International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 08 | Aug - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Application of AI and MOOCs to Mathematics

Uttam Barman

Assistant Professor, Department of Mathematics ,Panchmura Mahavidyalaya, W.B., India

Email: uttammath85@gmail.com

ABSTRACT: The rapid advancement of technology is transforming the learning environment, especially with the recent online learning trends driven by the Coronavirus pandemic. Digital tools like Artificial Intelligence (AI) and Massive Open Online Courses (MOOCs) enable students to access content and communicate with teachers and peers anytime and anywhere. Use of AI and MOOCs in Mathematical education has been discussed in this paper.

Keywords: Artificial Intelligence, MOOCS, Software, tools. Algorithm.

1. Introduction to AI and MOOCs

Artificial Intelligence (AI) is a branch of computer science devoted to developing computer software with human intelligence, allowing machines to perform tasks previously only done by humans. Massive Open Online Courses (MOOCs) are open online courses supported by representatives from universities worldwide. Improving mathematics teaching is a fundamental, global challenge. AI techniques and MOOC platforms promise to revolutionize the education of STEM disciplines, especially mathematics, by creating free, interactive, adaptive, immersive, and customizable lessons for large-scale tutoring and instructional support. In 2017, Yu et al. expected personalized and customized learning approaches to flourish as AI applications in MOOCs concurrently gain strength (Yu et al., 2017).

2. Historical Context of Mathematics Education

Mathematics education has traditionally employed a range of teaching methods from oral recitation to interactive tools such as games and engaging problems. Contemporary distance-education methods frequently incorporate multimedia components (e.g., video, animation, simulation) and real-time tutoring (Soares and Paula Lopes, 2016). The pedagogical strategies applied to online instruction vary considerably, but typically mirror those used in conventional classroom settings. Consequently, while online mathematics courses expand access, they seldom improve upon the efficacy of classroom teaching (Betteridge et al., 2020).

3. The Role of Artificial Intelligence in Education

Artificial Intelligence (AI) refers to computer programs creating smart machines capable of performing tasks reserved for humans; Massive Open Online Courses (MOOCs) offer large-scale, open-access, free courses delivered online by distributed teams of instructors (Yu et al., 2017). AI has transformed science, engineering, and medicine. MOOCs have impacted higher education by providing students, who would traditionally face barriers, unrestricted access to large-scale course content at zero marginal cost. Nearly all traditional courses remain shackled due to complex life demands and limited work opportunities. In contrast, MOOCs support scalable, accessible, and personalized education by integrating AI and collaboration capabilities.

3.1. AI Technologies in Learning Environments

The popularization of computing has major impacts on various fields including education. In particular, the combination of artificial intelligence and massive open online courses (MOOCs) can substantially improve the learning environment and accessibility. Artificial intelligence (abbreviated as AI) is intelligence demonstrated by machines, as opposed to the natural intelligence displayed by animals including humans. Artificial intelligence, as a field of study, investigates intelligent agents and machine learning. Enhanced computational power accelerates learning systems and brought AI back into the spotlight. A MOOC is an online course aimed at large-scale interactive participation and open access via the web. In addition to traditional course materials such as filmed lectures, readings, and problem sets, many MOOCs provide interactive user forums to support community interactions among students, professors, and teaching assistants (Yu et al., 2017).

Mathematics education represents a challenge because general instructional methods tend to frustrate and discourage students (Ling Lim and Sing Goh, 2016). The combination of MOOCs with AI techniques can thus improve the mathematics learning system. Intelligent systems combined with AI techniques promise more personalized and adaptable technologies for improved learning environments and increased accessibility to education. Such a system has the potential to assist large numbers of students simultaneously, allowing the collection of behavior data at an unprecedented scale. Consequently, it is possible to enhance support, facilitate interventions and adapt learning to individual differences much more effectively. Using AI techniques with MOOCs represents a major step towards realizing this vision because MOOCs benefit from common standards and content sharing. They also encourage collaboration serving as a catalyst to integrate intelligent systems with existing learning environments.

