive Technology Applications in Education
- Mobile Learning
- Smart Campus Technologies
- Social Analytics in Education

The first part of this volume represents the proceedings of the 10th Workshop on Cloud Technologies in Education (CTE 2022), held in Kryvyi Rih, Ukraine, on May 23, 2022. It comprises 4 contributed papers that were carefully peer-reviewed and selected from 11 submissions. Each submission was reviewed by at least 3 program committee members. The accepted papers present the state-of-the-art overview of successful cases and provides guidelines for future research.

### 1.1.2. CTE 2022 committees

#### Program committee

- *Leon A. Abdillah*, Universitas Bina Darma, Indonesia [10]
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- *Olga Bondarenko*, Kryvyi Rih State Pedagogical University, Ukraine [14]
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## 1.2. 5th International Workshop on Augmented Reality in Education

### 1.2.1. AREdu 2022 at a glance

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

AREdu topics of interest since 2018 [58, 59, 60, 61, 62]:

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


Figure 2: AREdu 2022 logo.

The second part of this volume represents the proceedings of the 5th International Workshop on Augmented Reality in Education (AREdu 2022), held in Kryvyi Rih, Ukraine, on May 23, 2022. It comprises 2 contributed papers that was carefully peer-reviewed and selected from 5 submissions. Each submission was reviewed by at least 3 program committee members. The accepted papers includes a current summary of successful cases as well as directions for future research.

### 1.2.2. AREdu 2022 committees

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- *Olga Bondarenko*, Kryvyi Rih State Pedagogical University, Ukraine [63]
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# 2. Articles overview

## 2.1. CTE 2022 overview

The research "Economic analysis of factors associated with education and employment" [94] by George Abuselidze (figure 3) and Gia Zoidze aims to analyze the current state of the Georgian economy and labor market, including workforce structure, challenges, and trends, by conducting qualitative and quantitative studies. Market requirements were analyzed, and consultations were held with experts, employers, and representatives from the Center for the Development of Quality Education. The study also examined the compatibility of higher education programs with market demands, practical components in the educational process, and the relationship between higher education institutions and students. The findings suggest that promoting professional education, with the proper involvement of the state, can positively impact the economy and the country's situation. Additionally, the study examined the influence of higher education on employment and income, indicating a discernible return on investment, but also highlighting that human capital developed in the higher education system is not efficiently employed. The

