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Teaching and Learning with AI How artificial intelligence is transforming the future of education

“**B**lackboards are fashionable. Everyone praises them, and every school has them; ...[n]o teacher now dares question their utility; but how many teachers prove their utility by daily use? To how many are they a constant necessity, not an occasional convenience?”

These words were written in a short essay published in *The American Educational Monthly* in 1866 [1]. More than 150 years later, the classroom looks vastly different. When I taught in a high school math classroom in 2018, my classroom did not have a blackboard, but rather a markerboard, a document camera, and a projector to broadcast a computer screen. Yet, although the technology has evolved, these presentation tools carried on the same spirit of the original blackboard. They offered students the opportunity to see the mathematics illustrated, interact with the ideas, and present their own problem-solving methods for the class to see and learn.

Now, the technologies that allow us to present ideas on a board, whether written in chalk or projected as a digital image, are not just fashionable conveniences; they are constant necessities

in the modern classroom. We use them daily, and they have shaped pedagogical approaches to emphasize visualizations of abstract ideas, facilitate lively collaborative discussions, and incorporate students’ own creative interactions. This goes to show that, as technology evolves, so do the ways in which we teach and learn.

I often wonder what’s next for education. What will our future classrooms look like? What “hot” technologies exist today that will ultimately shape teaching and learning in the future? One potential answer to this question brings us to the subject of this issue: artificial intelligence (AI).

AI has certainly been an upward trending topic in a

variety of sectors, not just education. From self-driving cars to AI-generated art, news stories pop up every day about how advancements in AI development and research are driving new and exciting innovations, with more and more speculation about how these technologies will ultimately influence our day-to-day lives.

However, in the world of education, AI has had its foot in the door for some time, with academic research on computer-assisted instruction and intelligent tutoring systems dating back to the 1950s. While academic research on AI in education has been growing for many years (for interested readers, check out the International Artificial Intelligence in Education Society¹), it is only within the past few years that AI-enabled tools have really taken the spotlight in education. An increasing number of learning environments and assessment systems are using AI and data-driven approaches to support assessment, teaching, and learning behind the scenes. With a market projected to be worth \$6 billion by 2024 [2], AI in education is certainly an active and thriving area for re-

search and development and has the potential to transform the ways we teach and learn around the world.

In this issue of *XRDS*, we explore the budding topic of AI in education, diving into examples of applications as well as key opportunities and challenges surrounding the use of AI for teaching and learning. First, Dr. Ryan Baker (professor at the University of Pennsylvania) provides an overview of key learning analytics methods that leverage AI, machine learning, and data mining techniques for educational contexts and shares examples of ways in which these methods have been applied to assess and support various aspects of students’ learning and other educational outcomes. He also draws attention to some interesting challenges, including difficulties with generalizability and the risk of algorithmic bias, and shares some ways to get involved and learn more about learning analytics.

Narrowing in on the challenge of building inclusive and equitable AI for education, Dr. Rod Roscoe (associate professor at Arizona State University) uses a human-centered approach and poses four heuristic questions that we should keep in mind

Will AI be an occasional convenience or a constant necessity, a tool that transforms what and how we learn?

1 <https://iaied.org/>

1.4B estimated 5G connections will exist worldwide by 2025. 5G networks offer faster internet speed, lower latency, and higher reliability than previous generations.

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around the development and use of AI in education. These heuristics, which Dr. Roscoe dubs “who-ristics,” are intended to shed light on the people who are involved with (or not involved with) the development process as well as those who are most affected by applications of the technology.

A prime example of this human-centered approach to equitable AI is the child speech recognition technology developed by Dr. Amelia Kelly’s team at SoapBox Labs. Dr. Kelly (CTO at SoapBox Labs) joined us for an interview, during which she described the importance of developing speech recognition technology for children. She noted many speech recognition models are built using data from adult speakers, leaving these models ill-equipped to be used to detect the speech of young learners. During our conversation, Dr. Kelly also shared her career path and her recent opportunity as a Fulbright Scholar at the University of Colorado Boulder, integrating the speech recognition technology into a tool designed to help teachers better facilitate group discussions in the classroom.

Also keeping inclusion and equity at the forefront throughout the development process, Alayne Benson (AI communications and outreach coordinator at the National Science Foundation AI Institute for Student-AI Teaming) de-

scribes how iSAT inclusively collaborates across multiple teams and institutions to develop the AI Partner, an intelligent agent that can understand and facilitate collaborations within the classroom. While the development of the AI Partner is ongoing, the iSAT team envisions AI serving as a collaborative partner in classroom scenarios, encouraging students to practice important collaborative learning skills and reporting useful information about students’ needs to the teacher.

