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Editorial: AI and robotics in reshaping the dynamics of learning

Introduction

As society progresses and technology develops, artificial intelligence (AI) and robots have received increasing attention. Innovations in AI and robot technology have allowed them to be integrated into daily life, and increasingly used in education demonstrating the potential impact (Johnson *et al.*, 2016). The *Horizon Report: 2016 Higher Education Edition* included robotics and AI technology as one of the six key technologies in education. In the 2020 version, the report proclaimed that "it can be seen that the integration of AI and robots with education is one of the most important contents of future education development" (New Media Consortium, 2020).

Globally, AI technology is developing rapidly, and new intelligent technologies have revolutionized educational potential (Hrastinski *et al.*, 2019). AI and robotics are slowly blending into education as an emerging technology. We envisioned this special section to map out the state-of-the-art in the area. The application of AI and robots for education has innovated teaching methods, enriched instructional tools, changed learning environments, redefined the roles of teachers and students and constructed a new type of educational ecology. For example, one study of the special section in library literacy activities demonstrates that the companionship of educational robots can provide students with the same cognitive understanding as can human company, can emotionally elicit more social interaction, and are popular with learners. The human–computer collaboration model, in which robots assist teachers to teach courses in the classroom or on online learning platforms, fully utilizes the advantages of teachers and AI, promotes the development of personalized education for learners (Haiguang, Shichong, Shushu, & Xianli, 2020). Studies have reported that chatbots for language learning can increase learners' motivation, learning interest and opportunities for improving their communicative competence (Kim, Cha, & Kim, 2019).

AI has considerably affected society and will influence education, such as from virtual and augmented reality, the Internet of Things, robots, virtual laboratories and blockchain technology (Hernandez-de-Menendez, Escobar Díaz, & Morales-Menendez, 2020). With technical support, students can use smart mobile devices for personalized learning and communication for active learning (Eggermont, Bloemendaal, & van Baalen, 2013). In such an environment, students can access a large amount of information at any time to become lifelong learners (Cloete, 2017). AI and robots provide various benefits for education, and they have the potential to enhance teaching and learning and possibly promote students' technology proficiency, cultivate their self-regulation for efficient learning, develop their critical thinking, foster innovation collaboration and interpersonal skills, and thus, help students better prepare for the future (Sharples *et al.*, 2016). As technology becomes fully integrated with teaching and learning, AI and educational robots will play key roles in technology-assisted instruction.

Special section

In this special section, we select five empirical studies to discuss how AI and robotics play a role in reshaping the dynamics of learning. The papers offer advice on applying AI and robotics in education and provide theoretical guidance and practical reference for researchers and educators.

In "*The Impact of AI and Robotics on Physical, Social-Emotional and Intellectual Learning Outcomes: An Integrated Analytical Framework,"* Sdenka Zobeida Salas-Pilco (in this issue) explores the use of AI and robotics in learning design from a learning sciences perspective. The research developed an integrated analytical framework, which reflected the influence of AI and robot technology

on the analysis of learning outcomes. The impact of AI and robots on students was varied, as reflected in their unique learning trajectories. The results indicated that the development of an integrated analytical framework enables a more comprehensive and balanced analysis of physical, social-emotional and intellectual learning outcomes, which can promote students' learning by using AI and robots.

In "*Refinement and Augmentation for Data in Micro Open Learning Activities with an Evolutionary Rule Generator"* by Geng Sun *et al* (in this issue). AI was leveraged to empower the adaptiveness of learning resource delivery in micro open learning scenarios. The study provides an evolutionary approach to extract meaningful association rules from a small amount of chaotic open data and apply them to refine and augment learners' behavioral data into a low-dimensional, descriptive and interpretable form.

In "*Humanoid Robots in Higher Education: Evaluating the Acceptance of 'Pepper' in the Context of an Academic Writing Course using UTAUT"* by Josef Guggemos, Sabine Seufert, and Stefan Sonderegger (in this issue), the acceptance of social robots by higher education students in social sciences was investigated. The unified theory of acceptance and use of technology was used as a conceptual framework. A questionnaire survey was conducted on 462 university freshmen in the "Introduction to Academic Writing" course. Through data analysis of partial least squares structural equation modeling, students' willingness to rely on social robots for learning is currently not strong, and behavioral willingness only reached 36.6% of the theoretical maximum.

In "*Fostering Students' Creativity via Educational Robotics: An Investigation of Teachers' Pedagogical Practices Based on Teacher Interviews"* by Yuqin Yang *et al* (in this issue)., how teachers implement educational robotics to cultivate the creativity of primary school students was explored, and the related challenges in the implementation of robotics were identified. The authors used grounded theory and semi-structured interviews to investigate 26 teachers from primary schools in Wuhan, China about the use of educational robot teaching for pedagogical practice development. The study identified a teaching framework for teachers to implement educational robot in the classroom to help students develop their creativity. The framework consists of four phases and eight sub-phases and proposes targeted teaching strategies to support students' learning outcomes.

In "*Reading with Robot and Human Companions in Library Literacy Activities: A Comparison Study"* by Hsiu-Ping Yueh *et al* (in this issue). 36 primary school students were selected as research participants to explore the perception and performance of children readers who used robot companions compared with human companions. The results indicated that the participants perceived the robot companion as more favorable and desirable to read with than a human co-reader. The children favored robotic verbalization over human verbalization. Cognitively, the two types of companions had the same facilitating effect on reading comprehension. Affectively, the robot co-reader induced more social interaction during the reading sessions.

Conclusions

AI has achieved good results in the education field, which include providing better learning experiences (Dede, Grotzer, Kamarainen, & Metcalf, 2017; Koć-Januchta, Schönborn, Tibell, Chaudhri, & Heller, 2020), reducing teachers' workload (Mavrikis, Geraniou, & Poulovassilis, 2019; Westera, Dascalu, Kurvers, Ruseti, & Trausan-Matu, 2018), and offering timely feedback (Banszki *et al*., 2018; Kao, Chiang, & Foulsham, 2019; Lee, Yu, Tang, Wong, & Poon, 2018). Further advances could be achieved by combining efficient educational approaches with AI technology to make learning more effective and tailored to the student. Robot education is more reflected in robot-assisted teaching and language learning and focuses on the interaction and attitude between teachers, students and robots to practice their learning ability and life skills.

Through educational robots, students can understand conceptual knowledge and improve robot technology. This content corresponds with the views of the five articles in the special section.

The potential of AI and robots in education are clearly demonstrated in the aforementioned five articles. When the influence of AI and robotics is reflected in the analysis of learning outcomes, the learning trajectory of students can be identified to analyze their results more comprehensively. Furthermore, implementing educational robotics among teachers cultivates the creativity of primary school students and promotes targeted teaching strategies to support students' learning outcomes. However, current research on using AI and robotics applications in education remains on the surface. Future research can continue to explore and predict the impact of robots on students and explore the role of robots in education in greater depth.

Hsiu-Ping Yueh
Department of Psychology, Department of Bio-Industry Communication and Development, National Taiwan University, Taipei, Taiwan
Center for Artificial Intelligence and Robot Research, National Taiwan University, Taipei, Taiwan

Feng-Kuang Chiang
Department of Educational Technology, College of Education, Shanghai Normal University, Shanghai, China.

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