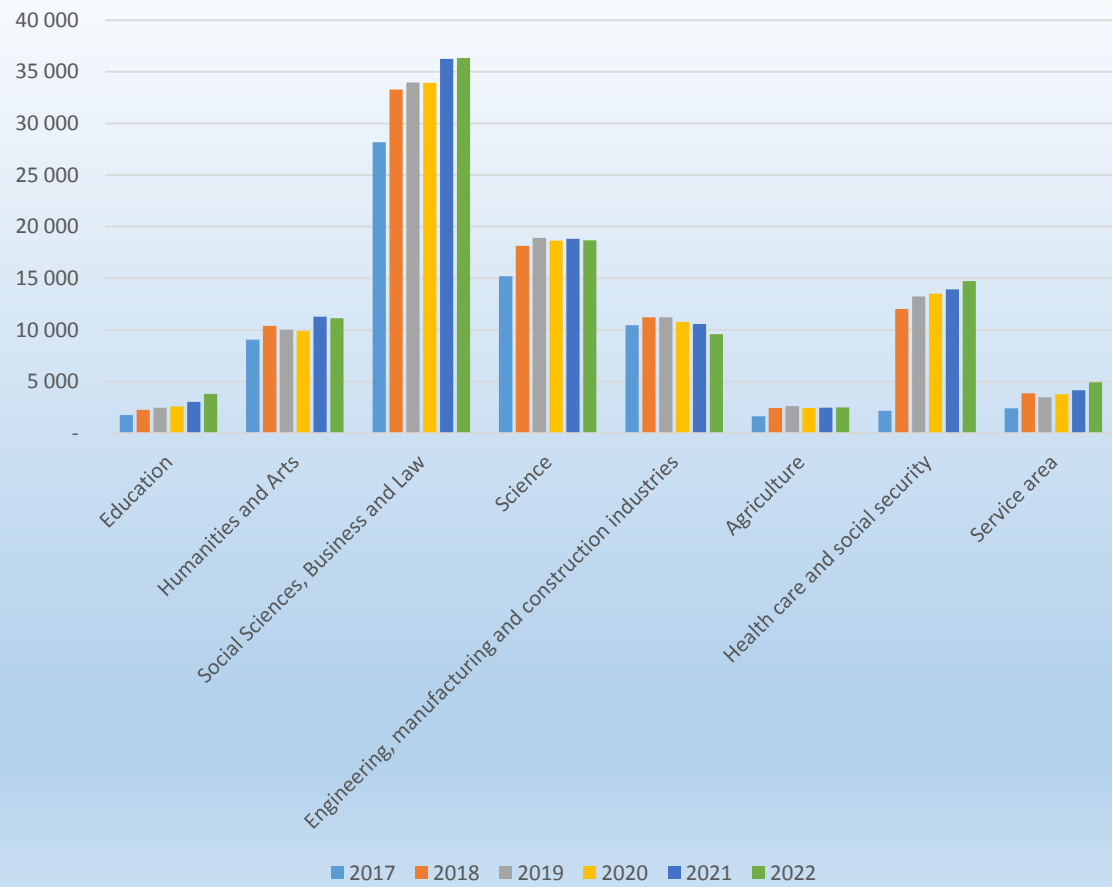



**Figure 3:** Presentation of paper [94].

study concludes with recommendations to address the issues facing the Georgian labor market and envision labor force demand. Overall, this research sheds light on the intersection of education and technology in addressing workforce needs in the Georgian context.

The authors' related works are referenced as [95, 96, 97].

The article "Smart education in the prospective teachers' training" [98] by Natalia Ye. Dmitrenko, Oksana V. Voloshyna, Svitlana S. Kizim (figure 4), Kateryna V. Mnyshenko and Svitlana V. Nahorniak explores the concept of smart education and its potential for developing the professional training of future teachers. The main components of smart education, including smart students, smart pedagogy, and smart environments, are examined, and the principles underlying this approach to education, such as mobile access and the creation of new knowledge, are defined. The features of smart education are also discussed, with a focus on its implementation in the context of the COVID-19 pandemic and military events in Ukraine. The study identifies the functions of the smart system in the pedagogical cycle, including its content, technological components, and facilities for students and teachers. The criteria for evaluating smart complexes, such as automation, sequencing, assessment, data collection, and self-organization, are


**Figure 4:** Presentation of paper [98].

identified. The study also examines distance learning systems for creating smart complexes in the training of prospective teachers, drawing on student surveys to evaluate the advantages and disadvantages of using smart technologies in the educational process. Finally, the article outlines avenues for further research on the integration of smart education into teacher training programs. Overall, this research contributes to the literature on education science by highlighting the potential of smart education for enhancing the professional development of future teachers.

The authors' related works are referenced as [99, 100, 101].

The COVID-19 pandemic led to a public health emergency that required the confinement of populations worldwide, including the suspension of face-to-face classes at all educational levels in the Spain. In response, educational centers and teachers turned to social media as the primary means of communication to continue teaching and socialization processes. The study "Possibilities and limitations of social media in education processes during the pandemic: The

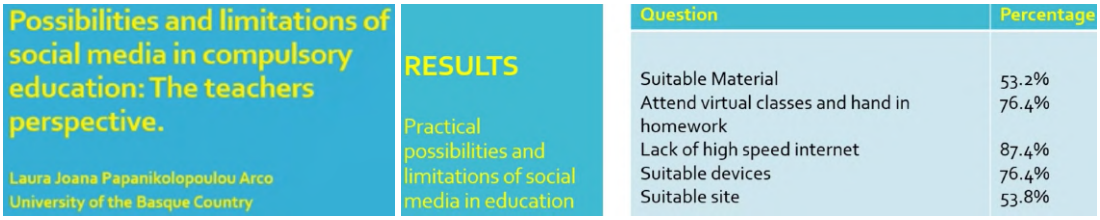



**Figure 5:** Presentation of paper [102].

teachers perspective" [102] by Laura Joana Papanikolopoulou Arco (figure 5) aims to investigate the possibilities and limitations of social media as the sole means of communication in education, from the perspective of teachers. The methodology involves the distribution of an anonymous questionnaire to secondary education centers in the Basque Country and Navarra regions, with data collection conducted electronically. The results reveal the possibilities and limitations of digital media in teaching processes, identifying both surmountable and insurmountable challenges. Overall, this research contributes to the growing body of knowledge on the role of technology in education, with implications for future educational policy and practice.

