From Vision to Reality: A New Paradigm for Cyber-Physical-Social Education

WITH great enthusiasm, we present the 2023 issue of the Journal of Cyber-Physical-Social Intelligence (CPSI). This issue features four carefully selected regular articles, each offering valuable insights into the evolving landscape of cyber-physical-social systems. In addition, we are proud to showcase an editorial titled "From Vision to Reality: A New Paradigm for Cyber-Physical-Social Education", which marks a significant milestone in advancing the field of cyber-physical-social education.

I. SCANNING THE ISSUE

TRUE Autonomous Organizations and Operations for Web3 *by JUANJUAN LI, XIAOLONG LIANG, RUI QIN, AND FEI-YUE WANG*

The first article proposes TRUE Autonomous Organizations and Operations (TAOs), which underscores the trustable, reliable, usable, efficient and effective essence of decentralization. It highlights the research issues that need to be addressed to realize the full potential of TAOs.

Reinforcement Learning for Optimizing Delivery Paths in Hospital Settings: A Review *by AAILA ARIF AND JIACUN WANG*

The second paper presents a comprehensive review of reinforcement learning applications in the healthcare industry. It focuses particularly on recent publications that address the optimization of pickup and delivery processes for essential supplies and medications with mobile robots. Additionally, the article also investigates the gap between research results and real-world applications and points out directions for future work.

Simulation and calculation of wide frequency harmonic temperature rise based on dry type hollow reactor *by WANWEI WANG, RAN ZHUO, RONGFU ZHONG, ZHIMING HUANG, CHENGZHOU ZHANG, YAN LUO, JIEMING HUANG, MENG GAO, QIULIN CHEN, AND YUN ZHANG*

The third paper addresses the growing challenge of harmonic pollution in power grids due to the increasing use of non-linear equipment and the expansion of grid size. In particular, the paper presents a two-dimensional axisymmetric model considering the line-turn magnetic induction by means of the finite element simulation software COMSOL.

Optimization of stray capacitance based on CVT harmonic voltage measurement *by RAN ZHUO, WANWEI WANG, YAN LUO, RONGFU ZHONG, ZHIMING HUANG, AND QIYE DU*

The last paper aims to solve the problem of CVT measurement error in harmonic environments. By proposing an optimization method based on equivalent circuit model, the key stray capacitance parameters are accurately identified and corrected, and its measurement accuracy is improved.

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II. FROM VISION TO REALITY: A NEW PARADIGM FOR CYBER-PHYSICAL-SOCIAL EDUCATION

In 2019, we envisioned a future where education would be transformed through the integration of cyber, physical, and social systems. This vision—coined as Cyber-Physical-Social Education (CPSE)—called for personalized, data-driven, and socially grounded learning environments [1]. Today, we extend this vision to a synergetic framework that unites three key directions: (1) digitizing learning through Cyber-Physical-Social (CPSS) Infrastructure, (2) augmenting learning experiences with AI-powered pedagogical agents, and (3) enabling comprehensive assessment. Together, these elements chart our journey from conceptualization to implementation.

A. DIGITIZING LEARNING VIA CYBER-PHYSICAL-SOCIAL INFRASTRUCTURE

Traditional one-size-fits-all instruction is no longer sufficient for today's diverse and dynamic student populations. Learners vary widely in their prior knowledge, learning style, and support needs. In response to this diversity, personalized learning has emerged as a key educational objective—tailoring learning experiences to each student's unique trajectory [2]. However, achieving this requires continuous, real-time insight into individual learning behaviors, something that conventional classroom tools simply cannot provide.

In traditional classrooms, educators primarily rely on episodic assessments, such as tests, assignments, and subjective observations, to gain insight into the learning process itself. These methods often miss critical cognitive, emotional, and behavioral indicators. Capturing the full spectrum of student learning behavior—moment-to-moment engagement, frustration, strategy shifts, and misconceptions—is physically impossible for even the most attentive educators without technological support.

This is where the digital transformation of education becomes essential. With advances in extended reality, sensor networks, and educational software, learning activities can now be embedded in fully instrumented digital environments [3]. These environments, ranging from early intelligent tutoring systems (ITSs) [4] to gamified platforms [5], not only deliver instruction but also capture rich, high-frequency streams of learner data, including tool usage, decision patterns, exploration, and even emotional responses.

