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# Advancing educational resilience: Key insights and innovations from the XVII International Conference on Mathematics, Science, and Technology Education (ICon-MaSTEd 2025)

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# Advancing educational resilience: Key insights and innovations from the XVII International Conference on Mathematics, Science, and Technology Education (ICon-MaSTEd 2025)

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**Abstract.** This paper presents a comprehensive review of the XVII International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2025), held from May 14-16, 2025, 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 31 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. The proceedings also commemorate the 90th anniversary of Professor Arnold Yukhymovych Kiv, co-founder of ICon-MaSTEd and a distinguished physicist whose contributions to solid state physics and educational innovation have shaped generations of scientists and educators.



## 1. Introduction

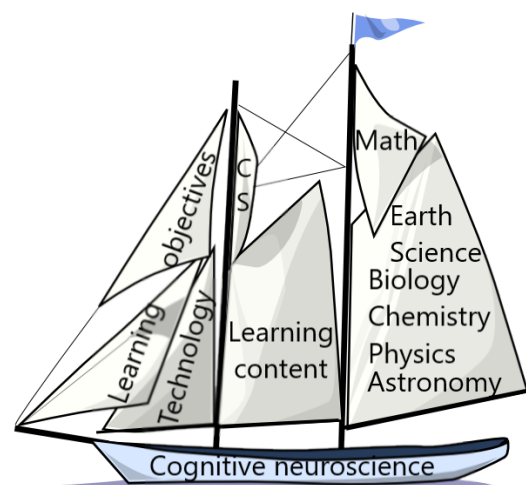
The XVII International Conference on Mathematics, Science, and Technology Education (ICon-MaSTEd 2025) represents a pivotal moment in the evolution of educational discourse, particularly as it convened amid unprecedented global challenges. Held from May 14-16, 2025, at Kryvyi Rih State Pedagogical University in Ukraine, this conference demonstrated the remarkable resilience and innovative capacity of the international educational community in addressing the complex demands of 21st-century learning environments. The hybrid format of the conference, necessitated by ongoing geopolitical tensions and the legacy of pandemic-induced transformations, brought together over 100 participants from 9 countries, including Ukraine, Norway, Israel, Greece, Philippines, Germany, Kazakhstan, Poland, and Slovakia, showcasing the truly global nature of contemporary educational challenges and solutions.

Since its inception in 2001, ICon-MaSTEd has established itself as a premier platform for researchers, educators, policymakers, and practitioners to exchange cutting-edge research findings and innovative pedagogical approaches in mathematics, science, and technology education (figure 1) [1–6]. The 2025 edition marks a particularly significant milestone, as it not only continues this tradition of scholarly excellence but also addresses the urgent need for educational adaptation in crisis situations. The conference's organization by the Academy of Cognitive and Natural Sciences (ACNS) in collaboration with Kryvyi Rih State Pedagogical University, the Institute for Digitalisation of Education of the NAES of Ukraine, and Ben-Gurion University of the Negev, underscores the importance of international cooperation in advancing educational innovation during times of adversity.

The primary objective of this paper is to present a comprehensive review of the key findings, innovations, and emerging trends discussed at ICon-MaSTEd 2025. Through the analysis of 31 carefully selected papers from a total of 71 submissions, this review synthesizes the collective wisdom of the conference participants across diverse domains including Mathematics Education, Science Education, Computer Science Education, and Educational Technology. Particular emphasis is placed on three overarching themes that permeated the conference proceedings: the integration of artificial intelligence and digital technologies in educational practices, the development of adaptive strategies for education in crisis contexts, and the cultivation of essential 21st-century competencies among learners.

The significance of this conference extends beyond traditional academic discourse. As educators worldwide grapple with the dual challenges of technological transformation and geopolitical instability, ICon-MaSTEd 2025 provides crucial insights into how educational systems can maintain quality and continuity under extraordinary circumstances. The conference highlighted innovative solutions ranging from augmented reality applications for laboratory work conducted in bomb shelters to AI-powered curriculum recommendation systems that personalize learning pathways in resource-constrained environments. These innovations are not merely temporary responses to crisis situations but represent fundamental advances in educational methodology that will continue to benefit learners long after current challenges have passed.

The conference's detailed program and session information was made available to all attendees



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

on the official website: <https://icon-masted.easyscience.education/2025/>. 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>).

The structure of this paper follows the thematic organization of the conference itself, with dedicated sections examining contributions in Mathematics Education, Physics Education, Science Education, Computer Science Education, and Educational Technology. Each section synthesizes the key findings from multiple presentations, identifying cross-cutting themes and highlighting particularly innovative approaches. Special attention is given to studies that address the unique educational challenges faced in Ukraine, demonstrating how adversity can catalyze innovation and foster the development of resilient educational ecosystems. Through this comprehensive review, we aim to provide educators, researchers, and policymakers with actionable insights that can inform educational practice and policy development in both crisis and normal circumstances.

## 2. A tribute to Professor Arnold Yukhymovych Kiv on his 90th anniversary

The XVII International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2025) holds special significance as it coincides with the 90th anniversary of its co-founder, Professor Arnold Yukhymovych Kiv (Arik E. Kiv), a distinguished physicist whose remarkable career has profoundly influenced both scientific research and educational innovation across multiple continents. Born on July 28, 1935, in Odesa, Ukraine, Professor Kiv's life journey exemplifies the transformative power of scientific dedication and educational vision, even in the face of historical upheavals and geopolitical challenges.



**Figure 2.** Professor Arnold Yukhymovych Kiv.

Professor Kiv's academic journey began at Odessa State University, where he graduated in 1959 with a degree in physics. His early career (1960-1972) at the Academy of Sciences of the Uzbek SSR in Tashkent saw him serving as a research scientist at the Institute of Nuclear Physics and Electronics, while simultaneously fulfilling duties as Scientific Secretary of the Division of Physical and Mathematical Sciences. During this formative period, he also served as Scientific Secretary of the Coordination Council for Peaceful Use of Atomic Energy (1962-1970) and taught at the Tashkent Polytechnic Institute, establishing the interdisciplinary approach that would characterize his entire career.

The years 1972-1983 marked a transformative period for both Professor Kiv and Kryvyi Rih State Pedagogical Institute (now University), where he served as Head of the Department of Physics. His leadership elevated the institution from regional to national and international prominence in solid state physics research. Under his guidance, the department developed a unique atmosphere of collaboration, mutual respect, and rigorous scientific standards that continues to inspire researchers today. His establishment of the International Scientific School "Radiation Electronics of Solid State" during this period created a vital scientific center that has, for over half a century, maintained significant influence on scientific and pedagogical activities in Ukraine and beyond.

Following his tenure at Kryvyi Rih, Professor Kiv joined South Ukrainian National Pedagogical University named after K. D. Ushynsky in Odesa (1983), where he served as

Head of the Department of Theoretical Physics and later the Department of Physical and Mathematical Modeling. His international career included a distinguished professorship at Ben-Gurion University of the Negev, Israel (1998-2007), where he continued his groundbreaking research while fostering international scientific collaboration. Since 2022, he has served as Professor in the Department of Innovative Technologies and Methods of Teaching Natural Sciences at South Ukrainian National Pedagogical University.

Professor Kiv's scientific contributions have fundamentally advanced our understanding of solid state physics, particularly in radiation effects in semiconductors. He developed the theory of subthreshold radiation effects and radiation-stimulated diffusion in semiconductors, demonstrated the influence of low-energy radiation on structural disorders in electronic materials and devices, and established mechanisms of natural aging in materials while developing methods for determining the operational lifespan of materials and devices. His research interests span solid state physics, microelectronics, photopolymerization, defect creation, and stimulated diffusion, with a remarkable h-index of 26 (22 in the last six years alone), demonstrating the continuing relevance and impact of his work.

The co-founding of ICon-MaSTEd represents one of Professor Kiv's most enduring contributions to education. His vision of a platform for interdisciplinary dialogue in mathematics, science, and technology education has fostered international collaboration for over two decades. The conference has become a crucial venue for addressing contemporary educational challenges, from the integration of digital technologies to crisis-responsive pedagogical innovations. His leadership has ensured that ICon-MaSTEd remains at the forefront of educational innovation, adapting to changing global circumstances while maintaining its commitment to scientific excellence.

Professor Kiv's exceptional contributions have been recognized through numerous prestigious awards, including the State Prize of the Ukrainian SSR in Science and Technology (1983), the State Prize of the USSR (1988), and a Certificate from the President of the National Academy of Sciences of Ukraine for achievements in scientific research (2010). He has been honored as an Excellent Worker of Public Education of the Ukrainian SSR and a Honored Worker of Education of Ukraine. His international recognition includes membership in the scientific councils of Prague and Riga Universities, designation as a Soros Professor, and membership on editorial boards of multiple scientific journals.

As we celebrate Professor Kiv's 90th anniversary, we acknowledge not only his scientific achievements but also his profound influence on generations of physicists, educators, and researchers. His students, now leading scientists and educators worldwide, continue to advance the traditions of rigorous scientific inquiry and innovative educational practice that he established. The scientific school he founded at Kryvyi Rih has produced numerous doctoral and candidate degree holders who carry forward his legacy of excellence in research and education.