The author' related works are referenced as [103, 104, 105].

The use of student response systems (SRS) has gained significant attention in recent years as a tool for increasing student engagement and improving the overall learning experience during online lectures. In the study "Interactive surveys during online lectures for IT students" [106], Olena S. Holovnia (figure 6), Natalia O. Shchur, Iryna A. Sverchevska, Yelyzaveta M. Bailiuk and Oleksandra A. Pokotylo provide a comprehensive overview of different SRS platforms such as Mentimeter, AhaSlides, Kahoot!, Wooclap, Socrative, Poll Everywhere, and Slido, and compare their features to determine their suitability for facilitating students' engagement in online lectures.

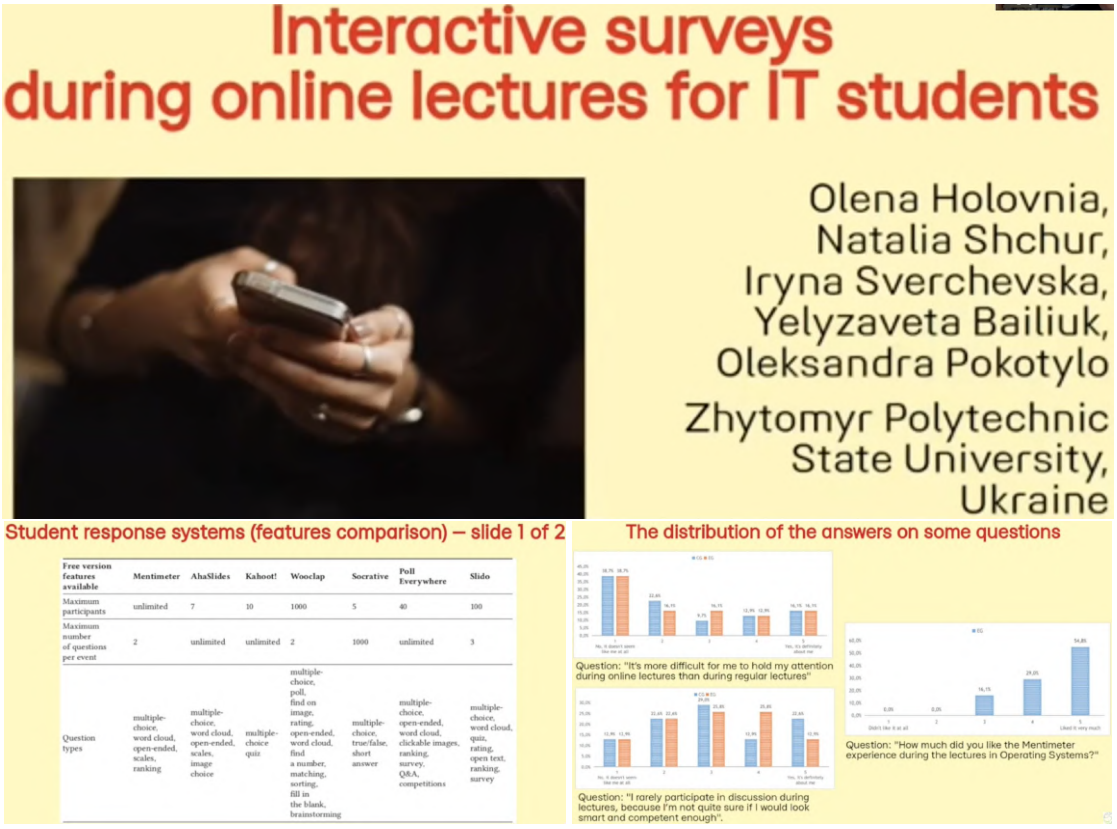
The authors then present their experience using Mentimeter in the Operating Systems course for second-year IT students of Zhytomyr Polytechnic State University with specializations in Software Engineering, Computer Science, Computer Engineering, and Cybersecurity. The study collects data through observation, surveys, and existing data and uses visual and statistical analyses to analyze the data. The study reports an increase in the number of students' answers within the lectures and highlights IT students' problems and preferences during online lectures.

Holovnia et al. [106] provide recommendations for using SRS during online lectures to improve the interaction between the lecturer and the audience, including increasing the number of questions, reducing the time between questions, and using open-ended questions to encourage critical thinking. This study contributes to the literature on SRS in online learning and provides valuable insights for educators seeking to enhance student engagement and learning outcomes in online lectures.