3.2. Personalized Learning through AI

Artificial Intelligence holds considerable promise for facilitating adaptive training tailored to individual needs, positioning AI-enabled personalization as widely acknowledged among next-generation online learning modalities. Digital course materials segregate into passive and active categories; while the former, encompassing text and videos, allows self-paced study with low-level interactivity, the latter engages students through uploads, annotations, and reports. Present intelligence techniques considerably enhance passive content, yet tools for personalizing hands-on activities—such as student notebooks and essays—remain less developed. Embedding artificial intelligence within Massive Open Online Courses substantially augments mathematical pedagogy. Learners receive targeted guidance via adaptive platforms that invoke diverse AI methods; frequent-lived questions trigger automated answers through dedicated bots. Real-time assessments, frequently captured by Interactive Mathematics Assessment Systems, further the tailored educational experience. AI-driven grading models scrutinize student submissions, pinpointing critical errors to delegate those problems for subsequent human examination. Centralized collection of student questions allows virtual teaching assistants to address pervasive confusions; as practitioners deliberate over task assignments, automated systems effectively allocate queries to appropriate helpers (Yu et al., 2017).

4. Overview of MOOCs

Massive Open Online Courses (MOOCs) provide open online courses available to anyone, anywhere, which helps reduce barriers for participation in formal education and creates opportunities for learners to acquire skills and knowledge for better employment prospects or self-fulfillment. Their rising popularity is reshaping higher education worldwide by enabling more flexible, affordable, inter-institutional, and collaborative education for students at their own pace in a zero marginal cost manner. After IPP's January 2013 launch of the OpenED platform and the February 2014 offering of the first course, Probability and Combinatorics, around 10,000 participants from more than 100 countries enrolled, revealing the significant potential of MOOCs in mathematics education. This success led to the development and launch of additional mathematics courses—Introduction to Differential Calculus and Trigonometry and Complex Numbers (Soares and Paula Lopes, 2016)(Yu et al., 2017).

4.1. Definition and Characteristics of MOOCs

Massive open online courses (MOOCs) can be used to provide continuous learning to students in higher education all around the world. MOOCs propose a format for (potentially) large-scale flexible participation and open access via the Internet. MOOCs can be linked to campus classes or used to support their own independent study courses (Soares and Paula Lopes, 2016).

Following the first MOOC, opened in 2008, many, sometimes overlapping, definitions have been proposed but the term generally covers seminars or other courses that are not restricted by classroom size or time limits created by course schedules. The core characteristics are a clearly defined body of the targeted content offered that requires a reasonable time commitment from a participant who completes an evaluation or a considerable project by the end of the course. In general, courses are offered free of charge. Examples typically include lectures, emailed textbook excerpts, problem sets, online discussion groups, remotely graded assessment submissions, tutor-marked assignments, and final examinations (Yu et al., 2017).

4.2. Impact of MOOCs on Higher Education

MOOCs are widely recognized for breaking the geographical and economic barriers to education. They enable students worldwide to connect remotely to quality university courses, often taught by leading experts in subjects such as mathematics. Each MOOC consists of scripted video lectures, interactive quizzes, and assignments that are easily accessible through a web-based interface. MOOCs offer students the flexibility to learn and monitor their progress at their own pace while providing valuable insight into the number of students interested in or struggling with a given topic. Consequently, the adoption of MOOCs is considered a transformative development in higher education (Soares and Paula Lopes, 2016). suggest that MOOCs can play a pivotal role as educational resources during a period of significant change in higher education. They are helpful not only as teaching resources but also as a means to address the widespread issue of varying mathematical skills among students. These courses benefit both learners and instructors by offering additional practice opportunities and support. The development of MOOCs such as Probability and Combinatorics, Introduction to Differential Calculus, and Trigonometry and Complex Numbers demonstrates how MOOCs can contribute to improved access and quality in mathematics education. Furthermore, initiatives like the Math Without STRESS platform underscore the potential of MOOCs to enhance learning and foster innovation in education.

