# Advancing Education in Challenging Times: A Review of the XVI International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2024)



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# Advancing Education in Challenging Times: A Review of the XVI International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2024)

**A E Kiv[1,2], S O Semerikov[3,4,5,6,7], A M Striuk[6,3,7], V V Osadchyi[8,7], T A Vakaliuk[5,4,3,7], P P Nechypurenko[3,7], O V Bondarenko[3,7], I S Mintii[9,4,3,5,10,7] and S L Malchenko[3]**

[1] Ben-Gurion University of the Negev, P.O.B. 653, Beer Sheva, 8410501, Israel
[2] South Ukrainian National Pedagogical University named after K. D. Ushynsky, 26 Staroportofrankivska Str., Odesa, 65020, Ukraine
[3] Kryvyi Rih State Pedagogical University, 54 Universytetskyi Ave., Kryvyi Rih, 50086, Ukraine
[4] Institute for Digitalisation of Education of the NAES of Ukraine, 9 M. Berlynskoho Str., Kyiv, 04060, Ukraine
[5] Zhytomyr Polytechnic State University, 103 Chudnivska Str., Zhytomyr, 10005, Ukraine
[6] Kryvyi Rih National University, 11 Vitalii Matusevych Str., Kryvyi Rih, 50027, Ukraine
[7] Academy of Cognitive and Natural Sciences, 54 Universytetskyi Ave., Kryvyi Rih, 50086, Ukraine
[8] Borys Grinchenko Kyiv University, 18/2 Bulvarno-Kudriavska Str., Kyiv, 04053, Ukraine
[9] University of Łódź, 68 Gabriela Narutowicza Str., 90-136 Łódź, Poland
[10] Lviv Polytechnic National University, 12 Stepana Bandery Str., Lviv, 79000, Ukraine

E-mail: kiv.arnold20@gmail.com, semerikov@gmail.com, andrey.n.stryuk@gmail.com, poliform55@gmail.com, tetianavakaliuk@gmail.com, acinonyxleo@gmail.com, bondarenko.olga@kdpu.edu.ua, irina.mintiy@kdpu.edu.ua, malchenko.svitlana@kdpu.edu.ua

**Abstract.** This paper presents a comprehensive review of the XVI International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2024), held from May 15-17, 2024, at Kryvyi Rih State Pedagogical University, Ukraine. The conference, organized in a hybrid format, brought together over 100 attendees from 9 countries, showcasing cutting-edge research and innovations in educational practices amid global challenges. The review synthesizes key themes and findings from 37 selected papers across various domains, including Mathematics Education, Science Education, Computer Science Education, and Educational Technology. Notable trends include the increased integration of artificial intelligence and digital technologies in education, the development of 21st-century skills, and adaptive strategies for education in crises. Particular attention is given to studies addressing the unique educational challenges faced in Ukraine, demonstrating the resilience and innovation of educators and researchers in conflict-affected regions. The paper highlights significant contributions in areas such as online learning environments, visual thinking in mathematics, AI applications in mental health education, and the design of university digital ecosystems.

## 1. Introduction

The **International Conference on Mathematics, Science, and Technology Education** (**ICon-MaSTEd**) stands as a prominent and esteemed platform for researchers, educators, professionals, policymakers, and practitioners to convene and exchange their cutting-edge research findings, innovative ideas, and practical applications in the realms of mathematics, science, and technology education. The conference also emphasizes technology-enhanced learning, encompassing various approaches such as blended learning, e-learning, ICT-based assessment, and mobile learning, among others, to enrich and advance educational practices (figure 1).

Initiated in 2001, ICon-MaSTEd has consistently fostered interdisciplinary collaboration, bringing together experts from diverse backgrounds to address the evolving challenges and opportunities in the fields of mathematics, science, and technology education. Over the years, the conference has witnessed substantial contributions from scholars and practitioners worldwide, propelling the domain forward with promising theories, models, tools, services, networks, and communications [1–5].

The XVI International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2024) marks a significant milestone in the ongoing dialogue on educational innovation and advancement. Held against the backdrop of global challenges, including the ongoing conflict in Ukraine and the lingering effects of the COVID-19 pandemic, this year's conference underscores the resilience and adaptability of the educational community.

