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Promoting equity and addressing concerns in teaching and learning with artificial intelligence

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This perspective article focuses on the exploration and advocacy of approaches to be considered in designing equitable learning experiences for students' use of artificial intelligence, machine learning, and technology through the Universal Design for Learning Framework (UDL) exemplifying chemistry examples that can be applied to any course in STEM. The use of artificial intelligence (AI) and machine learning are causing disruptions within learning in higher education and is also casting a spotlight on systemic inequities particularly affecting minoritized groups broadly and in STEM fields. Particularly, the emergence of AI has focused on inequities toward minoritized students in academic and professional ethics. As the U.S. education system grapples with a nuanced mix of acceptance and hesitation towards AI, the necessity for inclusive and equitable education, impactful learning practices, and innovative strategies has become more pronounced. Promoting equitable approaches for the use of artificial intelligence and technology in STEM learning will be an important milestone in addressing STEM disparities toward minoritized groups and equitable accessibility to evolving technology.

KEYWORDS

generative AI, education, AI integration, broadening participation, equity, inclusive teaching, technology, ethics

1 Introduction

Noting historical lessons learned about access and bias, how do we proactively address equitable learning using AI tools? The intersection of educational technologies and possibilities, including addressing equity and opportunity gaps between diverse populations, is an underexplored but crucial area, especially in the context of the impact of Artificial intelligence and its evolving role in education. Exploring this intersection can significantly impact how AI is integrated into educational systems to ensure learning environments that are effective for all, including potentially vulnerable populations (Kazimzade et al., 2019). Artificial intelligence and emerging technologies offer a powerful means to create an inclusive educational environment with the Universal Design for Learning (UDL). The use of AI technologies in education fosters outcomes to support learning and skill-building that has the potential to reach a broader audience of students, including and especially under resourced, underprepared, and other populations (Lalwani and Agrawal, 2018; Porayska-Pomsta and Kaśka, 2022). A barrier that hinders DEI progress is technology access (Holstein and Doroudi, 2022). Minoritized individuals fare worse than their white counterparts across every age and income level when it comes to societal outcomes—as they experience significant disadvantages—one of many is access to high-quality education (Equity in the Center, 2019). Equity provides the specific resources and access individual students need. Yet, few institutions have gone beyond scratching the surface or digging deep in their progress with diversity, equity, and inclusion, raising questions about what are holding them back—do they lack awareness, is DEI seen as an extra expense, or are they short on time and resources? (Honorlock, 2023) While educators and institutions aim to improve the teaching and learning experience, the intent of creating a fair and equitable environment must be included such as implementing low-cost technology initiatives and partnerships to ensure all students have access.

The COVID-19 pandemic has impacted education across all levels and accelerated the adoption of technology and digital pedagogy in education, but it has also highlighted the need for equity and accessibility in the delivery of education (Basham et al., 2020; Garcia Ramos and Towns, 2023). The education system needs to adapt and evolve to meet the needs of students, teachers (and nation), especially to bridge the gap in low-income schools. Coupled with the integration of artificial intelligence and other modern technologies, the Universal Design for Learning (UDL) framework serves to proactively accommodate learner variability and optimize student learning outcomes. Collaboration and conversations must ensue among educators, researchers, technology experts, and policymakers to constructively improve education and support students' learning with the use of evolving generative AI tools.

Improved learning outcomes are achieved through personalized teaching strategies that address each student's needs and prior knowledge. By providing support that is specifically tailored to student misconceptions and adapted to their level of understanding, educators can effectively bridge learning gaps and foster a more inclusive educational environment (Crompton and Burke, 2023). Technology can play a critical role in the creation of an accessible and equitable education—especially in the design of the environment, content difficulty, content, delivery, and development of technology-based pedagogical skills (Holstein and Doroudi, 2022). UDL's strong emphasis on designing instruction to be inclusive to a diverse range of learner needs and abilities can ease pedagogical adaptation (McMahon and Walker, 2019).

2 The machine, the individual, and the environment

The following section defines equity and its involvement in "the machine, the individual, and the environment." The "machine" refers to artificial intelligence and machine learning in any and all of its forms/personas. The "individual" refers to the single person, group of people or institutions/organizations that control the technologies and its execution. The "environment" refers to the physical location where the technologies are located and the climate created by the individual(s) that control and execute the use of the technologies.

