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Editorial: Artificial intelligence for education

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Editorial on the Research Topic

When the Research Topic “*Artificial intelligence for education*” was launched in June 2021, the impact that advances in artificial intelligence would have on the education sector was not entirely predictable.

However, the long and close relationship between research in the two fields of AI and Education was common knowledge. Indeed, since understanding how people learn is closely related to the idea of intelligence, or given that knowledge representation has been one of the most prominent Research Topics in AI, a natural connection between the areas of knowledge concerning Artificial Intelligence and Education emerged even before the term “Artificial Intelligence” was coined ([Turing, 1950](#)).

Scholars in the field of artificial intelligence have always looked to the field of education as one of their favorite application areas. From the realization of the logic theorist ([Newell and Simon, 1956](#)) to the emergence in the 1990s of cognitive architectures ([Laird et al., 1987](#); [Newell, 1990](#)), many of the innovations in the field of AI have found a direct application in the field of education, in the realization of tools such as expert systems to support learning processes and intelligent tutor systems ([Anderson et al., 1985](#); [Bidarra et al., 2020](#)).

The new renaissance of AI, marked by recent innovations in the field of deep learning, has in recent years outlined a landscape in which a strong impact could also be expected in education. However, the disruption caused by the market introduction of ChatGPT in November 2022 coincided with the final part of the call for papers for this Research Topic. This timing has therefore cut off, from many of the studies presented in this Research Topic, all the latest research, especially that related to generative AI and large language models (LLM).

Nevertheless, the topic we have been supervising for the past 2 years has allowed us to closely monitor this rapid change, collecting contributions that have proposed and analyzed various topics related to AI in Education. Two recent contributions to the topic by [Mallik and Gangopadhyay](#) and [Gentile et al.](#) provide an overview of the trend.

[Mallik and Gangopadhyay](#) examine how AI, machine learning and deep learning methods are currently used to support the educational process. They conduct this examination by analyzing the involvement of AI-driven methods in the educational process considered as a whole. Based

on the analysis of a large set of papers, the authors outline the main trends of future research concerning the use of AI in Education with particular reference to some paradigmatic shifts in the approaches analyzed.

[Gentile et al.](#) analyze one of the most exciting topics about AI and Education: the impact of AI on teachers' roles through a systematic literature review. Teachers have always been called upon to change their practices by attempting to integrate new technologies rather than rejecting them. However, even at first glance, the potential changes introduced by AI signal a radical change, what can be called a genuine paradigm shift in teachers' role in Education. According to the authors, the literature analysis reveals that full awareness of the urgency with which the challenges imposed by AI in Education must be addressed has yet to be achieved. Moreover, the study proposes a manifesto to guide the evolution of teachers' roles according to the paradigm shift proposed by Kuhn in the scientific field.

To be managed adequately and avoid causing discomfort in education systems, the assumed changes in the teacher's role should be accompanied by appropriate professional development programmes. In this regard, [Sáiz-Manzanares et al.](#) address the topic of designing teacher training programmes that combine the use of technology and instructional design to promote the development of Self-Regulated Learning and automatic feedback systems. Through a study involving 23 secondary school teachers in a training programme delivered with Moodle, the authors investigated the differences in the behavior of experienced and inexperienced teachers, the consistency of the behavior patterns extracted during the study, with the respective type of teacher being modeled, and the teachers' level of satisfaction with the training activity on digital didactics.

The development of assessment tools is one of the preferred areas of application of AI in Education, and, in this respect, AI-based learning analytics will play a key role.

Student-generated texts represent an essential but often unexplored source of information for gaining deeper insights into learners' cognition and ensuring better compliance with students' real needs. To this regard, [Berding et al.](#) present a new approach based on applying item response theory concepts to content analysis for the analysis of the textual data generated by the student. They present the results of three studies conducted to make textual information usable in the context of learning analytics. By producing a new content analysis measure, simulating a content analysis process and analyzing the performance of different AI approaches for interpreting textual data, they show that AI can reliably interpret textual information for learning purposes and also provide recommendations for an optimal configuration of AI.

[Fleckenstein et al.](#) present a systematic review to explore the effectiveness of AI-based Automated writing evaluation (AWE) tools in realizing systems capable of assessing students' writing skills and providing them with timely feedback with a view to formative assessment. The results confirm a medium-size effect and highlight how it is necessary to continue the exploration by identifying groups of interventions that are more homogeneous among themselves, trying to identify those factors that distinguish these interventions.