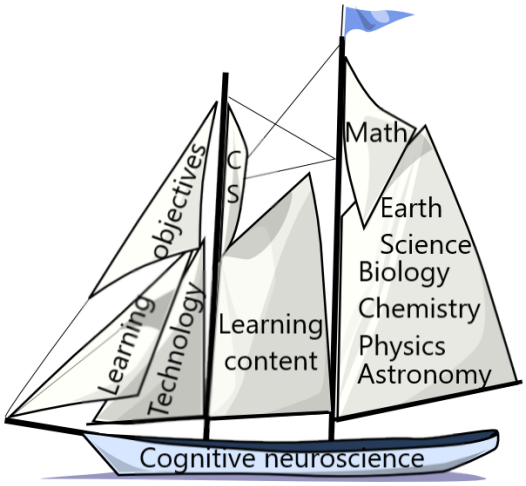


**Figure 1.** ICon-MaSTEd logo.

Organized by the Academy of Cognitive and Natural Sciences (ACNS) in collaboration with Kryvyi Rih State Pedagogical University, Kryvyi Rih National University, the Institute for Digitalisation of Education of the NAES of Ukraine, and Ben-Gurion University of the Negev, ICon-MaSTEd 2024 brought together a diverse group of researchers, educators, and practitioners from around the world. The conference, held from May 15-17, 2024, at Kryvyi Rih State Pedagogical University, Ukraine, adopted a hybrid format, accommodating both in-person and online participation to ensure inclusivity and global reach.

The primary objective of ICon-MaSTEd 2024 was to provide a platform for the exchange of cutting-edge research findings, innovative ideas, and practical applications in the realms of mathematics, science, and technology education. This year's conference placed a special emphasis on the integration of digital technologies, artificial intelligence, and innovative pedagogical approaches in addressing the evolving challenges in education.

The conference attracted over 100 attendees from 9 countries, including Ukraine, Norway, Israel, Greece, Philippines, Germany, Kazakhstan, Poland, and Slovakia. This international participation highlights the global relevance of the topics discussed and the collaborative spirit of the educational research community.

The program comprised a diverse array of subject areas, including Computer Science Education, Biology Education, Chemistry Education, Mathematics Education, Physics Education, Integrated Science Education, Educational Technology, and Technology Education.

A total of 61 submissions were received, each undergoing a rigorous peer-review process.

After careful deliberation, the program committee selected and accepted 37 high-quality papers for presentation at the conference. These papers represent the most impactful and innovative contributions to the field, covering a wide range of topics from theoretical frameworks to practical implementations of educational technologies.

The conference featured both invited talks and contributed presentations, providing a comprehensive outlook on the latest developments and emerging trends in mathematics, science, and technology education. The presentation format was thoughtfully structured to encourage interactive discussions and foster meaningful exchange of ideas among participants. Invited talks spanned 25 minutes, with a 15-minute presentation followed by a dedicated 10-minute session for questions and discussions. Other talks were allocated 15 minutes, comprising a 10-minute presentation segment and an additional 5 minutes for audience engagement and inquiry.

In light of the ongoing challenges posed by the conflict in Ukraine, special attention was given to topics addressing education in crises, the role of technology in ensuring educational continuity, and innovative approaches to maintaining academic excellence in challenging circumstances.

These proceedings compile the research presented at ICon-MaSTEd 2024, serving as a valuable resource for educators, researchers, and policymakers interested in the latest advancements in mathematics, science, and technology education. The papers included herein reflect the conference's commitment to fostering innovation, promoting interdisciplinary collaboration, and addressing the pressing educational challenges of our time.

The conference's detailed program and session information was made available to all attendees on the official website: `https://icon-masted.easyscience.education/2024/`. Additionally, to ensure wider accessibility and reach, video recordings of all talks were uploaded to the *Not So Easy Science* YouTube channel (`https://www.youtube.com/@NotSoEasyScience`).

As we present these proceedings, we invite readers to explore the diverse range of topics covered, draw inspiration from the innovative approaches discussed, and consider how these findings can be applied to enhance educational practices across various contexts and disciplines.