Professor Kiv's career demonstrates that true scientific leadership transcends disciplinary boundaries and geographical limitations. His ability to maintain productive research collaborations across political divides, his commitment to nurturing young scientists, and his vision for technology-enhanced education have created lasting impacts that extend far beyond his immediate sphere of influence. Even at 90, Professor Kiv continues to inspire through his unwavering dedication to science and education, serving as a living example of how passion for knowledge and commitment to human development can overcome any obstacle.

The ICon-MaSTEd 2025 conference, convening under challenging circumstances due to ongoing regional conflicts, embodies the resilience and determination that Professor Kiv has exemplified throughout his career. His life's work reminds us that science and education are universal human endeavors that transcend political boundaries and unite us in our common pursuit of knowledge and understanding. As we review the proceedings of this conference, we do so with deep appreciation for the foundation that Professor Kiv has laid and the pathways

he has opened for future generations of scientists and educators.

On behalf of the entire ICon-MaSTEd community, Kryvyi Rih State Pedagogical University and South Ukrainian National Pedagogical University, and the international scientific community, we extend our heartfelt congratulations to Professor Arnold Yukhymovych Kiv on his 90th anniversary. We wish him continued good health, happiness, and the joy of seeing his scientific and educational legacy flourish in the work of those he has inspired. May his remarkable journey continue to illuminate the path for scientists and educators worldwide.

### 3. ICon-MaSTEd 2025 organizers and partners

The XVII International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2025) was organized through a collaborative effort of leading educational and research institutions, reflecting the conference's commitment to fostering international cooperation and interdisciplinary dialogue in educational innovation.

#### 3.1. Primary organizer

The Academy of Cognitive and Natural Sciences (ACNS, <https://acnsci.org>) served as the primary organizing body for ICon-MaSTEd 2025. Established as a non-governmental organization dedicated to advancing research and education in cognitive and natural sciences, ACNS embodies the interdisciplinary spirit that has characterized ICon-MaSTEd since its inception. The Academy's mission encompasses:

- Fostering cutting-edge research initiatives in cognitive and natural sciences through collaborative networks of researchers across disciplines and institutions
- Organizing international conferences, workshops, seminars, and training programs that facilitate knowledge exchange and professional development
- Publishing high-quality scientific journals, conference proceedings, and scholarly works that disseminate research findings to the global academic community
- Supporting researchers' professional development through mentorship programs, research grants, and career advancement opportunities
- Protecting and advocating for researchers' rights, academic freedom, and ethical standards in scientific inquiry
- Building bridges between academic research and practical applications in education, industry, and society

ACNS's publishing portfolio includes several Diamond Open Access journals that align with ICon-MaSTEd's educational mission, most notably *Educational Technology Quarterly*, *Educational Dimension*, and *Science Education Quarterly*. These publications provide year-round platforms for disseminating research presented at ICon-MaSTEd and related conferences, ensuring that innovative educational practices reach practitioners worldwide without financial barriers.

Among ACNS's prominent publications is the Diamond Open Access *Science Education Quarterly* (SEQ) that covers a broad range of topics aligned with the ICon-MaSTEd goals. Here are select articles from *Science Education Quarterly* categorized by conference topics:

- Biology Education
  - Utilization of instructional materials in supporting biology learning in Tanzania [7]
- Chemistry Education
  - Enhancing high school students' understanding of molecular geometry with augmented reality [8]

- The rebirth of home chemistry experiments: An international perspective and the Ukrainian context [9]
- A bibliometric analysis of learning environments in chemistry education [10]
- Programmed learning in chemistry education: a critical review of theory, application, and effectiveness [11]
- Physics Education
  - Broadening didactic resource of physics dictation [12]
  - A relativistic approach to teaching electrodynamics: Deriving Maxwell's equations from first principles [13]
  - A relativistic approach to teaching electrodynamics: Analysis of conductor interactions and relativistic foundations [14]
- Astronomy Education
  - From smartphones to stargazing: the impact of mobile-enhanced learning on astronomy education [15].
  - Enhancing student engagement and performance in high school astronomy through a differentiated homework approach [16]
- Earth Science Education
  - Teaching geography with GIS: a systematic review, 2010-2024 [17]
- Integrated Science Education
  - Implementing an integrated natural sciences course in Ukrainian high schools: A nationwide experiment from 2018-2022 [18]
  - Environmental factors influencing girls' participation in science education in Tanzanian secondary schools [19]
- Educational Technology
  - Elements of computer modelling: 12 studies for beginners. Study 1: Models and modelling [20]
  - Elements of computer modelling: 12 studies for beginners. Study 2: Main stages of modelling [21]

### 3.2. Institutional partners

The conference benefited from strong partnerships with three distinguished institutions. **Ben-Gurion University of the Negev, Israel**, where Professor Kiv served as a professor from 1998 to 2007, brought international perspective and expertise in advanced research methodologies. **Kryvyi Rih State Pedagogical University** served as the host institution, providing both physical and virtual infrastructure for the hybrid conference format. As one of Ukraine's leading pedagogical universities, KSPU brought decades of experience in teacher education and educational research. **Institute for Digitalisation of Education of the National Academy of Educational Sciences of Ukraine** contributed expertise in educational technology and digital transformation of learning environments. The Institute's involvement ensured that the conference addressed contemporary challenges in digital education, including issues of accessibility, quality assurance, and pedagogical innovation in online and blended learning contexts. Their research on educational digitalization in crisis conditions proved particularly relevant given the ongoing challenges faced by Ukrainian educators.

### 3.3. Organizational structure and support

The conference organizing committee, comprising representatives from all partner institutions, worked collaboratively to ensure the conference's success despite unprecedented challenges. The committee structure included:

- Program committee responsible for peer review processes, session organization, and maintaining academic standards. The committee reviewed 71 submissions and selected 31 high-quality papers through rigorous double-blind peer review.
- Technical support team managed the hybrid conference platform, ensuring seamless integration of in-person and virtual participation. This team's expertise proved crucial in maintaining conference continuity during air raid alerts and infrastructure disruptions.
- Publication committee oversaw the preparation and dissemination of conference proceedings, ensuring timely publication and broad accessibility of presented research.

ICon-MaSTEd 2025 program committee members:

- *Leon A. Abdillah*, Universitas Bina Darma, Indonesia [22]
- *George Abuselidze*, Batumi Shota Rustaveli State University, Georgia [23–25]
- *Svitlana Amelina*, National University of Life and Environmental Sciences of Ukraine, Georgia [26–28]
- *Spencer A. Benson*, Education Innovations International, LLC and University of Maryland, United States [29–31]
- *Liudmyla Bilousova*, Independent Researcher, Israel [32–34]
- *Olha Bondarenko*, Kryvyi Rih State Pedagogical University, Ukraine [35–39]
- *Oleksandr Burov*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [40–42]
- *Roman Danel*, VSTE in České Budějovice, Czech Republic [43–45]
- *Tetiana Derkach*, Kyiv National University of Technologies and Design, Ukraine [46–50]
- *Helena Fidlerova*, Slovak University of Technology in Bratislava, Slovakia [51]
- *Nataliia P. Franchuk*, Dragomanov State University of Ukraine, Ukraine [52–54]
- *Irina Georgescu*, Bucharest University of Economics, Romania [55–57]
- *Liudmyla Gryzun*, Simon Kuznets Kharkiv National University of Economics, Ukraine [58–61]
- *Oleksii Haluza*, National Technical University “Kharkiv Polytechnic Institute”, Ukraine [62–65]
- *Pavlo Hryhoruk*, Khmelnytskyi National University, Ukraine [66–68]
- *Andrii Iatsyshyn*, Center for Information-analytical and Technical Support of Nuclear Power Facilities Monitoring of the NAS of Ukraine, Ukraine [69–72]
- *Anna Iatsyshyn*, State Scientific Organization “Ukrainian Institute of Scientific Technical and Expertise and Information”, Ukraine [73, 74]
- *Dragos-Daniel Iordache*, National Institute for Research and Development in Informatics - ICI Bucuresti, Romania [75–78]
- *Michail Kalogiannakis*, University of Thessaly, Greece [79]
- *Arnold Kiv*, South Ukrainian National Pedagogical University named after K. D. Ushynsky, Ukraine & Ben-Gurion University of the Negev, Israel [80]
- *Taras Kobylnyk*, Drohobych Ivan Franko State Pedagogical University, Ukraine [81–83]
- *Oleksandr Kolgatin*, Simon Kuznets Kharkiv National University of Economics, Ukraine [84–86]
- *Elena Komarova*, NitrosData, LLC [87]
- *Tetiana Kramarenko*, Kryvyi Rih State Pedagogical University, Ukraine [88]



