Learning under pressure: game-based, AI-driven, and crisis-responsive pedagogies in focus of the 12th Workshop on Cloud Technologies in Education

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Abstract

The 12th Workshop on Cloud Technologies in Education (CTE 2024), co-located with the 6th International Conference on History, Theory and Methodology of Learning (ICHTML 2025), convened on May 12, 2025, in Kryvyi Rih, Ukraine, and showcased 17 peer-reviewed contributions addressing urgent challenges and innovations in digital education. This review synthesizes the proceedings into five thematic clusters: (1) technology-enhanced pedagogical frameworks, (2) interactive and game-based learning, (3) artificial intelligence and automated tools, (4) crisis-driven adaptation and resilience, and (5) systemic issues of curriculum, assessment, and digital leadership. Findings across these clusters demonstrate measurable gains in student engagement, motivation, and digital competencies, with effect sizes ranging from 0.42 to 0.61. At the same time, the contributions reveal critical challenges including post-training sustainability, infrastructural inequities, and the risks of overreliance on AI. Crisis contexts – pandemic-related remote teaching and wartime disruptions – emerged as powerful accelerators of digital adoption but also highlighted systemic vulnerabilities. Collectively, the proceedings underscore the necessity of aligning technological innovation with pedagogical purpose and institutional capacity. This synthesis positions the CTE 2024 contributions within global debates on the future of digital transformation in education, offering a roadmap for evidence-based, context-sensitive, and human-centered integration of technology into teaching and learning.

Keywords

cloud technologies in education, digital transformation, educational technology, game-based learning, artificial intelligence in education, crisis pedagogy, curriculum innovation, teacher professional development, workshop proceedings

1. Introduction

1.1. CTE 2024 at a glance

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

CTE 2024: 12th Workshop on Cloud Technologies in Education,
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The workshop considers contributions in all aspects of educational technologies and cloud-based learning tools, platforms, paradigms and models, functioning programmes, or papers relevant to modern engineering and technological decisions in the IT age.

CTE topics of interest since 2012 [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]:

Figure 1: CTE 2024 logo.

1. **Cloud-Powered Learning Platforms & Infrastructure**
   - Next-Generation Adaptive Cloud Learning Platforms
   - Scalable and Secure Cloud-Based E-Learning Environments
   - Edge Computing for Faster and Smarter Educational Applications
   - AI-Driven Personalization in Cloud Learning
2. **Emerging Technologies in Cloud Education**
   - Blockchain for Secure and Transparent Digital Credentials
   - AI and Machine Learning for Intelligent Cloud Education Systems
   - Emotion AI and Sentiment Analysis in E-Learning
   - Immersive Technologies (VR/AR) for Cloud-Based Interactive Education
3. **Data-Driven Educational Insights**
   - Educational Data Mining & Learning Analytics in the Cloud
   - Social Learning Analytics: Tracking Engagement and Performance
   - Privacy, Ethics, and Cybersecurity in Cloud-Based Learning
   - Federated Learning and Distributed AI in Education
4. **Digital Transformation of Education**
   - Competency-Based & Outcome-Driven Cloud Learning Models
   - Smart Campus Technologies and IoT in Cloud Education
   - Mobile and Microlearning in Cloud Ecosystems
   - Gamification and Adaptive Learning in the Cloud
5. **Collaboration, Accessibility & Inclusion**
   - Cloud-Powered Remote Learning & Virtual Classrooms
   - Cloud-Based Assistive Technologies for Inclusive Education
   - Open Educational Resources (OER) and Cloud-Based Content Delivery
   - Hybrid & Blended Learning Models Using Cloud Infrastructure

This volume represents the proceedings of the 12th Workshop on Cloud Technologies in Education (CTE 2024), held in Kryvyi Rih, Ukraine, on May 12, 2025 (postponed due to the war in Ukraine). It comprises 17 contributed papers that were carefully peer-reviewed and selected from 28 submissions. Two program committee members reviewed each submission. The accepted papers present a state-of-the-art overview of successful cases and provide guidelines for future research.

1.2. CTE 2023 committees

Program committee

- *Marc Baaden*, CNRS Centre National de la Recherche Scientifique, France [13]
- *Nadire Cavus*, Near East University, North Cyprus [14]
- *Irina Alexandra Georgescu*, Bucharest University of Economic Studies, Romania [15]
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1.3. Research questions

Digital transformation in education has evolved from incremental innovation to systemic paradigm shift, catalyzed by global crises including the *COVID-19 pandemic* [43, 44, 45] and the *Ukrainian conflict* [46, 47, 48, 49]. These events compressed decades of anticipated change into months, generating a rich corpus of empirical research on technology integration under pressure.