The National Academy of Sciences defines equity as an outcome from fair conditions (such as policies, practices, structures, cultures, and norms) in which all individuals and groups have the opportunities and resources they need for general well-being or success (National Academies of Sciences, 2023). Barriers play an important role in determining who is and who is not included—especially in STEM (White et al., 2021; National Academies of Sciences, 2023). Educational debt—i.e. the foregoing of school resources that should have been invested in low-income students. These deficit leads to a variety of social problems, that also present themselves in the chemistry workforce and college chemistry courses through unjust experiences (Ladson-Billings, 2006, 2007; Palermo et al., 2022; Van Dusen et al., 2022) . The conscious and unconscious biases, cognitive mechanisms and social motives may act to keep the status quo intact and inhibit efforts to promote equity (National Academies of Sciences, 2023). Even when diversity is increased, or in this case access to technology, there can be challenges present or created to hinder the success of minoritized individuals (National Academies of Sciences, 2023).

There have been significant investments made by the global education community to enhance technology-enriched education opportunities (Basham et al., 2020). Notably, in 2018, a substantial investment of 1.4 billion dollars was directed towards education technology startup companies (Basham et al., 2020). Indiscriminate applications of AI in education pose the risk of perpetuating or exacerbating existing systemic biases and discrimination (Porayska-Pomsta and Kaśka, 2022; Vlasceanu and Amodio, 2022). This amplification of inequalities could further disadvantage marginalized groups (Porayska-Pomsta and Kaśka, 2022).

The development of AI systems for use in education has often been motivated by their potential to promote educational equity and reduce achievement gaps across different groups of learners—for example, by scaling up the benefits of one-on-one human tutoring to a broader audience (Holstein and Doroudi, 2022). However, research has shown that even when schools and individual learners have equal access to new technology, the technology tends to be used and accessed in unequal ways, exacerbating inequity (Holstein and Doroudi, 2022). Research has found that instructors at institutions with different demographic compositions adopted different attitudes toward students' digital literacy skills and expressions based on racial stereotypes about the student body, with schools that are better-resourced and serve students from more privileged backgrounds tend to use technology in more innovative ways (Puckett and Rafalow, 2020).

2.1 The machine and the individual

The rationalism of AI and its mechanisms aims to emulate individuals as cognitive machines, mirroring the internal mechanisms inherent in the digital technology we construct (Winograd, 2006; Gunkel, 2012). Whether or not the mechanisms align directly with formal logic, they function akin to logic by allowing the application of well-defined algorithmic rules to models, encompassing processes and knowledge used to optimize human interaction (Winograd, 2006). Since the 1950s, it has been predicted and proven that the majority of (online) communication is not human-to-human exchanges but interactions between humans and machines and machines and machines (Gunkel, 2012). The design approach of AI and its mechanisms centers around the interactions between humans, their interpretations, and behaviors—for which there are no predictive models—and there is a link between societal inequality, internet search algorithms, and human decision-making (Winograd, 2006; Vlasceanu and Amodio, 2022). Although there has been research focusing on debiasing an algorithm's training set and investigating the computations of deep neural network models, a closer look at how human decision-makers interact with and consume algorithmic output is needed to increase fairness and transparency in AI use (Baer and Kamalnath, 2017; Gleaves et al., 2020; Du et al., 2021; Nourani et al., 2021; Crawford et al., 2022; Vlasceanu and Amodio, 2022). The vast amount of information generative AI and its software is trained on and created by people—inherently reflecting the societal biases present in the training material and reflected on outputs such as racial and socioeconomic stereotypes (Kazimzade et al., 2019; LSU Online and Continuing Education, 2023). These outputs and biases embedded in the datasets perpetuate and amplify existing social inequalities—not only impacting the fairness and inclusivity of the technology but also its reliability and effectiveness in education and diverse real-world contexts and applications.

2.2 The environment

The environment the machine operates in is social in nature, indicating it functions within the socio-technical system that encompasses the social context it is found or being used in, user interactions of the individuals controlling and using the machine, and their underlying cultural values and beliefs (Kazimzade et al., 2019; Holstein and Doroudi, 2022; Bray et al., 2024). Understanding these dynamics is crucial for designing and implementing AI that aligns with the values and needs of the students and education community, ensuring that technology enhances rather than disrupt the social dynamics of promoting equity—especially towards minorities. To optimize the functionality and acceptance of machines in various environments, it is essential to consider the cultural, ethical, and social dimensions that influence how technology is perceived and used in education and society.