The authors' related works are referenced as [107, 108, 109].

## 2.2. AREdu 2022 overview

The paper "Using a mobile application to teach students to measure with a micrometer during remote laboratory work" [110] presents the experience of developing and using a mobile




| Free version features available | Mentimeter | AhaSlides | Kahoot! | Wooclap | Socrative | Poll Everywhere | Slido |
|---|---|---|---|---|---|---|---|
| Maximum participants | unlimited | 7 | 10 | 1000 | 5 | 40 | 100 |
| Maximum number of questions per event | 2 | unlimited | unlimited | 2 | 1000 | unlimited | 3 |
| Question types | multiple-choice, word cloud, open-ended, scales, ranking | multiple-choice, word cloud, open-ended, scales, image choice | multiple-choice quiz | multiple-choice, poll, find on image, rating, open-ended, word cloud, find a number, matching, sorting, fill in the blank, brainstorming | multiple-choice, true/false, short answer | multiple-choice, open-ended, word cloud, clickable images, ranking, survey, Q&A, competitions | multiple-choice, word cloud, quiz, rating, open text, ranking, survey |

**Figure 6:** Presentation of paper [106].

application for teaching micrometer measurements during remote laboratory work in higher education. The Oleksandr V. Kanivets, Irina M. Kanivets, Tetyana M. Gorda, Oleksandr V. Gorbenko and Anton O. Kelemesh (figure 7) conducted a literature analysis and found that while ICT is widely used in higher education, computer programs and mobile applications are typically developed for secondary school disciplines. To address this gap, the authors developed a mobile application that includes theoretical, educational, and practical components. The application was found to improve students' success rates in laboratory work on the topic of measuring parts with a micrometer during distance learning, with a 7.3% increase in the percentage of qualitative success compared to distance learning without the application. The paper details the process of developing the application, including modeling the micrometer in the CAD system, creating training scenes in the Unity game engine, and writing scripts to fully immerse students in the learning process. Overall, the paper highlights the potential of mobile applications in facilitating laboratory work during distance learning and provides a valuable example for educators looking to incorporate technology into their teaching practice.

The authors' related works are referenced as [111, 112, 113].

The article "Development of the information system for navigation in modern university campus" [114] by Liudmyla E. Gryzun (figure 8), Oleksandr V. Shcherbakov and Bogdan O.