## 2. ICon-MaSTEd 2024 program committee

- *George Abuselidze*, Batumi Shota Rustaveli State University, Georgia [6–8]
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- *Olha Bondarenko*, Kryvyi Rih State Pedagogical University, Ukraine [15–18]
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- *Oleksii Haluza*, National Technical University "Kharkiv Polytechnic Institute", Ukraine [38–41]
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- *Pavlo Hryhoruk*, Khmelnytskyi National University, Ukraine [49–51]
- *Andrii Iatsyshyn*, Center for Information-analytical and Technical Support of Nuclear Power Facilities Monitoring of the NAS of Ukraine, Ukraine [52–54]
- *Anna Iatsyshyn*, State Scientific Organization "Ukrainian Institute of Scientific Technical and Expertise and Information", Ukraine [55]
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- *Oleksandr Kolgatin*, Simon Kuznets Kharkiv National University of Economics, Ukraine [68–71]
- *Elena Komarova*, NitrosData, LLC [72–74]
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- *Olena Kuzminska*, National University of Life and Environmental Sciences of Ukraine, Ukraine [94–97]
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- *Oksana Lytvyn*, Borys Grinchenko Kyiv Metropolitan University, Ukraine [100–102]
- *Nataliia Maksyshko*, Zaporizhzhia National University, Ukraine [103–105]
- *Svitlana Malchenko*, Kryvyi Rih State Pedagogical University, Ukraine [106–112]
- *Mykhailo Medvediev*, ADA University, Azerbaijan [113–115]
- *Liliia Midak*, Vasyl Stefanyk Precarpathian National University, Ukraine [116–118]
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- *Natalia Moiseienko*, Kryvyi Rih State Pedagogical University, Ukraine [125]
- *Mattia Monga*, University of Milan, Italy [126–128]
- *Nataliia Morze*, Borys Grinchenko Kyiv Metropolitan University, Ukraine [129–131]
- *Pavlo Nechypurenko*, Kryvyi Rih State Pedagogical University, Ukraine [132–135]
- *Yuliia Nosenko*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [136–138]
- *Vasyl Oleksiuk*, Ternopil Volodymyr Hnatiuk National Pedagogical University, Ukraine [139–141]
- *Kateryna Osadcha*, Norwegian University of Science and Technology, Norway [142–144]
- *Viacheslav Osadchyi*, Borys Grinchenko Kyiv Metropolitan University, Ukraine [145–147]
- *Stamatis Papadakis*, University of Crete, Greece [148–151]

- *Larysa Petrenko*, Ivan Ziaziun Institute of Pedagogical and Adult Education of the National Academy of Educational Sciences of Ukraine, Ukraine [152, 153]
- *Olha Pinchuk*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [154, 155]
- *Oleg Pursky*, State University of Trade and Economics, Ukraine [156–159]
- *Natalya Rashevska*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [160]
- *Iryna Salnyk*, Volodymyr Vynnychenko Central Ukrainian State University, Ukraine [161–163]
- *Serhiy Semerikov*, Kryvyi Rih State Pedagogical University, Ukraine [164–167]
- *Etibar Seyidzade*, Baku Engineering University, Azerbaijan [168–170]
- *Yevhenii Shapovalov*, Junior Academy of Sciences of Ukraine, Ukraine [171, 172]
- *Oleksandr Shkolnyi*, Dragomanov State University of Ukraine, Ukraine [173]
- *Oleksandra Sokolyuk*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [174–176]
- *Andrii Striuk*, Kryvyi Rih National University, Ukraine [177, 178]
- *Viktoriia Tkachuk*, Kryvyi Rih National University, Ukraine [179]
- *Tetiana Vakaliuk*, Zhytomyr Polytechnic State University, Ukraine [180–184]
- *Nataliia Valko*, Kherson State University, Ukraine [185, 186]
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- *Kateryna Vlasenko*, National University of Kyiv-Mohyla Academy, Ukraine [188–190]
- *Yuliia Yechkalo*, Kryvyi Rih National University, Ukraine [191–194]

## 3. Proceedings overview

### *3.1. Mathematics Education*

The Mathematics Education section features seven papers that explore innovative approaches to mathematics teaching and learning at various educational levels.

Achkan et al. [195] present a case classification system for training prospective mathematics teachers. They identify key characteristics for classifying cases, such as complexity level, completion time, problem scope, and presentation method. The authors provide examples of cases that can be used in teaching methodological disciplines to mathematics education students.