This review synthesizes 17 studies from the *12th Workshop on Cloud Technologies in Education (CTE 2024)* and related venues, selected for their methodological rigor, empirical depth, and relevance to contemporary digital education challenges. The corpus represents diverse contexts – Ukraine, Turkey, Israel, Poland – and spans multiple educational levels and domains.

We address three central research questions:

RQ1: What are the dominant thematic clusters and methodological trends in current digital education research?

RQ2: How do digital tools affect learning outcomes, engagement, and psychological needs?

RQ3: What gaps and future directions emerge from the synthesis?

By integrating findings across disparate studies, this review provides a *meta-perspective* on digital transformation, identifying patterns, contradictions, and actionable insights.

2. Methodology of the synthesis

All 17 studies (table 1) were included in the thematic analysis; 12 were empirical (quasi-experimental, survey, or mixed-methods), 5 were development or theoretical.

We employed a thematic synthesis approach combining:

1. Content coding identified key technologies, pedagogies, outcomes
2. Methodological assessment evaluated design quality and limitations
3. Cross-study comparison mapped findings across contexts and tools
4. Gap analysis identified understudied areas and methodological weaknesses

3. Thematic analysis

3.1. Theme 1: Technology-enhanced pedagogical frameworks

Four studies (Tkachuk et al. [50], Lavrentieva et al. [52], Overko and Oleksiuk [53], Skvortsova et al. [55]) demonstrate the evolution of *integrated, scaffolded pedagogies* enabled by digital tools.

Tkachuk et al. [50] report a **17.65% improvement** in academic performance using MCU 8051 IDE, STC-ISP, and PROTEUS DESIGN, with gains in:

- Problem-solving: +22.54%

Table 1
Overview of 17 reviewed studies,

Study	Focus	Method	Sample	Key findings
Tkachuk et al. [50]	Microcontroller education	Quasi-experimental	68 students	17.65% performance gain
Lytvynova and Rashevska [51]	Mobile learning adoption	Survey	500 students	Google Classroom dominant (21.41%)
Lavrentieva et al. [52]	ICT competencies	Theoretical	N/A	Multi-component framework
Overko and Oleksiuk [53]	Video creation	Development	15 students	Enhanced creativity + skills
Voievoda et al. [54]	Math game interest	Comparative	Teachers	Cross-cultural differences
Skvortsova et al. [55]	Pre-service ICT	Experimental	Teachers	Competence gains, sustainability issues
Pozniakov and Merzlykin [56]	Python via games	Development	Junior students	Improved logic + motivation
Shakotko et al. [57]	Terminology gaps	Content analysis	4 textbooks	Significant curriculum gaps
Midak et al. [58]	Chemistry Wordwall	Development	8th grade	High interactivity, engagement
Mintii et al. [59]	Cross-lingual terms	Content analysis	2 dictionaries	Cultural variation in CS terms
Vakaliuk et al. [60]	COVID-19 training	Mixed-methods	1,500 teachers	54.4% completion rate
Hrytsenchuk et al. [61]	Digital leadership	Theoretical	N/A	5D model proposed
Ivaniuk and Pinchuk [62]	Parent engagement	Survey	Parents	Increased involvement, skill gaps
Küçükali [63]	Game platforms	Mixed-methods	45 students	Kahoot: motivation; Bamboozle: stress relief
Lukianova and Symela [64]	AI philosophy	Philosophical	N/A	Critical technological wisdom
Khrystych et al. [65]	Grammarly use	Case study	50 students	Efficiency vs. dependency
Korniienko [66]	Digital history	Systematic review	6 studies	Engagement $\neq$ knowledge transfer

- Technical proficiency: +25.00%
- Industry readiness: +27.69%

This reflects a shift from isolated lab work to *simulation-to-hardware progression*, aligning with engineering education best practices [67, 68].

Skvortsova et al. [55] developed an ICT competency module for pre-service teachers, achieving significant gains in digital skills but revealing **sustainability concerns** – only 38% of participants maintained tool use post-training. This highlights the need for *ongoing support systems*.

Overko and Oleksiuk [53] designed a nine-session video creation course, enhancing both technical skills and creative expression through project-based learning. This aligns with *constructionist pedagogy* [69], where creation drives learning.

3.2. Theme 2: Interactive and game-based learning

Four studies (Voievoda et al. [54], Pozniakov and Merzlykin [56], Midak et al. [58], Küçükali [63]) explore gamification and interactivity.

Küçükali [63] conducted a mixed-methods study comparing **Kahoot**, **Jeopardy**, and **Bamboozle** through *Self-Determination Theory (SDT)* [70]. Results show:

- **Kahoot**: 91% reported increased motivation (autonomy + competence)

- **Jeopardy**: 82% found it effective for review (structure + clarity)
- **Bamboozle**: 84% reported stress reduction (relatedness + emotional regulation)

Structural equation modeling confirmed that platform choice mediates learning outcomes ($\beta = 0.42$, $p < .001$), supporting SDT predictions.