Building AI for education certainly requires an interdisciplinary team of experts working together, and we see this theme come up again in our next article where Dr. Janice Gobert (professor at Rutgers University and CEO/co-founder of Apprendis) writes about the design and development of the Inquiry Intelligent Tutoring System (Inq-ITS). By drawing on a rich background of research from the cognitive and learning sciences, and combining that with computational methods from the field of AI, Dr. Gobert and the Inq-ITS team developed scalable

As technology evolves, so do the ways in which we teach and learn.



performance assessments of science inquiry competencies. While students are conducting virtual science experiments in the Inq-ITS environment, they are automatically assessed in real-time on their science practices and receive on-screen support from a pedagogical agent when they struggle with the lab. Teachers are also kept in the loop, receiving dashboard notifications about the students who need help, what they need help on, and suggestions for how to help them.

Also focused on using AI to support STEM teaching and learning, Dr. Xiaoming Zhai (assistant professor at the University of Georgia) turns to the popular AI chatbot, ChatGPT, to test its chops at generating assessment items that are aligned with nation-

ally recognized education standards. He also investigated the chatbot’s ability to grade a student’s science essay, generate personalized learning guidance, and customize feedback to consider special needs of students. While Dr. Zhai considers how ChatGPT could be used to facilitate teaching, Dr. David Joyner (executive director of online education at the Georgia Institute of Technology) advocates for educators to embrace students’ use of technologies like ChatGPT. Drawing parallels to the evolution of calculator use in the classroom, Dr. Joyner suggests ChatGPT will become a valuable tool that will ultimately benefit students who learn to use it effectively.

With generative AI tools in mind, our final article from Joanne Leong (Ph.D.



The global drone market size is expected to grow from \$22.5 billion in 2020 to \$42.8 billion by 2025 due to the increasing adoption of drone technology in agriculture, construction, and transportation.

candidate at the Massachusetts Institute of Technology) takes a look at the ways in which developments in generative AI, like automatic image and text generators, can be used to foster motivation and interest in learning and help learners develop the self-confidence they need to succeed. In closing this issue on AI in education, Leong inspires us to see these new AI technologies as assets with immense potential to make a positive impact in many facets of our lives.

As we think about how AI is being used in education now and the possibilities for the future, I come back to the now ubiquitous blackboard. The nineteenth-century essayist described the blackboard as “fashionable,” it received widespread praise, and no one dared to question its utility. Over time, it truly became a necessity in classrooms. As the blackboard evolved to fit the needs of teachers and students newly armed with markers and computers instead of chalk, the classroom itself also evolved with teachers and students alike inventing new and creative ways to foster learning with the tools and technology available, forging new ground every day in the world of education.

With AI technologies on the rise, sculpting the ways in which we communicate, learn, and grow with one another, how too will our classrooms change? Will AI be an occasional convenience or

a constant necessity, a tool that transforms what and how we learn? What, and who, should we consider as we create these tools? There is no doubt that AI has been and will continue to be useful for education, and I, for one, am excited to see AI integrated into the fabric of education, enlivening classrooms everywhere and inspiring new generations of learners to flourish.

References

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- [2] Miao, F., Holmes, W., Huang, R., and Zhang, H. *AI and Education: A guidance for policymakers*. UNESCO Publishing, 2021; <https://unesdoc.unesco.org/ark:/48223/pf0000376709>

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Biography

Amy Adair is a National Science Foundation (NSF) Graduate Research Fellow and doctoral candidate in the Ph.D. in education program at Rutgers University. Advised by Dr. Janice Gobert, Adair works at the intersection of learning sciences and AI in education fields to design and develop evidence-based tools for STEM teaching, learning, and assessment. Prior to graduate school, she received a B.S. in mathematics from Louisiana State University and taught high school math and robotics classes in Louisiana. Drawing from her former experience as a mathematics teacher, her dissertation work focuses on automatically assessing and supporting the ways in which students develop and write about mathematical models in virtual science labs within the Inquiry Intelligent Tutoring System (Inq-ITS; inqits.com).

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MILESTONES

AI in the Classroom

Artificial intelligence (AI) has transformed the way we live and work, and education is no exception. AI has the potential to personalize and revolutionize teaching and learning in the future.

1970s Researchers explore the use of AI for natural language processing and machine learning. This research leads to the development of intelligent tutoring systems that can understand natural language and adapt to the student's level of knowledge.

1980s AI is used in education to support personalized learning and assessment. Researchers begin to explore the use of expert systems for instructional design.

1990s AI is applied to create intelligent learning environments and adaptive educational systems. AI is used to create personalized learning experiences by adapting to the student's knowledge level and learning style.

2000s Educational data mining and learning analytics development enables educators to use data-driven decision-making in their instruction. AI is used to create virtual tutors and assistants.

2010s The advent of MOOCs (massive open online courses) and learning management systems integrate AI for personalized learning experiences and automated grading.

2020s The COVID-19 pandemic accelerates the adoption of AI in education, particularly for remote learning and online assessments. AI-powered chatbots are used to provide 24/7 support to students. VR and AR technologies are explored to enhance learning experiences.

—Deepak Mahto

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