- *Milan Kubiato*, Jan Evangelista Purkyně University in Ústí nad Labem, Czechia [89–91]
- *Andrey I. Kupin*, Kryvyi Rih National University, Ukraine [92–95]
- *Olena Kuzminska*, National University of Life and Environmental Sciences of Ukraine, Ukraine [96–98]
- *Olena Lavrentieva*, Kryvyi Rih State Pedagogical University, Ukraine [99–101]
- *Olena Lokshyna*, Institute of Pedagogy of NAES of Ukraine, Ukraine [102]
- *Oksana Lytvyn*, Borys Grinchenko Kyiv Metropolitan University, Ukraine [103, 104]
- *Nataliia Maksyshko*, Zaporizhzhia National University, Ukraine [105]
- *Svitlana Malchenko*, Kryvyi Rih State Pedagogical University, Ukraine [106–111]
- *Mykhailo Medvediev*, ADA University, Azerbaijan [112–114]
- *Liliia Midak*, Vasyl Stefanyk Precarpathian National University, Ukraine [115–119]
- *Franco Milano*, University of Florence, Italy [120–123]
- *Iryna Mintii*, University of Łódź, Poland [124–129]
- *Mattia Monga*, University of Milan, Italy [130, 131]
- *Pavlo Nechypurenko*, Kryvyi Rih State Pedagogical University, Ukraine [132–136]
- *Yuliia Nosenko*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [137–139]
- *Laima Okunevičiūtė Neverauskienė*, Lietuvos Respublikos Vyriausybė, Lietuvos socialinių mokslų centras, Lithuania [140–142]
- *Vasyl Oleksiuk*, Ternopil Volodymyr Hnatiuk National Pedagogical University, Ukraine [143–145]
- *Kateryna Osadcha*, Norwegian University of Science and Technology, Norway [146–149]
- *Viacheslav Osadchyi*, Borys Grinchenko Kyiv Metropolitan University, Ukraine [150–152]
- *Jaderick Pabico*, University of the Philippines System, University of the Philippines Los Banos, Philippines [153]
- *Olha Pinchuk*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [154–157]
- *Oleg Pursky*, State University of Trade and Economics, Ukraine [158]
- *Natalya Rashevskaya*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [159–161]
- *Iryna Salnyk*, Volodymyr Vynnychenko Central Ukrainian State University, Ukraine [162–165]
- *Serhiy Semerikov*, Kryvyi Rih State Pedagogical University, Ukraine [166]
- *Etibar Seyidzade*, Baku Engineering University, Azerbaijan [167–170]
- *Yevhenii Shapovalov*, Junior Academy of Sciences of Ukraine, Ukraine [171–175]
- *Svitlana Shokaliuk*, Kryvyi Rih State Pedagogical University, Ukraine [176]
- *Andrii Striuk*, Kryvyi Rih National University, Ukraine [177]
- *Oksana Strutynska*, Dragomanov Ukrainian State University, Ukraine [178]
- *Myroslav Syvvi*, Ternopil Volodymyr Hnatiuk National Pedagogical University, Ukraine [179, 180]
- *Tetiana Tashtan*, Kryvyi Rih State Pedagogical University, Ukraine [181]
- *Viktorii Tkachuk*, Kryvyi Rih National University, Ukraine [182–184]
- *Maria Umryk*, Dragomanov Ukrainian State University, Ukraine [185–187]

- *Mayank Vahia*, TIFR Mumbai, India [188,189]
- *Tetiana Vakaliuk*, Zhytomyr Polytechnic State University, Ukraine [190–192]
- *Nataliia Valko*, Kherson State University, Ukraine [193–195]
- *Nataliia Veretennikova*, Lviv Polytechnic National University, Ukraine [196–198]
- *Kateryna Vlasenko*, National University of Kyiv-Mohyla Academy, Ukraine [199–201]
- *Yuliia Yechkalo*, Kryvyi Rih National University, Ukraine [202–204]

### 3.4. Commitment to open science and accessibility

All organizing partners share a commitment to open science principles, reflected in the conference's approach to knowledge dissemination. Conference proceedings are published under open access licenses, ensuring that research findings are freely available to educators worldwide, regardless of institutional resources. Video recordings of all sessions are made available on the “Not So Easy Science” YouTube channel (<https://www.youtube.com/@NotSoEasyScience>), extending the conference's reach beyond registered participants.

This commitment to accessibility is particularly important given the conference's focus on education in crisis conditions. By removing financial and technical barriers to accessing conference content, the organizers ensure that innovative educational solutions developed in response to challenging circumstances can benefit educators facing similar challenges globally.

The collaborative organizational structure of ICon-MaSTEd 2025 demonstrates that international scientific cooperation can thrive even in the most challenging circumstances. The dedication of organizers, partners, and participants in maintaining this platform for educational innovation honors Professor Kiv's vision of science and education as universal human endeavors that transcend political boundaries and unite us in our common pursuit of knowledge and betterment of society.

## 4. Proceedings overview

### 4.1. Mathematics Education

The Mathematics Education section of ICon-MaSTEd 2025 featured eight innovative papers that explored contemporary challenges and opportunities in mathematics pedagogy, ranging from teacher preparation methodologies to century-long institutional perspectives. This session, moderated by Iryna Mintii and Svitlana Malchenko, brought together researchers from multiple Ukrainian universities and international institutions to share their insights on advancing mathematical education in the 21st century.

The session opened with a presentation by Achkan et al. [205] on “Using the case method while training would-be Mathematics teachers”. The authors developed a comprehensive methodology for implementing the case method in mathematics teacher preparation programs, proposing a classification system for cases based on execution time, presentation method, complexity level, and problem breadth. Their experimental verification confirmed the practicality of using the case method, with statistical analysis showing significantly higher achievement levels in methodological disciplines among students in the experimental group compared to the control group. The methodology encompasses six key components: motivation of educational activity, goal setting, content, methods, forms, and means of learning, providing a structured approach to modeling real professional activities that mathematics teachers encounter in their practice.

Following this pedagogical innovation, Vlasenko et al. [206] presented their research on the “Application of the Cobb-Douglas function for the formation of would-be economists' analytical skills”. This interdisciplinary approach demonstrates how mathematical modeling, specifically through the Cobb-Douglas production function, can develop crucial analytical skills in economics students. The authors systematized problems using a combination of table and clustering methods, organizing them into three types that progressively build students' abilities

in computing partial derivatives, constructing logical arguments, and adapting mathematical results to economic contexts. During the discussion, Professor Vladimir Sokolov raised an insightful question about the potential for revisiting the Cobb-Douglas function across multiple mathematical topics to deepen understanding, highlighting the challenge of limited instructional time while emphasizing the function's versatility in demonstrating real-world applications of bivariate functions, derivatives, and optimization problems.

Lovianova et al. [207] contributed a comprehensive study on "Measurement key competencies of high school students in teaching of Natural Science and Mathematics subjects", addressing the critical need for competency-based assessment in modern education. Their research developed instruments for measuring key competencies that align with contemporary educational standards, providing valuable insights into how mathematics education can contribute to broader educational goals beyond subject-specific knowledge.

The international perspective was enriched by Voievoda et al. [208] with their comparative study on "Peculiarities of implementing digital games in mathematics lessons in secondary schools of Ukraine and Israel". This cross-national research examined how gamification strategies can enhance mathematical learning, revealing both universal principles and culturally specific considerations in implementing educational technology across different educational systems.

Addressing motivational challenges in higher education, Petrovych et al. [209] presented "Modern aspects of forming the motivation of learning activities of bachelors of mathematics in the process of studying professional disciplines". Their research identified key factors influencing student motivation and proposed strategies for maintaining engagement throughout the demanding mathematics curriculum, particularly important given the abstract nature of many advanced mathematical concepts.

The increasing importance of adaptive learning technologies was highlighted by Astafieva et al. [210] in their paper "Supporting the mathematical education of STEM students: development of an adaptive learning course for independent study". The authors described the development of an adaptive learning platform that responds to individual student needs, supporting self-directed learning and addressing the diverse preparation levels of STEM students. The discussion revealed plans for an ambitious international Erasmus project involving eight universities across Ukraine, Slovakia, Czech Republic, and Norway to further develop and implement adaptive learning approaches.

A particularly significant historical perspective was provided by Kramarenko and Semerikov [211] in "A century of mathematics education at Kryvyi Rih State Pedagogical University: Honoring the past, shaping the future". This comprehensive historical analysis traced the evolution of mathematics education at the institution from its founding through Soviet times to contemporary challenges. Using qualitative case study methodology with multiple data sources including archival documents and 15 oral history interviews, the research illuminated patterns of continuity and change across different political and educational paradigms. The presentation sparked thoughtful discussion about the enduring values of fundamental mathematical knowledge and logical reasoning that transcend political systems, while acknowledging the need for adaptation to contemporary educational demands.

The session concluded with Klochko et al. [212] presenting "Mathematics for digital signal processing: series and integrals of Fourier in professional training", which addressed the critical intersection of pure mathematics and engineering applications. The authors emphasized how Fourier analysis serves as a fundamental bridge between abstract mathematical concepts and practical engineering problems, particularly relevant in the digital age. Their approach to integrating constructive and mathematical thinking through visualization and animation techniques demonstrated how modern pedagogical tools can make complex mathematical concepts more accessible to engineering students, addressing the common challenge of "math anxiety" among technical students.