3 UDL and AI tools' leverage to equitably teach (chemistry)

The Universal Design for Learning Framework (UDL) is a pedagogical approach designed to reduce barriers in education by providing multiple means of representation, expression, and engagement for all students—accommodating the diverse needs of all students aimed at creating inclusive and flexible learning environments (Al-Azawei et al., 2016; Flood and Banks, 2021; Bray et al., 2024; Bressane et al., 2024). New technologies such as AI allow for interactive learning. While the intent of AI/technology use in education is to create learning environments to enhance learning through the distribution of knowledge between the student and environment, the input is what will promote equity (Rose, 2000; Bray et al., 2024).

3.1 Multiple means of representation

The UDL framework transcends single methods of conveying information by providing diverse opportunities for expression. Traditionally, this has emphasized customizable displays of information, including multimedia, visual illustrations, and auditory descriptions. It may also involve using culturally relevant content to connect to students' prior knowledge or experiences. AI can augment means of representation in chemistry with creating more interactive sessions of social justice in chemistry, such as the Flint water crisis, and have chatbots designed to be culturally relevant visual representations of individuals (Buckley and Fahrenkrug, 2020; Livezey, 2022; Yu and Linden, 2022; Landis, 2024).

With personalized assessments and dynamic versions of assignments, AI can adapt to a student's unique styles and strengths while refining its methods based on successes and failures (Rose, 2000). This ensures relevancy and currency through content curation, personalized learning paths, and virtual learning assistants (Rose, 2000). The personalization integrated in online learning platforms can be beneficial to students from marginalized backgrounds who are typically overlooked in traditional education settings and help bridge the achievement gap often seen among these students. However, the assumption that there will not be any barriers constraining AI to provide students differing modes of representation, expression, or engagement needed are determinant of the individual(s) and the environment. Providing universally designed assessments requires flexibility to make the assessment accessible—increasing the instructional value by providing options as to what aligns with the learner—options that are more vastly available through artificial intelligence (Rose, 2000).

3.2 Multiple means of engagement

The UDL framework promotes various opportunities for students to engage with course materials and content. Traditional examples of engagement include group discussions, interactive activities, and enhancing student voice through individual choice and autonomy.

AI can support the creation of inclusive learning environments by providing resources that are culturally relevant and accessible—including tools for translating content into different languages (through AI-powered speech recognition and translation services) to ensure participation and presenting information on various formats to accommodate different learning preferences (Kazimzade et al., 2019; Chichekian and Benteux, 2022; Crompton and Burke, 2023). ChatGPT has shown to be capable of reformulating probability theory and statistics problem statements to biology, economics, law, and engineering—all while preserving the original theoretical meaning of the problem, representing real-world scenarios all while increasing student engagement and understanding (Einarsson et al., 2024). Large language models (LLMs) have the potential to be used to reframe chemistry problems to make them accessible to students across diverse academic fields—making complex concepts more accessible, relevant, and engaging (Einarsson et al., 2024). In conjunction with multiple means of representation, the use of chemistry-specific generation models, such as RxnScribe, can assist students in understanding reactions and reaction diagrams (Mater and Coote, 2019; Guo et al., 2021; Qian et al., 2023; Westermayr et al., 2023; RxnScribe – A Hugging Face Space by Yujieq, 2023).

3.3 Multiple means of action/expression

The UDL framework also broadens the range of methods for students to demonstrate their knowledge and learning. Traditionally, this has included exams, papers, and projects, but it also encompasses other ways for students to showcase growth in higher-order and critical thinking.