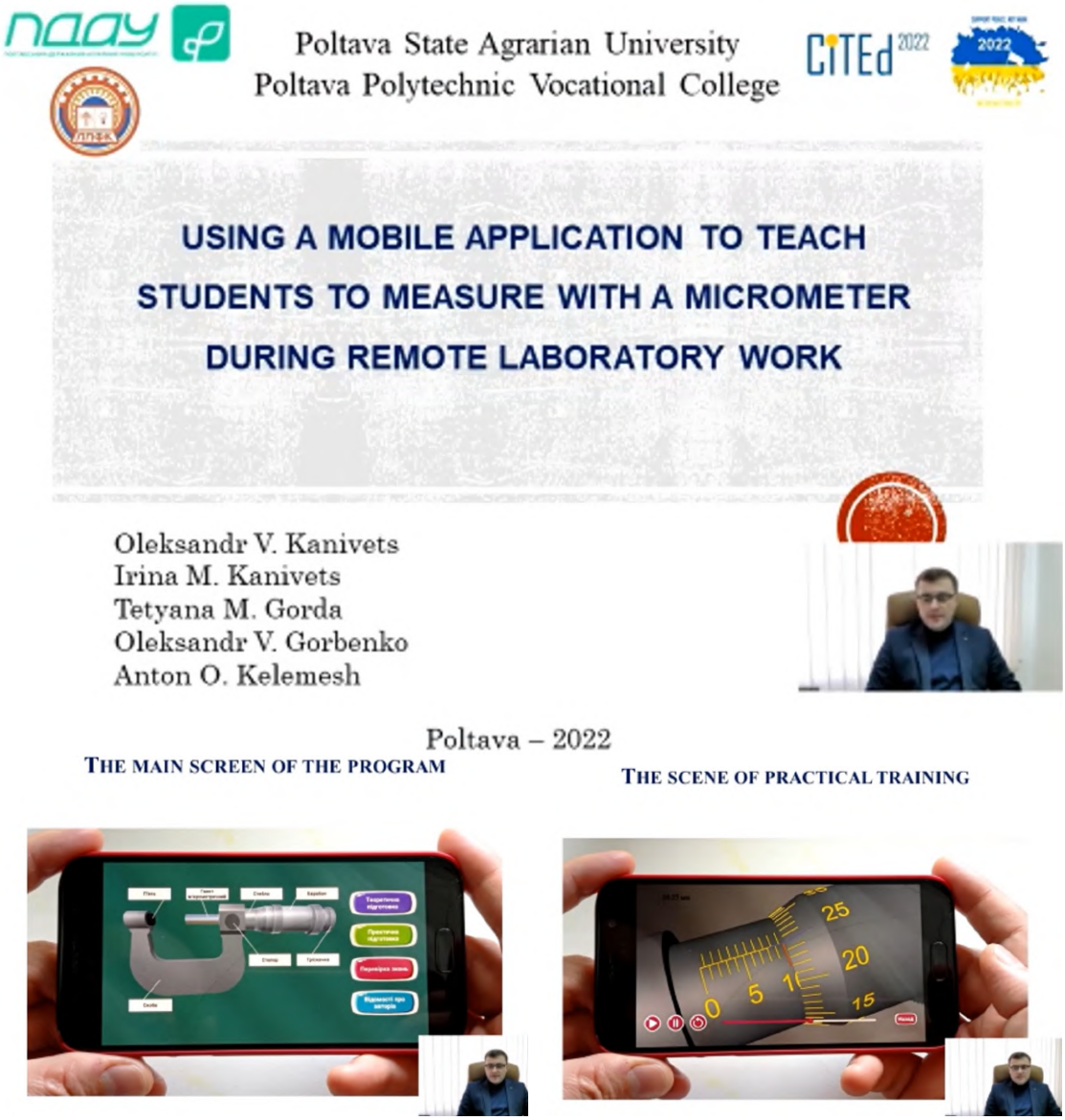



**Figure 7:** Presentation of paper [110].

Bida presents algorithmic, interface, and technological solutions for developing an information system for indoor navigation in university campuses. The scientific and applied problem of indoor navigation is analyzed, and the capabilities of existing navigation systems with similar functionalities are evaluated. The study concludes that the analyzed analogues have certain limitations. The functional and non-functional requirements for the university navigation system are specified, and its architecture is defined as a set of interconnected modules, for which appropriate interface and algorithmic solutions are elaborated. The design and development stages of the university navigation system are highlighted, along with its implemented


**Figure 8:** Presentation of paper [114].

functionality. The study establishes that the main limitations inherent in similar systems implementing indoor navigation can be overcome during the design process. The results of the system implementation in a national university are discussed, and user feedback is presented. The study confirms the feasibility of developing and using an information system for navigation in university campuses. Finally, the prospects for further work in this area are discussed.

The authors' related works are referenced as [115, 116, 117].

## 3. Conclusion

The Academy of Cognitive and Natural Sciences, in partnership with the Institute for Digitalisation of Education of the NAES of Ukraine, Kryvyi Rih State Pedagogical University, Kryvyi Rih National University, Ben-Gurion University of the Negev, and Zhytomyr Polytechnic State University, had the pleasure of hosting the 10th Workshop on Cloud Technologies in Education (CTE 2021) and the 5th International Workshop on Augmented Reality in Education (AREdu 2022).

We extend our sincere gratitude to the authors who submitted their papers and the delegates for their active participation and unwavering interest in our workshops, which have provided

a platform for the exchange of ideas and innovation. Our heartfelt appreciation goes to the program committee members for their continuous guidance and to the peer reviewers whose diligent efforts have substantially enhanced the quality of the papers by providing constructive criticisms, improvements, and corrections. We acknowledge and thank the authors for their significant contributions to the success of the conference.

Furthermore, we express our deepest appreciation to the developers and other professional staff of the *Academy of Cognitive and Natural Sciences* (https://acnsci.org) and *Not So Easy Science Education* platform (https://notso.easyscience.education) for providing us with an excellent and comprehensive conference management system that has facilitated every aspect of the conference's organization, from the call for papers and reviewer invitations to paper submissions, author communications, and beyond.

We anticipate excellent presentations and fruitful discussions that will broaden our professional horizons, and we trust that all participants will derive immense satisfaction from these workshops. We look forward to the day when we will be able to meet again in person under more tranquil and peaceful circumstances.

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