Throughout the session, several cross-cutting themes emerged. First, the integration of technology and digital tools was prominent across multiple presentations, from adaptive learning platforms to visualization techniques for complex mathematical concepts. Second, the importance of contextualizing mathematical learning through real-world applications was consistently emphasized, whether through economic modeling, engineering applications, or gamification. Third, the session highlighted the ongoing challenge of maintaining mathematical rigor while making content accessible and engaging for diverse student populations.

The discussion periods revealed rich exchanges between participants, with particular attention to the balance between theoretical foundations and practical applications. As noted in the closing remarks by session moderators, while artificial intelligence and machine learning were not central topics in this session, participants acknowledged the potential of these technologies to enhance mathematical productivity, referencing Terence Tao's recent explorations of AI-assisted theorem proving as an indicator of future directions in mathematical education.

The Mathematics Education section thus demonstrated the field's dynamic response to contemporary challenges while maintaining its commitment to fundamental mathematical principles. The research presented offers valuable insights for educators seeking to prepare students for an increasingly complex and technologically sophisticated world while preserving the essential character of mathematical thinking that has defined the discipline for centuries. The session's conclusion emphasized the importance of annual conferences like ICon-MaSTEd in maintaining international collaboration and knowledge exchange, particularly crucial given the current geopolitical challenges facing the region.

#### *4.2. Physics Education*

The Physics Education section of ICon-MaSTEd 2025 featured five innovative papers that explored diverse approaches to physics teaching, from early childhood interventions to advanced computational methods. This session, held on May 14, demonstrated the breadth of physics education research, addressing challenges from fundamental skill development to sophisticated teacher training programs. The presentations highlighted both practical tools for classroom implementation and theoretical frameworks for understanding physics learning across different age groups and educational contexts.

The session opened with Broniola et al. [213] from the Philippines presenting "Conversion Factor Wheel: a tool to improve unit conversion skills in Grade 12 STEM students". This practical research addressed a fundamental challenge in physics education – unit conversion competency. The team developed an Android-based application specifically designed for students at Cantilan National High School, providing a visual and interactive approach to converting units of length, mass, volume, and time. Using an experimental design with pre- and post-test assessments, the study demonstrated remarkable improvement in student performance, with mean scores increasing from 4.8 (48%) to 9.45 (94.5%), a significant mean difference of 4.65. The psychological validity rating of 74.13% indicated high student satisfaction and acceptance. Crucially, the app's offline functionality addressed infrastructure challenges, as the presenters noted: "This app is highly valuable for CNHS students because it can be used remotely without an internet connection, giving it a significant advantage over other online-only tools". This feature proved particularly important for ensuring educational continuity in areas with limited internet access.

A particularly innovative approach to early childhood physics education was presented by Ioannou et al. [214] with their paper "Fostering early understanding of vaporization in 5-6-year-olds via engineering design". This qualitative study involved 19 preschool children and employed a sophisticated Engineering Design Process (EDP) framework with four distinct stages: Problem, Inquiry, Designing and Testing, and Conclusions and Presentation. The researchers used everyday scenarios, such as wet clothes drying and water disappearing from a glass, to

make abstract concepts tangible for young learners. During the discussion, questions arose about adapting complex physics concepts for such young children. As the presenter explained, “We do not try to give children the total scientific accessible idea, but something less” – referring to their concept of “precursor models” that serve as cognitive bridges between children’s intuitive understanding and formal scientific knowledge. The study demonstrated that children could successfully connect thermal exchanges with vaporization phenomena, with post-test results showing improvement from 10% to 79% in understanding key concepts. When asked about potential adaptations to other media formats, the researchers acknowledged interest in developing animated content to further enhance accessibility.

Abdulayeva [215] from Kazakhstan contributed “Information educational environment and scientific process skills: experimental evaluation using the Likert scale”. This three-year longitudinal study (2021-2023) involved 56 middle school students divided into experimental and control groups. The experimental group engaged with ICT-enhanced laboratory activities following a structured progression model: adaptation (7th grade), development (8th grade), and self-realization (9th grade). Using a 31-question Likert scale questionnaire assessing nine core scientific process domains, the study demonstrated significant improvements in students’ self-perceived scientific competencies. During the Q&A, participants inquired about specific physics experiments that worked best with ICT integration. The presenter noted that mechanics experiments were particularly effective, as “in Excel we lost analysis data mechanical experiments”, highlighting the practical applications of spreadsheet software in physics education. The discussion also addressed the challenge of balancing traditional hands-on laboratory work with digital tools, emphasizing that ICT should enhance rather than replace physical experimentation.

Sadovyi et al. [216] presented a sophisticated theoretical and computational approach with “Computer modelling of atomic-molecular states leading to Maxwell distribution”. This research developed an integrative method using Python’s Matplotlib module to create visual-dynamic computer models of gas molecular velocity distributions. The team created simulations for four gases (helium, nitrogen, oxygen, and carbon dioxide) at 300K temperature across velocity ranges from 0 to 1400 m/s with 10 m/s increments. The pedagogical experiment at Volodymyr Vynnychenko Central Ukrainian State University and Dnipro State Medical University showed improved student comprehension of abstract thermodynamic concepts through visualization. The presenters emphasized how their approach “develops students’ computational thinking, fosters worldviews oriented toward independent truth-seeking, and provides opportunities to implement research ideas directly during studies”. The visual representation of Maxwell distribution helped students understand the physical meaning of temperature, pressure, and energy concepts that are typically challenging to grasp through traditional teaching methods.

The session concluded with Pavlenko et al. [217] presenting “Experience in the development and implementation of the course ‘Python for Physics Teachers’”. This comprehensive professional development program consisted of 13 lectures and 12 practical sessions designed to equip physics teachers with computational skills. The course covered foundational Python programming, visualization of physical phenomena, and modeling of school physics topics. During the discussion, concerns about the impact of large language models like ChatGPT on student learning arose. The presenter acknowledged this challenge, noting difficulties in distinguishing between student-generated and AI-generated code. A thoughtful exchange followed about embracing rather than resisting AI tools, with one participant suggesting: “Probably it will be more productive... our students should use this model and explain, modify and produce a new model”. The discussion highlighted the need for physics education to adapt to AI-enhanced learning environments while maintaining focus on conceptual understanding and critical thinking skills.

Throughout the session, several unifying themes emerged. First, the importance of

visualization and interactivity in making abstract physics concepts accessible to learners of all ages. Second, the critical role of appropriate technological integration that enhances rather than replaces traditional physics teaching methods. Third, the need for teacher professional development to effectively implement new tools and approaches. Fourth, the challenge of maintaining educational quality while adapting to technological disruptions like AI and remote learning requirements.

The session concluded with warm exchanges between participants, with the moderator noting it was “the best session as for today”, emphasizing the collaborative spirit and shared commitment to advancing physics education despite challenging circumstances. The research presented demonstrated that physics education continues to evolve, incorporating new technologies and pedagogical approaches while maintaining its fundamental goal of developing scientific understanding and reasoning skills.

#### *4.3. Astronomy Education*

The Astronomy Education section featured a single but comprehensive paper that addressed fundamental challenges in teaching astronomical concepts within contemporary educational contexts. This focused presentation demonstrated how astronomy education serves as a unique interdisciplinary platform for developing both scientific competencies and broader educational goals.

Malchenko [218] presented “Implementation of a competency-based approach in teaching astrophysics and astronomy”, offering a thorough examination of how astronomy education can transcend traditional knowledge transmission to develop essential 21st-century competencies. The research employed qualitative methodology, including content analysis of curricula, expert review of lesson plans, and systematic comparison with international best practices. The presenter emphasized that “astronomy is very interesting but not very popular... among the teachers of physics”, highlighting a fundamental challenge in the field. Despite this, Malchenko argued convincingly that astronomy provides unique opportunities for competency development that other subjects cannot easily replicate.

The presentation detailed how astronomy naturally integrates multiple disciplines – physics, mathematics, chemistry, and even philosophy – making it an ideal vehicle for holistic education. The competency-based approach shifts focus from memorizing celestial facts to developing practical skills: data analysis, problem-solving, scientific reasoning, and technological literacy. The research identified core principles including result-oriented learning, integration of knowledge and skills, practical application, flexibility, and continuous self-assessment. As Malchenko noted, “Today’s world demands more than just theoretical knowledge. Students need to be able to adapt, solve problems, and work effectively in teams”.

During the extensive discussion period, practical implementation challenges dominated the conversation. When asked about organizing real telescope observations, Malchenko acknowledged significant logistical hurdles: “It’s very hard to organize real observing with telescope... I need good weather. I need some many interesting bodies on the night sky”. The presenter described requiring specific lunar phases for optimal first-time observations, explaining that “when moon in the first phases... you have a very interesting emotion”, highlighting the importance of carefully orchestrated observational experiences to maintain student engagement.