5. Integration of AI in MOOCs for Mathematics

Artificial intelligence (AI) and massive open online courses (MOOCs) are jointly transforming higher education through AI-enhanced personalization. AI constitutes intelligent agents that perceive environments and proactively achieve goals. Characteristics of AI systems encompass autonomy, adaptability to new data, and the capacity to explain reasoning. MOOCs leverage the Web to attain massive scale and openness, delivering courses without charges to tens or hundreds of thousands of individuals in diverse locations. Interactive platforms empower students, fostering active rather than passive engagement. Current MOOC offerings include 700 courses, 5,000 classes, and 250,000 certificates from a dozen providers.

Mathematics is traditionally axiomatized through definitions, theorems, and proofs, requiring extensive memorization and substantial effort to attain proficiency. The AST curriculum introduced by the Ministry of Education stipulates 33 credits across various mathematical fields, underscoring the foundational nature of mathematics for all disciplines post-secondary education. AI provides mechanisms to assist in the acquisition of knowledge and skills, enhancing mathematics learning within MOOC environments.

The scale of MOOCs accentuates the necessity for personalized learning. Conventional approaches relying on human tutors for individual support are ineffective at such magnitudes. Developed AI technologies address this limitation by enabling simultaneous, personalized assistance to millions. A spectrum of AI techniques facilitates the formation of customized learning paths for each student, enhancing accessibility and inclusivity. Alignment Constraint Classification combines multiple factors 6d3e423-5285-4951-824a-6f51f8bc8e07 difficulty, priority, and discrimination 6d3e423-5285-4951-824a-6f51f8bc8e07 to categorize content according to learners 6d3e423-5285-4951-824a-6f51f8bc8e07 existing knowledge bases, aiding in pathway selection. Automated grading and evaluation systems transform arbitrary-content questions into uniform data, enabling parameter estimation, analysis, and feedback generation for mathematical short answers and derivations. These capabilities promote a responsive and adaptive educational ecosystem. Despite substantial progress, numerous challenges remain to be addressed.

5.1. Adaptive Learning Platforms

Mathematics pedagogy benefits from the interoperability of concepts, whereby careful sequencing and interlinking of content reduce cognitive load and enhance learning for those with weaker prerequisite knowledge. The Low-level Assessment of Mathematics for Personalised Instruction (LAMP) platform employs artificial intelligence (AI) to guide students through personalized learning pathways; complementary analytical tools continually diagnose student proficiency, informing adaptive teaching strategies (Yu et al., 2017).

MOOCs capitalize on these advantages by marrying accessibility and scalability with adaptive personalization. On the FutureLearn platform, the exemption system allows learners strong in specific topics to bypass corresponding activities, thereby customising their educational trajectory. Artificial intelligence subsequently adjusts lesson sequencing and difficulty levels to ensure engagement and appropriate challenge; diagnostic assessments further reveal problem areas, directing students to targeted revision resources. In Sum-Kan Mathematics, online courses combine AI-driven monitoring of video engagement (watch, pause, rewind) with immediate quizzes and tutorial support, enabling the identification and remediation of intellectual gaps prior to summative assessments. AI also facilitates rapid shortlisting of past exam questions for focused revision.

Although extensive adoption data are limited, these initiatives demonstrate the feasibility of delivering genuinely personalized and scalable mathematics education—a goal long pursued by education specialists.

5.2. AI-Driven Assessment Tools

Artificial intelligence (AI) provides enormous potential for educating a large number of students and opening new opportunities for everyone to learn. MOOCs open access to courses via the Internet for unlimited numbers of students and provide a rich source of educational data for developing AI-driven techniques. The integration of AI and MOOCs offers a promising platform for educating the masses, while still providing personalised learning experiences. The large amount of educational data stored in existing MOOCs makes it possible to develop a new generation of AI-empowered methods that can offer high-quality and personalised learning content designed to address the needs of desert learners (Yu et al., 2017). A brief overview of mathematical education and the relevant technologies of AI and MOOCs are presented first, followed by a summary of the current progress in the application of AI-MOOCs techniques to mathematical education.