B. AUGMENTING LEARNING EXPERIENCES WITH AI-POWERED PEDAGOGICAL AGENTS

With learning now digitized through cyber-physical systems, we are no longer limited to post-hoc assessments or surface-level observations. Instead, we can continuously and comprehensively capture rich streams of learner behavior data—tracking how students interact with content, tools, and peers over time. This transformation not only enhances our ability to understand how learning unfolds but also opens powerful new avenues for using that data to support learning in real time.

One of the most promising directions is the development of AI-powered pedagogical agents that respond dynamically to student behavior. These agents can act as tutors, using signals from the learning environment—such as task performance, error patterns, and engagement levels—to adapt instruction, scaffold learning, and keep students within their zone of proximal development. This aligns with longstanding research in ITSs, which aims to deliver personalized instruction by mimicking the guidance of human experts. Traditional ITSs have delivered support through structured hints, step-by-step guidance, and predefined feedback mechanisms. However, recent advances in large language models (LLMs) have opened up a new direction-rather than merely offering corrections or suggestions, LLM-powered tutors can facilitate reflective dialogue, help students articulate their thought processes, and guide them through complex reasoning with a conversational tone that mimics peer or teacher interaction. This shift enables a more natural, context-aware tutoring experience, moving beyond rigid decision trees to dynamic, language-rich support.

Further, learning is not an isolated endeavor—it is inherently social [6]. Students learn not only through instruction but also through collaboration, dialogue, and shared problem-solving. When these students interact with peers on an equal level, even a simple encouragement or a fresh perspective can help them reconstruct their cognitive understanding, allowing them to grow intellectually beyond the current limit of their capabilities [7]. To support this essential dimension, we must go beyond expert-style tutors and develop learning companions—agents that act more like non-player characters (NPCs) in games. These peer-like agents employ evidence-based educational methodologies such as peer modeling [8], where students enhance their learning by observing others, and the protégé effect [9], which reinforces knowledge through teaching.

By combining the adaptive structure of tutor agents with the social fluency of peer agents, we can create a synergistic learning environment where students receive both targeted instruction and relational support. Drawing inspiration from gaming and narrative design, these agents are not merely reactive tools—they are proactive, context-aware companions capable of shaping the learning experience in meaningful ways.

C. ENABLING COMPREHENSIVE ASSESSMENT

With the digitization of learning and the deployment of AI-powered agents, vast amounts of behavior data are now continuously generated within digital learning environments. These include not just scores or task completions, but fine-grained indicators such as time-on-task, persistence through difficulty, help-seeking behavior, exploration patterns, emotional responses, and metacognitive signals. This wealth of data, when properly structured and analyzed, presents a powerful opportunity to rethink assessment.

Traditional assessment often provides snapshots of learning through discrete events—pre-tests, post-tests, and occasional formative checks. In contrast, data-rich digital environments enable continuous, embedded assessment, where student progress and challenges can be inferred in real time from interaction patterns. These assessments do not interrupt learning but are woven into the fabric of the learning experience.

Beyond guiding agent behavior, this data can also be used to generate comprehensive reports for educators, parents, and even students themselves. These reports offer insights into not just what students have learned, but how they are learning: Are they persisting through challenges? Do they exhibit signs of frustration or disengagement? Are they independently exploring new concepts? Such insights provide a holistic view of student growth, going beyond right-or-wrong answers to highlight effort, strategies, and affective engagement.

Moreover, by leveraging both domain-specific knowledge graphs and machine learning models, these systems can detect patterns over time, compare learners to meaningful benchmarks, and identify when intervention may be needed. Ultimately, this capability supports data-informed decision-making for teachers and allows for timely, personalized support rather than delayed remediation.

In short, CPSE not only make learning more personalized and socially grounded—they also redefine assessment as a dynamic, continuous, and learner-centered process, giving all stakeholders a clearer window into the learning journey.

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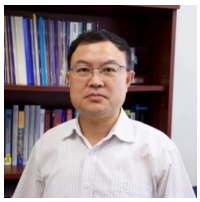

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