A particularly fascinating aspect of the discussion centered on the use of professional astronomical data in education. Malchenko detailed how students work with real data from solar observations and variable star catalogs, utilizing resources like SIMBAD and other professional databases. The presenter shared a remarkable success story: “One of pupils three years ago... discovered a new type of stars. She was in the ninth class... she used computer science specific computer apps”. This example powerfully illustrated how authentic scientific research can be integrated into secondary education, providing students with genuine discovery opportunities

while developing both astronomical knowledge and computational skills.

The conversation took a poignant turn when discussing resources and facilities. Malchenko mentioned the loss of access to the Crimean Astronomical Laboratory, stating, “Unfortunately we can’t use this laboratory today and more than 10 years”, a reminder of how geopolitical circumstances impact scientific education. Despite such challenges, the presenter emphasized adaptation through virtual observations, online databases, and collaborative international projects that provide alternative pathways for astronomical education.

The research presented practical examples of competency development through astronomy. Students learn to work with large datasets, apply mathematical models to real phenomena, use modern software for data analysis, and communicate scientific findings effectively. The interdisciplinary nature of astronomy projects – combining observation, computation, theoretical understanding, and presentation skills – creates rich learning environments that prepare students for diverse career paths, not just in astronomy but in any field requiring analytical and problem-solving capabilities.

Malchenko’s presentation also addressed assessment challenges in competency-based astronomy education. Traditional testing methods often fail to capture the full range of skills developed through astronomical study. The research proposed portfolio-based assessment, project presentations, and peer evaluation as more appropriate evaluation methods that align with competency development goals. These approaches allow students to demonstrate not just knowledge retention but also their ability to apply astronomical concepts in novel situations, work collaboratively on complex problems, and communicate scientific ideas effectively.

The session revealed astronomy education’s unique position in the curriculum as a gateway science that can inspire lifelong learning and scientific literacy. Despite challenges including limited class time, lack of specialized teacher training, and equipment constraints, the research demonstrated that well-designed competency-based approaches can transform astronomy from a marginal subject into a powerful educational tool. The emphasis on using freely available online resources, citizen science projects, and virtual observatory tools showed how modern astronomy education can be accessible even in resource-constrained environments.

The discussion concluded with reflections on future directions for astronomy education. Participants expressed hope that despite current challenges, the collaborative spirit of the international astronomy education community would continue to foster innovation and resource sharing. The session highlighted how astronomy, perhaps more than any other science, connects students to fundamental questions about our place in the universe while developing practical skills essential for the modern world. As Malchenko concluded, looking toward future programs that would allow students to pursue “real scientific awards” through astronomical research, the presentation demonstrated that astronomy education, when properly implemented, serves not just as a subject to be learned but as a platform for developing the critical thinking, technological competency, and scientific literacy essential for the 21st century.

#### *4.4. Chemistry Education*

The Chemistry Education section of ICon-MaSTEd 2025 featured two papers that addressed critical challenges in chemistry pedagogy, from teaching in foreign language environments to implementing reflective practices in organic chemistry instruction. This session, held on May 15, demonstrated innovative approaches to overcoming cognitive load challenges and enhancing student engagement through systematic reflection, highlighting the adaptability of chemistry education in diverse and challenging contexts.

The session opened with Derkach and Yaroshenko [219] presenting “Instructional design for teaching analytical chemistry in English as a foreign language”. This comprehensive study addressed the unique challenges of teaching complex chemical concepts to Chinese undergraduate students at Kyiv College of the Qilu University of Technology. The research, spanning 2019-

2023 and involving approximately 800 students across biotechnology and chemical technology programs, revealed a paradoxical trend: while students' English proficiency steadily improved over the years (from 60-62 points in 2019 to 74-76 points in 2023), their analytical chemistry exam results remained static at 75-77 points despite unchanged curricula and teaching staff. The authors systematically optimized instructional materials based on cognitive load theory, implementing changes across multiple dimensions. They reduced the total number of slides by 16% while increasing the average number of integrated elements per slide, transitioning from isolated information presentation to more cohesive, contextually linked content. As the presenter explained during the Q&A, cognitive load was measured using the secondary task method, where students performed dual tasks requiring the same cognitive resources, with reaction times indicating load levels. The optimization included three key strategies: managing intrinsic load through graduated complexity and the "part-whole" approach, reducing extraneous load by preventing split-attention effects and adhering to multimedia principles, and increasing germane load through worked examples and conceptual diagrams. Particularly innovative was their application of Johnstone's triangle, integrating macro, micro, and symbolic levels of chemical knowledge representation. The number of slides showing isolated levels decreased while those demonstrating double and triple transitions increased, with triple transitions growing from nearly zero to 10% of content.

Following this methodological innovation, Kutuhina, Kravchenko, and Nechypurenko [220] presented "Organisation of students' reflective activity when studying the topic 'Oxygen-containing organic compounds'". Their research, presented through a pre-recorded video due to technical constraints, addressed the critical gap between theoretical knowledge and practical application in organic chemistry education. A survey of 28 chemistry teachers in Kryvyi Rih revealed that while 89.3% considered reflection necessary for creating a developmental learning environment, only 50% systematically organized reflective activities, and merely 14.28% applied these methods when teaching oxygen-containing organic compounds. The authors developed a five-stage model of reflective activity: transpositional (role position change), reproductive (sequence reconstruction), analytical-evaluative (multifaceted analysis), resultative (fixation of outcomes), and prognostic (future planning). Their practical implementations included innovative techniques such as the "Microphone" method for content reflection, "YES or NO?" games for conceptual understanding, "Snowball" exercises for collaborative reflection, and "Fishbone" diagrams for process analysis. During the discussion, provocative questions arose about the dual nature of reflection involving both students and teachers. As translated during the session, the teacher "as the organizer of learning should understand why they are doing anything at the lesson", emphasizing that reflection serves as bidirectional feedback enabling continuous instructional improvement. When asked about extending reflection to homework and independent study, the presenters acknowledged this as an important area for future research, noting they had focused primarily on classroom activities but recognized the potential for broader application.

The Chemistry Education session revealed several critical insights for the field. First, the challenge of teaching chemistry in foreign language contexts extends beyond simple translation issues to fundamental cognitive processing differences. The counterintuitive finding that improved language skills did not correlate with better chemistry performance suggests that discipline-specific cognitive demands require targeted instructional design rather than general language support. Second, the widespread recognition but limited implementation of reflective practices indicates a significant theory-practice gap in chemistry education. Teachers acknowledge the value of reflection but lack practical tools and training for systematic implementation.

The COVID-19 pandemic's impact featured prominently in both presentations. Derkach and Yaroshenko noted that their instructional optimizations were partly driven by the need to adapt



to remote learning during 2020-2021, with students in China and teachers in Ukraine. The pandemic revealed existing weaknesses in instructional design while accelerating innovation. As one presenter noted regarding the shift from traditional to online learning, “the combination of high intrinsic and extraneous cognitive load can become critical for learning, as it can significantly exceed the capabilities of working memory”, emphasizing the heightened importance of cognitive load management in remote contexts.

Both presentations emphasized the importance of visualization and multi-level representation in chemistry education. Derkach and Yaroshenko’s use of Johnstone’s triangle to integrate macroscopic, microscopic, and symbolic levels mirrors Kutuhina et al.’s emphasis on connecting abstract concepts to observable phenomena through techniques like the Fishbone diagram. This convergence suggests that effective chemistry education requires systematic approaches to helping students navigate between different representational levels, particularly important given chemistry’s inherent abstraction.

The discussion periods revealed practical implementation challenges. Teachers face time constraints, with one noting the difficulty of covering extensive curricula while implementing reflective activities. Resource limitations, particularly in conflict-affected regions, necessitate creative solutions. The loss of access to physical laboratories during the pandemic and ongoing conflict has accelerated the adoption of virtual laboratories and simulation tools, though presenters emphasized these complement rather than replace hands-on experimentation.

Cultural considerations emerged as significant factors. Teaching Chinese students required adaptations beyond language, accounting for different learning preferences and educational backgrounds. Similarly, implementing Western pedagogical approaches like systematic reflection in Ukrainian classrooms required cultural adaptation. As noted during discussions, Chinese students demonstrated “more global” learning styles compared to Ukrainian students, though pandemic-driven remote learning appeared to be shifting Ukrainian students toward similar patterns.

The session highlighted the evolution of chemistry education assessment. Traditional testing methods inadequately capture the complex competencies developed through modern chemistry instruction. Both presentations advocated for alternative assessment approaches: Derkach and Yaroshenko through integrated problem-solving tasks that span representational levels, and Kutuhina et al. through portfolio-based assessment and peer evaluation that capture reflective competencies. These approaches align with broader educational trends toward competency-based rather than knowledge-based evaluation.

Looking forward, both presentations pointed toward increased technology integration while maintaining pedagogical focus. The forced experimentation during the pandemic has yielded valuable insights about effective online chemistry instruction that will persist post-crisis. However, presenters emphasized that technology serves pedagogical goals rather than driving them. As Derkach noted, the goal is not to “avoid presenting data in several autonomous formats simultaneously” through technology but to use it purposefully to reduce cognitive load and enhance understanding.