Vlasenko et al. [196] investigate the use of stochastic matrices in teaching the topic of eigenvalues and eigenvectors in linear algebra courses. Through an experiment with students in different specialities, they demonstrate how problems based on Markov chains can improve students' skills and understanding of this important mathematical concept.

Semenets et al. [197] delve into the content, components, and typology of structural-mathematical thinking. They propose a developmental-conceptual model for teaching mathematics that fosters students' theoretical thinking skills. The authors experimentally validate the effectiveness of their methodology for enhancing structural-mathematical thinking in prospective mathematics teachers.

Pylypenko and Kramarenko [198] present a structural-functional model for developing STEM competencies in students of professional pre-higher education institutions through mathematics education. The model incorporates motivational, content, activity, and diagnostic components. The authors provide examples of STEM projects and learning activities that can be implemented using their approach.

Voievoda et al. [199] examine the geometric properties of metric spaces and propose using the dynamic geometry environment GeoGebra 3D for visualizing concepts such as rectilinear and

planar point configurations. They argue that this approach can help students better understand the abstract concepts of metric geometry.

Kuzmich et al. [200] introduce an analytical and geometric interpretation of planar point arrangements using methods from metric geometry. They demonstrate how the GeoGebra dynamic mathematics software can be used to model and visualize these configurations in Cartesian coordinate systems, making the concepts more accessible to students.

Horoshko et al. [201] focus on solving problems with parameters using a digitized approach. They analyze various computer mathematics systems, such as GeoGebra, Wolfram—Alpha, Maxima, SageMath, and GRAN1, in terms of their suitability for graphical and analytical problem-solving. The authors provide methodological recommendations for using these tools in teaching mathematics.

### *3.2. Physics and Astronomy Education*

The Physics and Astronomy Education section features eight papers exploring various aspects of teaching and learning in these domains.

Malchenko et al. [202] investigate the use of visualization technologies, specifically the Universe Sandbox 2 simulation software, to study the probability of life on exoplanets. The research demonstrates the effectiveness of interactive simulations in enabling students to model and analyze conditions necessary for life on exoplanets.

Felicidario and Delos Santos [203] present a study on enhancing student performance through laboratory-based instruction, focusing on concepts of relative density and buoyancy of liquids. The findings reveal significant improvements in student performance and positive perceptions towards laboratory activities.

Kaliampos et al. [204] explore the mental representations of 5-6 year old children regarding coagulation phenomena and the impact of a storytelling teaching intervention. The study highlights the potential of narrative approaches in helping young children construct precursor models compatible with scientific knowledge.

Pacala [205] examines the effectiveness of laboratory-based instruction in teaching fundamental concepts of physics. The research underscores the significant role of hands-on experiments in enhancing student understanding and performance.

Abdulayeva [206] conducts rapid foresight research to identify trends and directions in physics teaching, including the integration of artificial intelligence. The study emphasizes the importance of involving students in the foresight process to inform future teaching practices and strategies.

Batsurovska et al. [207] present a technology for online control of educational results in the unit “Electricity” within a blended learning context. The findings demonstrate the effectiveness of the developed technology in improving student knowledge and skills.

Velychko et al. [208] analyze various computer modelling tools for studying the interaction between charged particles. The research compares the advantages and limitations of different software packages and programming languages for implementing computer models in physics education.

### *3.3. Earth Science Education*

The Earth Science Education section contains one paper focusing on using mapping technology with ArcGIS tools to train geography students.

Tsidylo et al. [209] present a study on developing professionally oriented tasks to teach future geography teachers mapping technology using ArcGIS services. The authors emphasize the importance of geoinformation technologies in modern geography education and the need for students to acquire practical skills in using GIS software.

The paper outlines the main aspects of introducing professionally oriented tasks into the educational process of pedagogical institutions. Educational and methodological guidelines for

studying and using mapping technology with ArcGIS tools are developed for students and future geographers.

As a practical application, the authors demonstrate the creation of a series of maps depicting various indicators of Ukraine's regions, such as a cartogram of population distribution, using the quantitative background method. The data for these maps is sourced from the State Statistics Service of Ukraine and the Main Statistical Offices of Ukrainian regions.