Midak et al. [58] used Wordwall to create 8 interactive chemistry exercises, reporting **high engagement and usability**. The platform's flexibility allowed adaptation to diverse learning styles and paces.

Pozniakov and Merzlykin [56] leveraged game development in Python to teach programming to junior students, combining motivation and skill development – a *dual-purpose pedagogy*.

3.3. Theme 3: AI integration and critical perspectives

Two studies (Lukianova and Symela [64], Khrystych et al. [65]) examine AI's dual role: *assistant vs. dependency risk*.

Khrystych et al. [65] studied Grammarly use among pre-service teachers. While students appreciated time savings and vocabulary suggestions, they struggled with **developing independent writing strategies**. The authors warn against *AI overreliance*, advocating for *teacher-AI co-feedback* models [71, 72].

Lukianova and Symela [64] offers a **philosophical critique**, advocating for *critical technological wisdom* – balancing AI's efficiency with preservation of human judgment, creativity, and ethical reasoning. This echoes broader calls for *human-centered AI* in education [73].

3.4. Theme 4: Crisis response and educational resilience

Two studies (Vakaliuk et al. [60], Ivaniuk and Pinchuk [62]) document *emergency-driven innovation*.

Vakaliuk et al. [60] reports a **three-wave digital training program** during the pandemic, achieving an **816 completions (54.4% completion rate)** among 1,500 teachers. Despite 5-day cycles, participants demonstrated rapid skill acquisition, suggesting that *necessity drives adoption* more than perceived ease of use [74].

Ivaniuk and Pinchuk [62] examines Ukrainian parents' digital engagement during wartime. While involvement increased, **technical and pedagogical gaps** emerged, with 67% reporting difficulty supporting children's digital learning. This reveals a critical need for *parental digital literacy programs* in crisis contexts.

3.5. Theme 5: Curriculum, assessment, and leadership

Five studies (Lytvynova and Rashevska [51], Shakotko et al. [57], Mintii et al. [59], Hrytsenchuk et al. [61], Korniienko [66]) address systemic dimensions.

Hrytsenchuk et al. [61] propose a **5D digital leadership model**: digital competence, digital culture, differentiation, digital management, and advocacy. This framework supports *distributed leadership*, where digital skills are cultivated across organizational roles.

Mintii et al. [59] use computational linguistics to analyze computer science terminology in textbooks, revealing **significant gaps** between curriculum expectations and content – highlighting the need for *terminological standardization*.

Korniienko [66] conducts a PRISMA-compliant review of digital history pedagogy, finding consistent engagement gains but limited knowledge transfer, suggesting *engagement* $\neq$ *learning*.

4. Methodological overview and quality assessment

The reviewed corpus comprises seventeen studies employing diverse research designs (table 2). Tkachuk et al. [50] conducted a quasi-experimental study with 68 participants over one semester, applying

quantitative analysis to establish causal relationships. Lytvynova and Rashevska [51] surveyed 500 participants in a cross-sectional design using descriptive statistics. Several studies adopted theoretical approaches without empirical data collection, including Lavrentieva et al.'s [52] conceptual framework development and Hrytsenchuk et al.'s [61] leadership model construction.

Table 2
Methodological characteristics of reviewed studies.

Paper	Design	Sample	Duration	Analysis	Strength
Tkachuk et al. [50]	Quasi-experimental	68	1 semester	Quantitative	Causal inference
Lytvynova and Rashevska [51]	Survey	500	Cross-sectional	Descriptive	Large sample
Lavrentieva et al. [52]	Theoretical	N/A	N/A	Conceptual	Framework
Overko and Oleksiuk [53]	Development	15	9 sessions	Mixed	Practical innovation
Voievoda et al. [54]	Comparative	N/A	Ongoing	Qualitative	Cross-cultural
Skvortsova et al. [55]	Experimental	N/A	1 module	Quantitative	Pre-service focus
Pozniakov and Merzlykin [56]	Development	Junior	1 course	Descriptive	Pedagogical model
Shakotko et al. [57]	Content analysis	4 texts	N/A	Computational	Novel method
Midak et al. [58]	Development	8th grade	Trial	Descriptive	Subject-specific
Mintii et al. [59]	Content analysis	2 texts	N/A	Computational	Cross-lingual
Vakaliuk et al. [60]	Mixed-methods	1,500	5 days	Mixed	Crisis context
Hrytsenchuk et al. [61]	Theoretical	N/A	N/A	Conceptual	Leadership model
Ivaniuk and Pinchuk [62]	Survey	Parents	Wartime	Mixed	Parental role
Küçükali [63]	Mixed-methods	45	1 semester	Mixed	SDT validation
Lukianova and Symela [64]	Philosophical	N/A	N/A	Theoretical	Critical perspective
Khrystych et al. [65]	Case study	50	6 months	Qualitative	AI dependency
Korniienko [66]	Systematic review	6 studies	2013–2025	Meta-analysis	Synthesis

Mixed-methods research appeared in multiple studies. Overko and Oleksiuk [53] developed a video creation course tested with 15 participants across nine sessions. Vakaliuk et al. [60] examined crisis-driven digital adoption with 1,500 participants over five days. Küçükali [63] combined survey and interview data from 45 students to validate self-determination theory applications.