The Chemistry Education section thus demonstrated the field’s resilience and adaptability in facing multiple simultaneous challenges: linguistic barriers, cognitive load management, pandemic disruption, and the need for pedagogical innovation. The research presented offers practical strategies for educators worldwide facing similar challenges, from systematic instructional design based on cognitive science principles to implementing reflective practices that deepen conceptual understanding. The session’s conclusion emphasized that these innovations, born from necessity, represent genuine advances in chemistry pedagogy that will benefit students long after current crises pass. The warm exchanges between presenters and participants, despite technical challenges and language barriers, underscored the international chemistry education community’s commitment to collaborative problem-solving and continuous improvement.

#### 4.5. *Earth Science Education*

The Earth Science Education section of ICon-MaSTEd 2025 featured two comprehensive papers on geospatial analysis and data integration in geography education, demonstrating how modern geographic information technologies can transform traditional geography teaching. This session, held on May 15, brought together researchers from Ukrainian institutions to explore the theoretical foundations and practical implementations of geospatial technologies in school geography courses, addressing both opportunities and challenges in bringing real-world geographic analysis into classrooms.

The session began with Kholoshyn et al. [221] presenting “Principles and methods of integrating geospatial analysis into the school geography course”. The authors argued that geographic information technologies have become essential tools for understanding geographic space, enabling students to study spatial differentiation of processes, objects, and phenomena while solving practical problems across ecology, agriculture, transport, and urban planning. Their research identified six fundamental principles for implementing geospatial analysis in schools. First, geospatial technologies should be integrated into existing curriculum topics rather than added as supplementary content, making traditional material more accessible through new perspectives. Second, working with real geospatial data makes learning interactive and practically oriented, with students able to collect data through field research, GPS devices, and community surveys. Third, project activities provide effective means for applying knowledge to real-world problems, as exemplified by students at Bishop Dunne Catholic School in Dallas who analyzed police robbery data, identified hotspot areas, and provided recommendations that contributed to actual crime reduction. Fourth, Geographic Information Systems (GIS) serve as powerful support tools, though the authors noted teachers should begin with accessible online platforms like MapMaker Interactive and GeoInquiries before progressing to complex software like ArcGIS or QGIS. Fifth, interdisciplinary integration allows geospatial analysis to enhance not only geography but also history, biology, economics, and mathematics instruction. Sixth, successful implementation requires comprehensive teacher training in geoinformation technologies.

Building on these principles, Kholoshyn et al. [222] presented “Geospatial data in school geography courses: Sources, methodological features of use and implementation challenges”. This complementary research examined the practical aspects of implementing geospatial data in education, emphasizing that geospatial data represents more than coordinates – it forms the “dynamic basis of our interconnected world” combining spatial, attribute, and temporal components. The authors established six essential criteria for educational geospatial data: high quality and currency, accessibility without financial barriers, clarity with appropriate structure, alignment with educational objectives, support for interactive exploration, and protection of privacy and security. They detailed various pedagogical approaches including problem-based learning where students analyze real environmental challenges, project activities involving authentic data collection and analysis, gaming technologies like GeoGuess that develop spatial reasoning through interactive challenges, and independent work with professional databases and satellite imagery. The presentation featured practical examples, such as students using Sentinel-5P satellite data to analyze NO<sub>2</sub> pollution patterns across Ukrainian cities, demonstrating how authentic scientific data can be integrated into secondary education.

During the extensive Q&A session, critical implementation questions emerged. When asked about the optimal phase for introducing geospatial analysis, the presenters emphasized adaptability across all educational stages while considering individual student characteristics. They recommended beginning with demonstration and visualization for younger students, progressively introducing analytical tools, and culminating in full project-based implementations for senior students. This graduated approach acknowledges both cognitive development and technical skill progression. Tetiana Derkach inquired about specific project examples, prompting detailed descriptions of successful implementations. One highlighted project involved combining

tectonic plate maps with earthquake data to help students discover correlations between seismic activity and plate boundaries – a powerful demonstration of how geospatial analysis makes abstract geological concepts tangible. Another example described monitoring Carpathian forest development over time, illustrating environmental change and human impact. The presenters emphasized how such projects develop cause-and-effect thinking while integrating multiple disciplines.

Technical accessibility emerged as a crucial concern. When asked about specialized software requirements, the presenters stressed the availability of free, browser-based tools requiring no special installation. They highlighted platforms like Google Maps, OpenStreetMap, and educational-specific resources like GeoInquiries that provide professional-grade analysis capabilities without cost barriers. This emphasis on accessibility reflects awareness of resource constraints in many schools, particularly relevant given Ukraine's current challenges. The discussion about data quality and verification prompted insights about crowdsourced platforms like OpenStreetMap, where "different researchers can take and correct the data", creating collaborative knowledge construction opportunities while teaching critical evaluation skills.

The integration of artificial intelligence in geospatial analysis generated thoughtful discussion. When asked about student use of AI tools, presenters acknowledged both opportunities and challenges. They noted AI's tendency to "make mistakes", especially with Ukrainian-language queries, emphasizing the need for verification skills. Rather than viewing AI as a threat, they positioned it as another tool requiring critical evaluation – students and teachers must "learn with artificial intelligence how to use it in our studies". This perspective frames AI literacy as an essential component of modern geographic education.

Practical challenges dominated much of the discussion. Limited instructional hours in geography curricula remain a primary obstacle, with most schools allocating only 2-3 weekly hours to geography. The presenters suggested integrating short 15-20 minute geospatial tasks into existing topics rather than requiring curriculum expansion. They provided specific examples, such as using Map Viewer to create demographic visualizations when studying population geography, demonstrating how geospatial analysis enhances rather than replaces traditional content. The lack of adapted educational materials and teacher training represents another significant barrier. While professional geospatial data sources proliferate, most lack pedagogical adaptation for secondary students. The presenters advocated for developing simplified, theme-oriented datasets with clear educational alignments, alongside comprehensive teacher professional development programs.

Methodological considerations received detailed attention when asked about the most effective approaches for geography lessons. While acknowledging this area needs further research, the presenters identified several promising methods: working with mapping services for visualization and basic analysis, thematic mapping for pattern recognition and correlation, and spatial modeling for understanding geographic processes. They emphasized that method selection depends on learning objectives, student capabilities, and available resources. The discussion revealed tension between the potential of advanced technologies and practical classroom realities, with presenters advocating for pragmatic approaches that prioritize pedagogical effectiveness over technological sophistication.

Both presentations addressed the unique challenges facing Ukrainian education during wartime. References to lost access to facilities, such as the Crimean Astronomical Laboratory mentioned in another session, and the need for offline-capable resources reflect the reality of education under conflict. However, rather than dwelling on limitations, the presenters demonstrated remarkable adaptability, showing how virtual resources and international collaboration can partially compensate for physical resource loss. The emphasis on freely available online tools and crowdsourced data takes on additional significance in this context, providing continuity despite infrastructure disruptions.

Looking toward future developments, the presenters introduced the concept of GeoAI (Geospatial Artificial Intelligence), combining AI, GIS, and geospatial data to address complex geographic problems. While acknowledging GeoAI remains nascent in educational contexts, they outlined potential applications including automated data collection from satellite imagery, real-time processing of geographic information, and predictive spatial analytics for environmental and urban planning. These capabilities could revolutionize geography education by providing students with tools for authentic scientific investigation previously available only to professional researchers.

The session revealed geography education at a transformation point, where traditional map-based instruction evolves into dynamic, data-driven exploration of spatial phenomena. The research presented demonstrates that despite significant challenges – limited resources, insufficient training, curriculum constraints, and ongoing conflict – innovative educators are successfully integrating geospatial technologies to enhance geographic understanding. The emphasis on practical, accessible solutions rather than idealized implementations provides valuable guidance for educators worldwide facing similar constraints.

The Earth Science Education section thus offered both vision and pragmatism, showing how geospatial analysis can transform geography from a descriptive to an analytical discipline while acknowledging the real challenges of implementation. The presenters' combination of theoretical frameworks, practical examples, and honest discussion of obstacles provides a roadmap for educators seeking to modernize geography instruction. As noted in closing remarks, these technologies offer students not just knowledge about the world but tools to analyze, understand, and ultimately shape it – a capability increasingly essential in our interconnected, spatially complex global society. The session concluded with expressions of gratitude for the opportunity to share experiences and learn from international colleagues, reinforcing the importance of continued collaboration in advancing geographic education despite challenging circumstances.

#### *4.6. Computer Science Education*

The Computer Science Education section of ICon-MaSTEd 2025 featured seven innovative papers that addressed contemporary challenges in computing education, from artificial intelligence integration to game development pedagogy. This session, held on May 16, 2025, brought together researchers and educators from Ukraine and international institutions to explore how computer science education can evolve to meet the demands of a rapidly changing technological landscape while maintaining pedagogical effectiveness and student engagement.