Geography students are used to experimentally verify the effectiveness of using professionally oriented tasks to learn ArcGIS mapping technology. The results show an increase in students' abilities according to specified criteria: motivational, cognitive, and personal-reflective.

The authors conclude that the mapping approaches presented, based on the implementation of professionally oriented tasks, allow students to apply their acquired knowledge and skills, enabling them to adapt flexibly to situations arising in their future professional activity as geographers.

This paper highlights the importance of integrating GIS technology and practical, profession-oriented tasks into the training of future geography teachers, equipping them with valuable skills for their field.

### *3.4. Computer Science Education*

The Computer Science Education section features seven papers exploring various aspects of teaching and learning in this domain.

Shpakov et al. [210] conduct an ontological analysis of business process modelling in higher education institutions based on an electronic document management system. They study the main business processes, analyze the structure, functions, and information flows, and develop an ontological model of interaction between subjects and objects. The model enables the assessment of system efficiency and the prediction of critical processes that may impact decision-making and institutional functioning.

Pavlenko et al. [211] present a method for developing teamwork skills among students in the "Professional Education. Computer Technology" program through the use of digital tools and a collective scientific research lifecycle. The proposed iterative model consists of preparatory, analysis, storage, organization, sharing, reuse, citation, and data creation stages. An experimental study confirmed the effectiveness of the method in improving students' teamwork abilities.

Balyk et al. [212] investigate the use of STEM technologies in training competitive computer science teachers to meet social needs and challenges, particularly during wartime in Ukraine. Key components of a STEM teacher training model are identified, and an experimental study determines students' attitudes towards STEM technologies. The necessity of ensuring high teacher qualifications for effective STEM education is substantiated.

Leshchuk et al. [213] implement a STE(A)M approach through Scratch projects to foster students' creativity and problem-solving skills. The developed "Creative Self-Fulfilment in Scratch" course extends into projects in algebra, geometry, physics, and musical culture, demonstrating the unity of technology and creativity. Each project serves as an independent development tool for students.

Bilousova et al. [214] highlight the importance of engaging pre-service IT specialists in interdisciplinary projects to understand the mathematical foundations and algorithmic nature of coding tasks. A model for such projects is described, focusing on the development of student's awareness of the value of mathematical knowledge in their professional activities. A survey and monitoring program revealed positive changes in students' perceptions.

Kolhatin et al. [215] present a distance learning technology for the "Robotics Fundamentals" course, combining virtual simulations and remote-controlled physical robots. Students progress

from modelling and testing algorithms in a virtual environment to implementing them with real robots, gaining practical experience in robotics system development and software engineering.

Semerikov et al. [216] propose a methodology for teaching the development of web-based augmented reality applications with integrated machine learning models. The three-step approach involves integrating standard TensorFlow.js models, creating custom image classification models with Teachable Machine, and modifying WebAR applications to utilize the exported models. The methodology aims to incrementally introduce machine learning integration and inspire ideas for enhancing educational content.

### *3.5. Integrated Science Education*

The Integrated Science Education section features six papers exploring interdisciplinary approaches to teaching science.

Valko and Kushnir [217] present their experience conducting long-term integrated robotics projects in summer camps, scientific studios, and extracurricular clubs. The projects combine various activities to explore topics and conduct scientific and technological research. The authors emphasize the importance of mastering robotics technology and understanding the principles of operation to prepare children for life in a high-tech world. The foundation for studying and applying these technologies is mathematics, physics, engineering, and programming. STEM education, aimed at developing in-demand competencies and increasing motivation to study challenging subjects, is of particular importance. The article shares the experience of a volunteer project teaching robotics to Ukrainian children, detailing organizational conditions, typical difficulties, project examples, and lesson scenarios.

Ludovice and Delos Santos [218] study the absorbance of methyl orange (MO) dye using an adapted and modified photoresistor-based photometer. They aim to improve the stability of the reference setup while maintaining accuracy. The methodology includes photometer fabrication, MO sample preparation, and evaluation of molar absorptivity. Results show that the estimated molar absorptivity is close to the literature value, with a 1.44% error. This demonstrates the modified photometer's effectiveness, supported by method repeatability measurements. The device may be helpful in teaching light absorption as an alternative to the "black box" approach and for exploring purified natural dyes with solar cell applications.