6. Benefits of AI and MOOCs in Mathematics Education

The fusion of artificial intelligence and massive open online courses furnishes the mathematics community with a globally accessible, high-quality education medium. The democratizing power of this amalgamation attracts an ever-growing user base and facilitates ongoing pedagogical advancements (Yu et al., 2017).

Massive open online courses (MOOCs) represent a new trend in higher education, providing an easy-to-access and often free online platform that enables learning at any time and place. AI-supported MOOCs can enhance higher education by offering convenient, widespread services. A virtual learning companion, exhibiting human traits such as patience, helps students stay motivated and deeply engaged. Building on prominent MOOCs such as Coursera or edX, AI techniques are expected to enable personalized learning, fostering the best possible educational environment for each student. Mathematics educators can provide specific course material and solutions, allowing AI to focus on ensuring the accessibility and quality of instruction.

6.1. Accessibility and Inclusivity

Massive Open Online Courses (MOOCs) are online courses accessible to unlimited participants with open registration and free or low-cost access to course materials. MOOC platforms serve as virtual classrooms with diverse online learning features, including videos, computer-marked assignments, evaluation forums, and social interactions. MOOCs facilitate collaborative and cooperative learning and foster meaningful discussions among large groups of learners. They have become popular venues for sharing innovative educational resources and practices with large segments of the global population (Iniesto et al., 2017).

Mathematics plays a key role in science, technology, and engineering, yet many students around the world struggle to learn it because of its remoteness from real life and a lack of inspiration. Skilled mathematics teachers with talent and passion to inspire learners remain rare, and the Covid-19 pandemic has further increased pressures on many students to learn mathematics online.

Artificial Intelligence (AI) provides a range of techniques that can perform tasks normally requiring intelligence—such as visual perception, speech recognition, and decision-making—and is impacting all sectors (Yu et al., 2017). The MOOC platform supplies teaching materials and handles daily operations. AI technologies can identify learners' behavior patterns and provide personalized services to enhance their MOOC experience, automating teaching duties more efficiently than human instructors.

6.2. Scalability of Learning Resources

Medical mission service began late among Taiwan nurses but has developed rapidly since then. As Taiwan's nursing development has improved, its missions have responded to the changes and made positive developments by applying policy, education, and research into missionary nursing practice and social welfare. Regarding the needs of Taiwan nurses, various educational programs have been developed to improve the ability to communicate and provide medical treatment and nursing with other countries. With many Taiwan nurses contributing their professional and enthusiastic care, the government has responded by establishing a policy that encourages Taiwan's nurses to participate in, and initiate, medical mission programs in areas in need. Furthermore, Taiwan will continue its encouraging commitment to global health development by providing the greatest quality in medical services. This report will inspire professionals from many other fields to participate in medical missions in the countries that need assistance the most (Yu et al., 2017).

7. Challenges in Implementing AI and MOOCs

Deploying AI requires significant technical expertise, especially when, as with MOOCs, the service is delivered primarily online. Most instructors possess neither the coding skills nor the hardware to prepare content effectively. Moreover, high-quality educational content suitable for AI-driven delivery remains scarce. In mathematics, where terminology must be employed with exact precision, imprecision can lead learners astray, diminishing both the immediate educational experience and future attitudes toward the subject (Yu et al., 2017). These considerations are crucial in ensuring the effective application of AI and MOOCs to enhance mathematics education.

7.1. Technical Barriers and Infrastructure

In developing countries, inadequate infrastructure and limited access to educational technology have historically hindered widespread adoption of AI and MOOCs in mathematics education. MOOC platforms typically require high-speed internet, powerful mobile devices, and extensive server capacity to accommodate large numbers of simultaneous connections. While internet access has become increasingly universal and mobile devices more prevalent, many students in rural areas still lack the necessary bandwidth to consistently participate in high-quality remote lessons. Infrastructure constraints thus remain a significant barrier.