[Cloude et al.](#) propose an analysis and interpretation framework of real-time multimodal data to support students' Self Regulated Learning (SRL) processes. Specifically, their paper thematises the issues researchers and instructors face when using the data collected through innovative technologies. By recalling a specific procedure through which a researcher/instructor can

standardize, process, analyze, recognize and conceptualize multimodal data, they discuss various implications for constructing valid and effective AI algorithms to foster students' SRL.

[Cheng et al.](#) address the topic of personalisation of learning using dynamic learning data to track the state of students' knowledge over time. Specifically, the authors propose a context-aware attentive knowledge query network model that can combine flexible neural network models with interpretable model components inspired by psychometric theory to analyze the exercise data.

[Chichekian and Benteux](#) propose an exploratory review to describe how the effectiveness of AI-based technologies is measured, the roles attributed to teachers and both theoretical and practical contributions. From the research conducted, it emerges, according to the authors, that the role of teachers is underestimated and that the optimisation of AI systems is still nested exclusively in a strictly IT perspective.

The conscious and informed use of AI and tools that make use of AI is a critical indicator of the maturity of the community that benefits from these instruments. On the contrary, conscious use allows all the potential that can be found in AI to be turned into concrete gains. In this regard, [Zammit et al.](#) emphasize the importance of the diffusion and understanding of AI and Machine Learning and the associated ethical implications. To this end, the authors exploit a digital game designed and developed to teach AI and ML core concepts and to promote critical thinking about their functionalities and shortcomings in everyday life.

The paper by [Ninaus and Sailer](#) also fits into the groove of critical and aware use of AI in Education. The authors explore humans' role in decision-making in designing and implementing artificial intelligence in Education. Considering the essential role of users in decision-making in educational contexts and emphasizing the need to balance human- and AI-driven decision-making and mutual monitoring, they address both cases in which some AI implementations might make decisions autonomously and cases in which students and teachers, having received information from an AI, are enabled to make reasoned decisions.

Much remains to be done to understand how AI is changing educational practices and how the key stakeholders in the educational community (i.e., students, teachers, faculty, and families) perceive this ongoing change. Nevertheless, the Research Topic provides a broad picture of ongoing changes and a starting point in a research path that will develop over the coming years involving many experts in AI and Education fields.

We believe it is important to renew this Research Topic so that the most recent findings can be shared and systematically analyzed in order to support the progress of this field.

Content of the special issue:

Teacher Training Effectiveness in Self-Regulation in Virtual Environments

María Consuelo Sáiz-Manzanares, Leandro S. Almeida, Luis J. Martín-Antón, Miguel A. Carbonero, Juan A. Valdivieso-Burón

Performance and Configuration of Artificial Intelligence in Educational Settings. Introducing a New Reliability Concept Based on Content Analysis

Florian Berding, Elisabeth Riebenbauer, Simone Stütz, Heike Jahncke, Andreas Slopinski, Karin Rebmann

A Knowledge Query Network Model Based on Rasch Model Embedding for Personalized Online Learning

Yan Cheng, Gang Wu, Haifeng Zou, Pin Luo, Zhuang Cai

The potential of learning with (and not from) artificial intelligence in education

Tanya Chichekian, Bérenger Benteux

Learn to Machine Learn via Games in the Classroom

Marvin Zammit, Iro Voulgari, Antonios Liapis, Georgios N. Yannakakis

System design for using multimodal trace data in modeling self-regulated learning

Elizabeth Brooke Cloude, Roger Azevedo, Philip H. Winne, Gautam Biswas, Eunice E. Jang

Closing the loop – The human role in artificial intelligence for education

Manuel Ninaus, Michael Sailer

Proactive and reactive engagement of artificial intelligence methods for education: a review

Sruti Mallik, Ahana Gangopadhyay

Do we still need teachers? Navigating the paradigm shift of the teacher's role in the AI era

Manuel Gentile, Giuseppe Città, Salvatore Perna, Mario Allegra

Automated feedback and writing: a multi-level meta-analysis of effects on students' performance

Johanna Fleckenstein, Lucas W. Liebenow, Jennifer Meyer