The corpus demonstrates methodological diversity alongside several constraints. Most studies limited data collection to single semesters or shorter periods. Only two investigations extended beyond six months. Geographic representation skewed heavily toward Ukrainian contexts, with eleven of seventeen studies originating there. Outcome metrics varied significantly across studies, complicating cross-study comparisons.

5. Empirical findings and theoretical developments

Digital platform engagement increased in all studies measuring this variable, with effect sizes ranging from 0.42 for game-based platforms to 0.61 for microcontroller laboratories. Teacher training programs achieved rapid initial competency gains, though sustained support proved necessary for long-term implementation.

Three theoretical frameworks emerged from the research. Küçükali [63] demonstrated how self-determination theory explains differential platform effects based on psychological need satisfaction. Hrytsenchuk et al. [61] developed a five-dimensional leadership model integrating organizational change processes with digital transformation. Lukianova and Symela [64] proposed a critical technological wisdom framework balancing innovation with ethical considerations.

Practical innovations included eight interactive chemistry templates developed by Midak et al. [58], a nine-session video creation curriculum from Overko and Oleksiuk [53], and Vakaliuk et al.'s [60] five-day intensive teacher training protocol designed for emergency contexts.

6. Persistent challenges and research gaps

The relationship between engagement and learning remains complex. High platform engagement did not consistently translate to improved knowledge acquisition or skill development. Different digital tools served distinct psychological and pedagogical functions, requiring careful matching to learning objectives. Crisis contexts accelerated adoption rates while simultaneously revealing infrastructure limitations and competency gaps.

Several populations remain underrepresented in current research. Students with learning disabilities appeared in only one study. Rural learners, adult education participants, and indigenous communities received no dedicated investigation. Geographic bias toward Eastern European contexts limits generalizability to other regions, particularly Global South settings.

Methodological improvements could strengthen future research. Longitudinal designs tracking skill retention over two or more years would clarify durability of interventions. Randomized controlled trials comparing multiple platforms could establish relative effectiveness. Mixed-methods approaches combining quantitative outcomes with ethnographic observation would capture implementation nuances often missed by survey research alone.

Emerging technologies present new research opportunities. Adaptive tutoring systems using artificial intelligence require evaluation for personalization effectiveness and ethical implications. Virtual and augmented reality applications in science and history education need assessment of learning transfer and cost-effectiveness. Blockchain credentialing systems raise questions about portfolio portability and employer acceptance. Affective computing applications demand scrutiny regarding privacy, consent, and emotional manipulation risks.

The evidence base would benefit from replication studies across diverse contexts, standardized outcome measures enabling meta-analysis, and attention to unintended consequences such as the dependency effects observed by Khrystych et al. [65] regarding automated writing assistance tools.

7. Conclusion

Digital transformation in education is neither uniform nor inevitable – it is a **complex, context-sensitive process** shaped by pedagogy, culture, infrastructure, and crisis. This synthesis of 17 studies reveals that while digital tools consistently enhance engagement and enable new pedagogies, their *educational value depends on thoughtful integration.*

Key takeaways:

- **Effectiveness is conditional**: Tools must align with learning objectives and psychological needs.
- **Crisis drives innovation**: Emergency contexts can catalyze rapid but sustainable change.
- **AI requires balance**: Efficiency gains must not come at the cost of autonomy.
- **Systemic change is essential**: Leadership, curriculum, and assessment must co-evolve.

As Lukianova and Symela [64] remind us: *"The question is not whether AI will transform education – that transformation is already underway – but how we can guide it to serve humanity's highest aspirations."* This review provides a roadmap for that guidance: evidence-based, context-aware, and human-centered.

Declaration on Generative AI

This work was completed with assistance from generative LLMs: claude-opus-4-1-20250805, grok-4-0709, and gpt-oss-120b. These models were used for initial brainstorming, structural organization, and editing support. All substantive content, analysis, and conclusions represent the author's original thinking and have been thoroughly reviewed and verified for accuracy. Grammarly served primarily as a writing assistant to improve clarity and flow rather than as a source of ideas or research findings.

Specific uses included:

- Grammatical and stylistic refinement
- Reorganization of existing content for improved coherence
- Generation of alternative phrasings for complex concepts
- Identification of potential gaps in argumentation

The author maintains full responsibility for all content, including any errors or misrepresentations.

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