Fedorets et al. [219] reveal the phenomenology of cognitive transformations in the human-artificial intelligence interaction based on their "Concept of cognitive multi-channel Human-Computer interaction". The interaction is implemented through the formation of typical cognitive phenomena, considered as relatively independent types of interactions, stages, strategies, channels, and ontologies. Seven types of cognition are distinguished. Identifying these types aims to represent the interaction as a complex, dynamic, multidimensional, multichannel intellectual system. A study among university students determined the cognitive specificity of the interaction. Analysis of test answers and cluster analysis results showed the dominance of the "orientational-cognitive" type, indicating significant initial interest in AI technologies. The even distribution of other cognitive types correlates with respondents having developed different types of cognition.

Suchikova and Kovachov [220] explore the integration of Nanoart within the STEAM education framework, highlighting its role in enhancing interdisciplinary learning. Through a project-based learning initiative, students specializing in "Applied Physics and Nanomaterials" engage in creating nanostructures via electrochemical etching and transforming them into Nanoart. This exemplifies the seamless integration of STEAM components and deepens students' understanding. The article details each project phase, illustrating how students navigate nanoscience complexities and apply interdisciplinary knowledge to produce artistic and scientific outcomes. By transforming abstract concepts into visually stimulating Nanoart, the project encourages creative thinking and innovation. It demonstrates how integrating art

into STEM can make scientific education more accessible and engaging, attracting a broader array of students.

Levytska et al. [221] present the development of virtual laboratory work to determine the dispersed composition parameters of dust for teaching environmental protection technologies to bachelors. The authors analyze publications on using virtual laboratories in universities and emphasize their role in supporting modern educational approaches, stimulating learning, and enabling more effective material mastery. The article describes an example of developing laboratory work as a web application with a user-friendly interface and data saved into a database. Students can work at their own pace, repeat experiments, and adapt their learning approach. The virtual laboratory is relevant for distance learning.

Homeniuk et al. [222] propose a methodology for increasing mathematics students' motivation to implement STEM education elements through teaching mathematical modelling in elementary mathematics. The three-stage methodology involves students constructing, investigating, and interpreting mathematical models while solving tasks related to Science, Technology, Engineering, and Mathematics. In the second stage, students perform operations with mathematical models to solve integrative tasks combining all STEM components. The third stage focuses on constructing, analyzing, and solving STEM-related applied problems from various elementary mathematics sections. The methodology combines collective, individual, and group work. A survey confirmed the effectiveness of STEM-oriented activities like STEM-hackathon, STEM-quest, and STEM-project in developing students' understanding of mathematics' role in STEM fields and their ability to work in teams.

### *3.6. Educational Technology*

The Educational Technology section features eight papers exploring various aspects of digital transformation in education and the application of innovative technologies in teaching and learning processes.

Semerikov et al. [223] present a bibliometric analysis of research articles published in Educational Technology Quarterly (ETQ) from 2021-2023. Their study aims to identify key themes and changes in focus within the educational technology domain over this period. The authors analyze 72 research articles, examining patterns in keywords, temporal trends, and geographic distribution of authors. The findings reveal emerging topics such as digital competence, blended learning, and cloud-based learning environments. The study also highlights the impact of the COVID-19 pandemic on research priorities and the growing interest in digital skills development.

Symonenko et al. [224] investigate the application of chatbots for enhancing the communication skills of IT specialists. The authors developed a chatbot named BEbot (Business English bot) to support a Business English course for IT professionals. The study demonstrates how chatbot technology can be effectively integrated into language learning, particularly for developing business communication skills. The results show an improved understanding of business English concepts and increased student engagement through interactive chatbot-based learning.

Shumeiko and Osadcha [225] explore the application of artificial intelligence in higher education institutions for developing the soft skills of future IT specialists. The study focuses on the use of AI tools in teaching humanitarian subjects, particularly in forming project competence. The authors present a system of quality factors for video-based microlearning technology and discuss the effectiveness of AI-enhanced learning in developing soft skills such as communication, negotiation, and problem-solving.

Hlazunova et al. [226] examine microlearning technology based on video content, discussing its advantages, methodology, and quality factors. The study investigates the impact of video-oriented e-courses and microlearning technology on learning effectiveness. The authors develop

a procedure for microlearning based on video content and identify critical factors affecting the quality of e-courses for microlearning.