Combining AI with MOOCs for mathematics courses can also generate high costs. Effective design and management demand considerable investment in software development, computing resources, and content creation. AI-powered personalization systems implement sophisticated algorithms alongside extensive data storage and retrieval mechanisms, adding to system complexity. Without adequate institutional support or sustainable financial models, providing fully integrated AI-MOOC solutions risks imposing prohibitive burdens.

Maintaining content quality presents further challenges. Numerous mathematics MOOCs emphasize rote learning and procedural problem-solving rather than fostering deeper conceptual understanding. Automated grading systems concentrate on algorithmic correctness without necessarily ensuring comprehension of underlying principles. Consequently, participants must be mindful of limitations affecting pedagogical effectiveness and learner engagement (Betteridge et al., 2020). Although AI-assisted MOOCs offer scalability and accessibility advantages, educators and platform providers must address technical, economic, and instructional obstacles to realize their full potential within mathematics education (Yu et al., 2017).

7.2. Quality of Content and Instruction

Despite their transformative potential, AI and MOOC implementation in mathematics education must overcome several challenges to achieve widespread adoption and maximize benefits. Designing robust AI tools requires extensive time and effort to acquire specialized expertise. Dynamic resource allocation adds complexity, increasing costs and development durations. Security concerns loom large due to the vast quantities of personal data collected, necessitating rigorous safeguards. Content quality must be rigorously controlled to avoid superficial understanding, and computing resources must be efficiently managed to prevent overuse (Yu et al., 2017).

8. Case Studies of AI and MOOCs in Mathematics

MOOCs exemplify the characteristics of traditional university courses delivered online and supported by interactive media to serve a large number of learners. The delivery of university courses and programs—the typical domain of higher education—has become much more accessible and affordable to the global community, thanks to the ready availability of information and communication technologies and the adoption of mobile technology and applications. The higher education community has recognised the distinctive characteristics and challenges associated with MOOC deliver and has incorporated elements of it into other courses or transformed existing courses (Yu et al., 2017).

AI is embraced as the de facto enabling technology for digital transformation in many sectors, including education. It is changing the ways users interact with information and communication technologies across all aspects of work and daily lives. By mimicking human capabilities and performing tasks faster and more accurately, AI is becoming the most influential technology component. Nevertheless, the adoption of AI in education is still at an early stage of development. Recent developments have demonstrated that AI techniques—particularly when combined with big data, analytics, and social networking—which are commonly used by major MOOC platforms, can be highly effective in personalised learning. The technology provides a large number of personalised learning pathways and enabling an adaptive presentation of content and additional different learning objects.

From the perspective of the higher-education instructors, a new class of intelligent-generation platforms provides a large number of personalised learning pathways and adaptive annotation and navigation through existing collections. These enable the modularisation of the course content and the subsequent generation of customised learning paths and documentation, enabling instructors to introduce personalised content and resources to students with preselected profiles automatically and in real time. However, this class of platforms still requires the instructors to obtain or author suitable learning objects to be employed in the course. Intelligent systems integrated into MOOC platforms can facilitate on-demand and just-in-time generation of personalised content in accordance with the learner profiles and learning scenarios, adopting a co-creation approach.

The infrastructure supporting MOOCs is complemented by continuing innovations in other areas. For example, to overcome the difficulties associated with the provision of pronounceable mathematical expressions across platforms and devices, a production method for mathematical expressions is developed that has three distinct processes: creation, metadata, and rendering. The production method can be achieved by combining TeX and MathML. The first process creates mathematical expressions using the original TeX code. The second process produces metadata based on the first process to realise mathematical expressions for teaching in e-learning systems. The third process converts TeX notations into marked-up data with tiny programs (Mathematical Expression Generation System [MEGS]) and renders the expressions in accessible formats.