The session opened with a compelling presentation by Osadcha et al. [223] on “AI tools and their application for developing soft skills of computer science students: the perspectives of IT specialists and university teachers”. This timely research addressed the critical intersection of technical and interpersonal competencies in IT education. Through comprehensive surveys of IT professionals and educators, the authors identified a strong correlation between teaching experience and satisfaction with AI tools for developing soft skills. Their findings revealed that tools such as ChatGPT, Grammarly, Microsoft Copilot, and various intelligent tutoring systems can effectively support the development of communication, collaboration, critical thinking, and problem-solving abilities. The presentation sparked discussion about implementation strategies, with particular attention to helping less experienced educators become comfortable with AI integration. As one participant noted during the Q&A, the research found that “the more teaching experience respondents have, the more their satisfaction with AI exploiting”, highlighting the need for targeted professional development programs.

Building on the theme of cognitive development through technology, Chernenko and Lysenko [224] presented “The impact of AI on the development of cognitive competence in gifted youth”. Their study, conducted at the “Polit” Science Lyceum, demonstrated how participation in AI project development significantly enhanced students' scientific thinking, critical analysis, and

decision-making skills. The research emphasized that cognitive competence has become essential for young people to adapt to new conditions of work and life, particularly in the context of rapid technological change. The authors argued that engaging gifted students in AI projects not only develops their technical skills but also cultivates the flexible thinking necessary for addressing global challenges through innovative approaches and cutting-edge technologies.

Koniukhov et al. [225] contributed an important methodological framework with their paper on “Creating of collaborative learning framework for Computer Science students training in the field of database design”. The authors conducted a comprehensive bibliometric analysis using Scopus data to identify key trends in collaborative learning and database education. Their framework emphasized techniques such as the Jigsaw method and gather.town platform for online collaboration, demonstrating how collaborative learning can develop both hard skills in database design and essential soft skills through group interaction. The research particularly highlighted the challenges of organizing collaborative learning in online environments, including increased teacher workload for live group management and technical problem-solving, while also showcasing successful implementations in courses like “Software Product Line Engineering”.

A particularly innovative mathematical perspective was provided by Gryzun [226] with “Computational and algorithmic explorations of polygonal numbers: their role in computer science education”. This research addressed the challenge of students’ insufficient awareness of the value of mathematical knowledge for their professional development as computer scientists. By using polygonal numbers as a bridge between abstract mathematics and practical computation, the author demonstrated how these mathematical concepts appear in real-world applications from spider webs to network topology. The exploration activity developed by Gryzun integrates algebra, geometry, and computation, providing students with hands-on experience in mathematical modeling and algorithm development. The paper’s emphasis on making mathematics tangible and relevant resonated with educators seeking to overcome the common perception among CS students that advanced mathematics is purely abstract and disconnected from professional practice.

The growing importance of game development in computer science education was highlighted by Pruhlo and Moiseienko [227] in their presentation on “Integrating game development into the secondary school informatics curriculum: A case study from Ukraine”. Their implementation of a Unity-based game development course demonstrated significant improvements in student engagement and programming skills. Students reported that creating interactive games made abstract programming concepts concrete and meaningful, with one participant noting, “The best part of the class was seeing my own ideas come to life on the screen”. The authors identified both challenges, such as varying levels of prior programming experience and technical limitations of school computer labs, and success factors, including the intrinsically motivating nature of game creation and the balance between structured learning and creative freedom.

Complementing this focus on game-based learning, Pozniakov and Merzlykin [228] presented “Development of a PyGame workshop for extracurricular Computer Science education”. Their analysis of existing Ukrainian extracurricular programs revealed significant gaps, including outdated materials, expensive software requirements, and inappropriate inclusion of Russian-language resources. The authors developed a comprehensive PyGame workshop using Google Sites, providing free, accessible learning materials with step-by-step game creation guides. The workshop’s project-based learning approach, where students build a functional game that serves as a foundation for future projects, received positive feedback from participants who appreciated the practical orientation and clear progression of skills. As the authors noted, Python and PyGame were chosen for their accessibility, extensive documentation, and suitability for beginners, making game development approachable for students with basic programming knowledge.

The session concluded with Ryzhanina and Tarasova [229] presenting “Development of an

elective course on Scratch programming for specialized computer science education in lyceums". Their 12-week pedagogical experiment demonstrated significant improvements in students' Scratch programming skills and computational thinking abilities. The research showed that 90% of participating students had prior exposure to Scratch in school, but the specialized elective course deepened their understanding and creative application of programming concepts. Students' self-assessed proficiency increased from an average of 6.3 to 8.6 points out of 10, with project evaluations averaging 5.1 out of 6 possible points. Student feedback highlighted the course's effectiveness, with one participant commenting, "Interesting tasks, clearly described. Could use separate lessons on algorithms and events", while another praised the extensive effort visible in the course design.

Throughout the session, several unifying themes emerged that characterize the current state and future directions of computer science education. First, the integration of artificial intelligence is no longer optional but essential, both as a subject of study and as a pedagogical tool. Second, the development of soft skills alongside technical competencies has become a central concern, reflecting industry demands for well-rounded professionals. Third, game development and visual programming environments like Scratch and PyGame serve as powerful motivational tools that make abstract concepts tangible and engaging. Fourth, collaborative learning frameworks are essential for developing both technical and interpersonal skills, though they require careful adaptation for online and hybrid environments.

The session also highlighted specific challenges facing computer science education, particularly in the Ukrainian context. These include resource limitations in schools, the need to update curricula to remove outdated or inappropriate content, and the challenge of supporting educators with varying levels of experience with new technologies. However, the research presented also demonstrated remarkable resilience and innovation, with educators developing creative solutions such as free online workshops, adaptive learning platforms, and project-based curricula that engage students despite challenging circumstances.

The discussion periods revealed rich exchanges between participants about practical implementation strategies. Questions about adapting methodologies for different cultural settings and resource constraints led to thoughtful discussions about the universality of certain pedagogical approaches versus the need for localization. As noted by session moderator Serhiy Semerikov in closing remarks, while the conference would continue with an Educational Technology session the following day, the Computer Science Education presentations had already provided valuable insights that would influence future research and practice.

The Computer Science Education section thus demonstrated the field's dynamic evolution in response to technological advancement and changing educational needs. From AI integration to game-based learning, from mathematical foundations to soft skills development, the research presented offers a comprehensive view of how computer science education is adapting to prepare students for an increasingly complex and interconnected digital world. The session's conclusion with warm exchanges between participants, expressing gratitude for the opportunity to share ideas despite challenging circumstances, underscored the importance of international collaboration in advancing computer science education for all learners.

#### *4.7. Educational Technology*

The Educational Technology section of ICon-MaSTEd 2025, held on May 17 as the conference's final session, featured six innovative papers that explored the transformative potential of digital technologies in education. This session brought together researchers from across Ukraine and international collaborators to address critical challenges in educational technology implementation, from intelligent systems in engineering education to augmented reality applications in laboratory work. The presentations demonstrated remarkable resilience and innovation in educational technology development despite the ongoing challenges faced by

Ukrainian educators.

The session opened with Batsurovska et al. [230] presenting “Implementation of digital technologies and intelligent systems in teaching general technical disciplines”. The authors addressed the critical need for modernizing engineering education through digital transformation, emphasizing the integration of artificial intelligence, industry collaboration, virtual laboratories, personalized learning pathways, and automation. Their experimental study involved 100 students in a control group and 101 in an experimental group participating in dual education that combines theoretical instruction with practical workplace training. The experimental group utilized digital technologies and intelligent systems during their university studies and applied these skills in workplace environments, while the control group used traditional and online forms of education. The results demonstrated significant improvements in professional competency formation among students using the integrated digital approach. During the discussion, questions arose about modifying online learning approaches for students with limited technology access, particularly in Ukrainian regions affected by conflict. The presenters emphasized the importance of developing both online and offline variants of educational materials to ensure accessibility regardless of internet connectivity.

Akhiiezer et al. [231] contributed a sophisticated technical solution with their paper on “A curriculum recommendation system using a vector database for challenge-based learning”. This innovative system employs mixed integer programming algorithms to optimize personalized curriculum recommendations based on multiple constraints, including logical sequencing and credit accumulation requirements. The authors developed a k-nearest neighbors clustering method for assessing student grades and generating performance vectors for uncompleted tasks, essential for personalizing learning recommendations. The architecture leverages vector databases to efficiently match students with appropriate challenges based on their competencies and learning objectives. The system’s ability to adapt to individual student needs while maintaining curricular integrity represents a significant advancement in personalized learning technology, particularly relevant for challenge-based learning approaches that prepare students for real-world problem-solving.

Kovtoniuk et al. [232] presented an imaginative approach to mathematics education with their “Virtual educational mathematics park as a platform for educational and research activities at the university”. This innovative project combines physical and virtual spaces to create an immersive mathematical learning environment. The authors developed 3D models of mathematical objects, including Platonic solids and other geometric structures, integrated with QR codes for augmented reality experiences. The virtual park concept extends beyond simple visualization, incorporating virtual laboratories where students can explore mathematical concepts through interactive 3D models that can be rotated, scaled, and manipulated. The project also included a proposal for a physical landscape mathematics park in Vinnytsia, demonstrating the potential for bridging digital and physical educational spaces. The authors emphasized how this approach harmoniously combines past mathematical achievements with modern digital technologies, creating platforms that serve both educational and research purposes while increasing the attractiveness of educational institutions for academic tourism.