Buinytska et al. [227] present a theoretical exploration of university ecosystem design under conditions of digital transformation. The paper analyzes international and Ukrainian legal acts related to the digital transformation of higher education and proposes a model for an open university ecosystem. The authors describe the digital campus of Borys Grinchenko Kyiv Metropolitan University as a current stage of digital transformation and a starting point for open university ecosystem design.

Klochko et al. [228] discuss the formation of visual thinking of students in technical universities in the context of higher mathematics education. The study explores the use of visualization techniques in teaching mathematics and presents examples of how visual representations can enhance understanding of complex mathematical concepts.

Bondar et al. [229] investigate the role of AI in enhancing mental health and productivity amidst Ukraine's challenges. The paper explores the convergence of human intelligence with artificial intelligence in the realm of mental health education, particularly within Ukrainian educational institutions following the pandemic and amid wartime conditions.

Hapon-Baida and Derkach [230] present an educational technology for the formation of project competence for engineering students. The study describes the development and implementation of a project-based learning approach to enhance project competence among engineering students.

## 4. Conclusion

The XVI International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2024) has once again proven to be a vital platform for researchers, educators, and practitioners to share their latest findings and innovations in education. This year's conference, held in challenging circumstances due to the ongoing conflict in Ukraine, demonstrated the resilience and dedication of the academic community to advancing knowledge and improving educational practices.

The conference proceedings encompass a wide range of topics across various disciplines, reflecting the multifaceted nature of contemporary education. From mathematics and science education to computer science and educational technology, the papers presented offer valuable insights into current trends, challenges, and innovative solutions in these fields.

A notable trend observed throughout the proceedings is the increasing integration of digital technologies and artificial intelligence in education. This is evident in papers discussing the use of AI in mental health education, the application of chatbots for language learning, and the development of digital ecosystems for universities. These studies highlight the potential of technology to enhance learning experiences, improve accessibility, and prepare students for a rapidly evolving digital world.

Another significant theme that emerged is the focus on developing essential skills for the 21st century. Several papers addressed the formation of critical thinking, visual thinking, and project competence, emphasizing the importance of these skills in preparing students for future challenges in their academic and professional lives.

The conference also strongly emphasised addressing the unique challenges faced by educators and students in Ukraine. Papers exploring the adaptation of educational practices during wartime and the use of technology to maintain educational continuity in difficult circumstances provide valuable insights for the global academic community.

The proceedings reflect a growing interest in interdisciplinary approaches to education. Studies combining elements from different fields, such as the integration of art in STEM education or the application of psychological principles in computer science education, demonstrate the potential of cross-disciplinary collaborations in enhancing educational outcomes.

The quality and diversity of the research presented at ICon-MaSTEd 2024 underscore the conference's significance as a forum for exchanging ideas and advancing the field of education. As we look to the future, the insights gained from these proceedings will undoubtedly contribute to shaping more effective, inclusive, and innovative educational practices.

We extend our gratitude to all the authors, reviewers, organizers, and participants who contributed to the success of ICon-MaSTEd 2024. Their collective efforts, especially in the face of challenging circumstances, have resulted in a valuable contribution to the field of education. We look forward to seeing how the ideas and findings presented in these proceedings will influence future research and practice in mathematics, science, and technology education.

We hope all participants enjoy this conference and meet again in a more friendly, hilarious, and peaceful way, ICon-MaSTEd 2025. The next meeting in the series is the XVII International Conference on Mathematics, Science and Technology Education, 2025, Kryvyi Rih, Ukraine (`https://icon-masted.easyscience.education/2025/`).

## ORCID iDs

S O Semerikov `https://orcid.org/0000-0003-0789-0272`
A E Kiv `https://orcid.org/0000-0002-0991-2343`
A M Striuk `https://orcid.org/0000-0001-9240-1976`
V V Osadchyi `https://orcid.org/0000-0001-5659-4774`
T A Vakaliuk `https://orcid.org/0000-0001-6825-4697`
P P Nechypurenko `https://orcid.org/0000-0001-5397-6523`
O V Bondarenko `https://orcid.org/0000-0003-2356-2674`
I S Mintii `https://orcid.org/0000-0003-3586-4311`
S L Malchenko `https://orcid.org/0000-0001-8291-6642`

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