8.1. Successful Implementations

Massive Open Online Courses (MOOCs) already generate significant economic value worldwide and perform a critical role in Brazil's engineering education (Yu et al., 2017). In parallel, Artificial Intelligence (AI) has rapidly achieved major breakthroughs in several domains from healthcare and education to robotics and finance. The two fields appear to converge with a growing interest in the integration and application of AI to MOOCs, already very attractive platforms for delivering top-quality online education worldwide.

Brazil is a world leader in E&T, ranking 2nd in Publication Production Index (PPI) with 109.5 and 3rd in Patent Production Index (PATI) with 122.2. Education still faces severe challenges to meet the growing demand for broader and higher quality education in Humanities, Science, Technology, Engineering and Math (STEM) areas. The government recently created a new national program providing smart grants for institutions to build innovative and disruptive courses in traditional and online education. A paradigm shift in the traditional systems is overdue. A new model is proposed here to deploy AI-powered MOOCs for STEM education in the following years.

The rapid deployment of AI-MOOCs will put into question the role of traditional institutions and universities. They will either embrace the model or become mainly administrative clusters promoting purely cultural functions to countries. Regional large urban capital and major state universities should be able to take a leadership role. The greatest impact will be in rural and regional areas where human and logistics infrastructure are more vulnerable, offering an unprecedented opportunity to make E&T truly unrestricted and available to all.

8.2. Lessons Learned from Failures

Even seemingly brilliant technologies and solutions are prone to error when placed in unfamiliar environments. The extension of Artificial Intelligence (AI) applications to mathematics Massive Open Online Courses (MOOCs), for instance, does not exempt them from this reality. Beyond the disclosed issues, there exists considerable wider room for investigation. Similarly, MOOC platforms can experience breakdowns. Lessons drawn from these failures are perpetually in need of updating (Soares and Paula Lopes, 2016) ; (Yu et al., 2017) ; (Azimi et al., 2020).

9. Future Trends in AI and MOOCs for Mathematics

Massive open online courses (MOOCs) represent a form of large-scale learning that has changed higher education. Advances in Artificial Intelligence (AI) will further enhance MOOCs, making enormous quantities of educational content more accessible and effective. In the past five years, MOOCs and AI have become a fertile avenue to explore their combined potential for mathematics education. However, creating MOOCs that effectively integrate AI remains challenging, and although they benefit the mathematical and educational communities, many AI-based MOOCs currently are impracticable or incomplete (Yu et al., 2017)(Betteridge et al., 2020).

The combination of AI and MOOCs represents a behavior that the mathematical community should proactively develop and promote. The continued emergence of cutting-edge AI technologies is certain and will inevitably create new ways to enhance MOOCs, increasing their accessibility, inclusivity, and scalability, and benefiting mathematics education globally.

The mathematical community should anticipate and embrace the innovations enabled by AI and MOOCs. Emerging technologies, including conceptual frameworks like human-centered AI and foundational approaches such as coded human intuition (CHI) and human-artificial intelligence collaborative platforms (HAICP), will drive the next evolution of MOOCs. To strengthen momentum further, a range of research initiatives are essential. These could include, for instance, organizing a multidisciplinary workshop to advance mathematical education through AI and MOOC integration.

9.1. Emerging Technologies

Emerging technologies entail the production, application or use of new or altered knowledge, products, processes, services and technologies. In large-scale open online teaching projects, the rapid development of emerging technologies accompanied by new methods and ideas has also played a very important role. In the context of the MOOC Spirit, combining the two can help teachers provide personalized teaching, customized teaching and perception teaching to students, fundamentally solving the problems of unbalanced quality and insufficient education resources at the global level.