Addressing the critical issue of pandemic and war-related educational disruption, Pronina et al. [233] presented “The use of cluster analysis in measuring educational losses”. Their research developed comprehensive software using Python’s Anaconda environment to identify and quantify learning losses among students affected by COVID-19 and ongoing military conflict. The software implements k-means and hierarchical clustering algorithms to group students with similar educational deficits, enabling teachers to develop targeted intervention strategies. Working with data from 103 students in grades 5-6 from Nikolsk Secondary School, the researchers analyzed performance in mathematics, Ukrainian language (writing), and Ukrainian literature (reading) as core indicators of educational achievement. The clustering results revealed

three distinct groups: students with consistently high scores, those with moderate achievement and significant variability, and students showing substantial learning losses requiring immediate intervention. As the presenter noted, “The teacher can predict the overall grade for the subject and timely inform parents about possible deterioration”, highlighting the tool’s predictive capabilities for early intervention.

Manziuk et al. [234] tackled the serious issue of cyberbullying with their paper on “Multifactorial analysis of mobbing behavioral signs in educational environments posts by NLP means”. The researchers developed a sophisticated natural language processing system to detect and analyze mobbing patterns in educational social media posts. Using machine learning algorithms, the system processes text from educational chat rooms and social platforms to identify potential bullying behaviors based on linguistic patterns, sentiment analysis, and contextual indicators. The experimental implementation involved real chat data, as confirmed during the Q&A when asked about practical deployment: “Yes, we take this text from text walking chats. And this is a real experiment”. The system’s ability to detect negative communication patterns in real-time offers educational institutions a powerful tool for early intervention in cyberbullying situations, contributing to safer online learning environments.

The session concluded with Kanivets et al. [235] presenting “Virtual laboratory work with augmented reality elements to teach metal hardness measurement”. This practical application addressed the challenge of conducting laboratory work during air raids when students must relocate to shelters lacking laboratory equipment. The team developed a mobile application featuring AR visualization of hardness testing equipment, including detailed 3D models of the HS-2M hardness tester created in CAD systems. The application combines theoretical content with practical simulators, allowing students to virtually operate equipment, select testing parameters, measure indenter impressions, and calculate hardness values using integrated tables. Statistical validation using Pearson’s criterion showed that experimental group students achieved quality success rates exceeding control groups by 14%, confirming the effectiveness of AR-enhanced laboratory instruction. As the presenters explained, “AR technology plays a critical role in creating interactive hybrid learning environment and developing digital skills”, particularly crucial when physical laboratory access is restricted.

Throughout the session, several unifying themes emerged that characterize the current state of educational technology in challenging circumstances. First, the necessity of developing resilient educational solutions that function despite infrastructure limitations, including intermittent internet access and displacement from traditional learning spaces. Second, the critical role of data analytics and artificial intelligence in personalizing education and identifying at-risk students. Third, the importance of immersive technologies like AR and VR in maintaining practical skill development when physical resources are unavailable. Fourth, the integration of assessment and intervention tools that enable rapid response to learning deficits.

The discussion periods revealed practical concerns about implementation, with particular attention to questions of accessibility and scalability. When asked about adapting technologies for regions with limited resources, presenters consistently emphasized the importance of developing multiple delivery modes and offline capabilities. The session also highlighted the collaborative nature of educational technology development, with several presentations featuring interdisciplinary teams combining expertise in education, computer science, and domain-specific knowledge.

As the conference’s closing session, the Educational Technology presentations demonstrated both the challenges and opportunities facing education in the digital age. The research presented offers practical solutions to immediate problems while advancing theoretical understanding of technology-enhanced learning. The session concluded with warm exchanges between participants, with acknowledgments of the importance of continuing such collaborations despite difficult circumstances. As noted in the closing remarks, these technologies are not merely temporary



solutions to crisis situations but represent fundamental advances in educational methodology that will continue to benefit learners long after current challenges have passed. The Educational Technology section thus provided both inspiration and practical tools for educators navigating the complex landscape of 21st-century education, demonstrating that innovation can flourish even in the most challenging circumstances.

## 5. Conclusion

The XVII International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2025) has demonstrated that educational innovation not only persists but flourishes even in the face of extraordinary challenges. The conference proceedings, encompassing 31 rigorously selected papers across multiple educational domains, provide compelling evidence that the global educational community remains committed to advancing pedagogical excellence and ensuring equitable access to quality education regardless of circumstances. The hybrid format of the conference itself exemplified this commitment, enabling meaningful international collaboration despite physical barriers and safety concerns.

A profound transformation in educational technology integration emerged as the dominant theme across all conference sessions. The widespread adoption of artificial intelligence, augmented reality, and sophisticated digital ecosystems represents more than a temporary response to crisis conditions; it signals a fundamental reimagining of educational delivery and assessment. Papers discussing AI applications in mental health education, chatbot-mediated language learning, and vector database-driven curriculum recommendation systems demonstrate that these technologies are moving from experimental periphery to pedagogical mainstream. Particularly noteworthy is the emphasis on developing both online and offline variants of educational materials, ensuring that technological innovations remain accessible even in regions with intermittent internet connectivity or damaged infrastructure.

The conference revealed a remarkable evolution in conceptualizing 21st-century competencies, with presenters consistently emphasizing the integration of technical skills with critical thinking, visual reasoning, and adaptive problem-solving abilities. The Mathematics Education section highlighted how gamification and real-world applications can transform abstract concepts into engaging learning experiences, while the Computer Science Education presentations demonstrated the importance of developing computational thinking from early childhood. These approaches reflect a growing recognition that future-ready education must balance domain-specific knowledge with transferable cognitive and metacognitive skills. The emphasis on project-based learning, evident in multiple presentations, suggests a pedagogical shift toward more authentic, context-rich learning experiences that better prepare students for complex real-world challenges.

The resilience and innovation demonstrated by Ukrainian educators and researchers deserves special recognition. Far from being passive victims of circumstance, they have emerged as pioneers in crisis-responsive education, developing solutions that have global applicability. The development of mobile AR applications for laboratory work that can function in bomb shelters, the creation of adaptive learning systems that respond to interrupted study patterns, and the implementation of peer support networks for mental health represent innovations born of necessity but refined through rigorous research and evaluation. These contributions underscore an important principle: constraints often catalyze creativity, and the solutions developed under pressure frequently surpass those emerging from more comfortable circumstances.

The interdisciplinary nature of the conference discussions points toward a future where traditional academic boundaries become increasingly permeable. The integration of mathematics with engineering applications, the fusion of computer science with humanities education, and the application of physics concepts to environmental studies all suggest that effective education for the coming decades will require more fluid, interconnected approaches to knowledge construction.

This interdisciplinarity extends to the composition of research teams themselves, with successful projects increasingly featuring collaborations between educators, technologists, psychologists, and domain experts. Such collaborations are essential for developing holistic solutions that address not only cognitive learning objectives but also emotional, social, and practical dimensions of education.

Looking forward, the conference proceedings suggest several critical areas requiring continued attention and research. The ethical implications of AI in education, particularly concerning data privacy, algorithmic bias, and the digital divide, demand ongoing scrutiny and proactive policy development. The challenge of teacher professional development in rapidly evolving technological landscapes remains acute, with multiple presenters noting the gap between technological possibilities and pedagogical implementation. Additionally, the need for robust assessment frameworks that can evaluate both traditional academic achievements and emerging digital competencies represents an urgent research priority.

The warm exchanges and expressions of gratitude that concluded many conference sessions remind us that education remains fundamentally a human endeavor, grounded in relationships, empathy, and shared purpose. Technology serves as an amplifier and enabler, but the core mission of education – to develop human potential and foster understanding – remains unchanged. As one presenter noted in the closing session, these gatherings are essential not merely for sharing research findings but for maintaining the international solidarity that sustains educational progress even in the darkest times.

ICon-MaSTEd 2025 has provided both a snapshot of current educational innovation and a roadmap for future development. The conference demonstrates that crisis can accelerate positive change, that international collaboration transcends political boundaries, and that the educational community's commitment to serving learners remains unshakeable. As we move forward, the insights, methodologies, and technologies presented at this conference will undoubtedly influence educational practice globally, contributing to more resilient, inclusive, and effective educational systems. The journey toward educational excellence continues, informed by the remarkable contributions of all conference participants and sustained by their collective dedication to advancing human knowledge and capability.

We hope all participants enjoy this conference and meet again in a more friendly, hilarious, and peaceful way, ICon-MaSTEd 2026. The next meeting in the series is the XVIII International Conference on Mathematics, Science and Technology Education, 2026, Kryvyi Rih, Ukraine (<https://icon-masted.easyscience.education/2026/>).

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