To assist students in rural, underserved, and low-infrastructure settings, AI can be used to deliver educational content by leveraging mobile technology—improving literacy and educational outcomes where traditional educational resources are scarce (Madaio et al., 2019a,b, 2020). As a way to embrace racial equity, instructors can reflect on their preconceived attributions that they have about students and challenge their own assumptions—which will in turn build behavioral and cognitive strengths within students so they may overcome academic challenges as independent learners (Dray and Wisneski, 2011; Takemae et al., 2022). AI can provide instructors with data-driven insights from Learning Management Systems (LMS) on student performance and engagement, such as math challenges in stoichiometry problems. Flipped instruction has been shown to promote equity in general chemistry and can be augmented with AI through technological applications and used in the delivery of the material (Bancroft et al., 2020). AI can help educators identify and address systemic issues of inequality and discrimination, ultimately enabling them to develop strategies for creating more inclusive classroom environments (Kostick-Quenet et al., 2022). The exploration and advocacy of equitable approaches using the UDL Framework exemplifies the significance in bridging the digital divide between technological advancements and equitable/inclusive education.

4 Facing the equity challenges of artificial intelligence

Faculty and student concerns about the use of AI have been documented, such as student fears of AI's unreliable answers negatively impacting their grade and instructors' predicted conflicts with the students due to AI-based misinformation and misleadings (Seo et al., 2021; Alasadi and Baiz, 2023; Mai et al., 2024; Walter, 2024). While these concerns may not have explicitly focused on equity, they have the potential to address it. The following further discusses other AI-centered scenarios not previously highlighted.

The presence and use of AI in education present significant challenges, such as the need for continuous professional development for educators in AI technologies and pedagogical practices (Walter, 2024). Furthermore, the requirement of diverse and inclusive training in bias recognition, transparency, and privacy-respecting practices is needed for educators using AI (Walter, 2024). Students believe the anonymity provided by AI would make them less self-conscious, allowing them to ask more questions (Seo et al., 2021). In turn, the instructors reported that AI could help answer simple repetitive questions, which allows them more allotted time to support their students and give more meaningful communication (Seo et al., 2021).

AI presents a challenge for underserved institutions to invest in technology and fair access policies—equitable access to AI tools is crucial to prevent educational inequalities (Walter, 2024). For example, access to paid subscriptions of generative AI tools, such as ChatGPT, is of concern due to restrictions on the prompt length of a task created (Mai et al., 2024). The limitation of prompt and answer word length compromises the depth and quality of the feedback and responses received from the generative AI tools (Mai et al., 2024). The access to paid subscriptions also compromises the accuracy of information received (Mai et al., 2024).

Communication is key in addressing these and other challenges posed by AI (Seo et al., 2021). The design and implementation of AI use should promote fairness, transparency, and inclusivity to foster a more equitable technological and educational landscape.

5 Conclusion

The integration of Artificial intelligence and machine learning into educational frameworks presents both a challenge and an opportunity to fundamentally rethink and redesign the education experience. These tools are catalyzing disruptive innovations through their ability to perform a diverse array of natural language tasks with transfer learning—transferring knowledge from a source domain to a target domain using previously acquired knowledge (Lu et al., 2015). To effectively use these new and rapidly evolving tools, students must be able to critically assess AI-generated products, particularly in STEM contexts. However, in addition to the academic perspective, students are faced with more scrutiny involving technology use and academic integrity—affecting minoritized students the most. As educators, whom are and should be invested in equity, it is critical to employ AI and technology in a manner that ensures its positive impact on education and society for the long term. Creating equitable learning experiences with and within AI and technology usage ensures equitable access to emerging technology for all students and is a critical step towards diminishing STEM disparities.

To promote inclusivity in emerging technologies, it is essential for researchers, educators, and advocates from diverse fields to actively participate in integrating these innovations into mainstream education—going against the resistance of adopting new technologies/pedagogies due to an assessment-based culture and breaking the generational viewpoint of technopanic. Thus, employing artificial intelligence to enhance pedagogical and assessment practices has the potential to further revolutionize education (Baidoo-Anu and Owusu Ansah, 2023).

Informed implementation choices with new technologies using UDL ensures that these innovations accommodate diverse learning needs and preferences. Educators need to ensure educational access of technology, including AI, for all students to address contemporary global challenges. UDL has the potential to render high-impact practices, hallmarks of excellence, accessible and beneficial to all. Proactive effort from educational institutions must occur to recruit and best support students from diverse backgrounds and communities; and include them in technology-rich pedagogical environments that are intentionally inclusive. Despite the availability of technology, there continues to be an underutilization of technology and resources to effectively support learner variability—indicating a need for a more strategic approach to technology use in education (Basham et al., 2020; Song et al., 2024).

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JGR: Writing – original draft, Writing – review & editing. ZW-K: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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