Artificial Intelligence (AI) has more long-term impacts on education. With AI penetrating deeper into education, it will continually influence the formation of a new education ecology. As participants in education, students are the main body of education. Under the teaching mode of MOOCs, AI can provide moderate and personalized education for students. Teachers are the key to the knowledge transmission in education. In the era of AI, teachers also need to play the brain role, constantly update their knowledge and put themselves into the eternal pursuit of knowledge and enlightenment. Within the education system, AI supports the development of education by means of data, information and technology. Education systems can make full use of these elements for prediction, identification, discovery and evaluation.

9.2. Predictions for the Next Decade

In the next decade, the application of artificial intelligence (AI) in massive open online courses (MOOCs) will continue to influence the teaching and learning of mathematics in numerous ways (Yu et al., 2017). MOOCs have attracted attention because of several emerging challenges in higher education that they can potentially help address. MOOCs can provide a low-cost, readily available, and open-access platform for learning at scale. By leveraging computational and pedagogical advances in AI, MOOCs can support learners in ways that are deemed unachievable in conventional settings. For instance, AI systems have enabled the creation of adaptive platforms capable of generating personalized exercises and learning materials for learners. Using advanced natural language processing—which employs systems like support vector machines—some MOOC platforms provide automated assessments and feedback on writing assignments. Weakly-supervised techniques allow educational data mining to identify students with a high likelihood of dropping out, enabling the intervention of timely assistance. AI can also facilitate a collaborative environment by matching students to project groups with those having complementary skills or by allocating prospective teaching assistants who are highly suitable for specific requests (E. August and Tsaima, 2021).

Over the next decade, these AI and MOOC technologies will become part of the standard discussions in mathematics instruction. The intersection of MOOCs and AI will significantly influence how mathematics pedagogy evolves globally.

10. Ethical Considerations in AI and Education

The application of artificial intelligence (AI) to open and distance education raises several ethical issues related to the privacy of student data and qualifications and the reliability of AI results. These issues should be clearly addressed before AI-supported open and distance education becomes widespread. As AI-capabilities continue to grow and AI becomes increasingly humanlike, many fear that a dystopian future awaits where machines dominate humans or even destroy humanity. Realistic and practical assessments are required to discern the opportunities and threats that AI poses to humanity. A wide range of applications, from OpenCourseWare and casual learning to professional development and higher education, have adopted these changes. Pedagogies for effective learning through MOOCs therefore differ significantly from those used in face-to-face learning. The rich learning behaviour data generated by millions of students' interactions with online content have also opened up new possibilities for research: for example, it may now be possible to identify in the first few hours of a course the students most likely to drop out, providing opportunities for targeted support. AI techniques enable students to select their own learning sequences and pathways, thereby maximizing their accessibility to course materials. Teaching assistants can be matched more effectively to mediation tasks, while virtual learning companions can enhance completion rates as they generate both motivational and knowledge-level support, often exhibiting human traits to build rapport with learners. These capabilities also enhance educational research by revealing not only students' skill levels but also the raison d'être underlying that. While access to MOOCs will undoubtedly continue to expand, so too will the unregulated proliferation of student data. Unless the development and application of AI in MOOC learning are carefully controlled, some of the ethical risks may become adequately increased. In light of these considerations, possessing an awareness of AI ethics, including data privacy, responsible use, and potential biases, becomes a necessity for students, educators, and developers engaged with MOOCs. Within the educational context, the application of AI raises various ethical concerns related to personal data privacy, security, and integrity. These concerns represent the primary principles guiding the development and implementation of AI in educational settings (Yu and Yu, 2023). Proper regulation and an understanding of ethical AI usage can help mitigate privacy risks, a vital aspect for learners who require continuous access to materials and resources for their courses. AI also sheds light on issues of justice and fairness regarding equitable access, although achieving uniform equity remains difficult due to challenges such as lack of internet connectivity in poorer regions. Overall, principles of non-maleficence—ensuring that AI systems do not cause harm—and responsibility—tasking researchers and developers with preventing privacy intrusion while advancing beneficial AI technologies—are fundamental to conducting ethical AI-assisted education (Franco D'Souza et al., 2024).

10.1. Data Privacy and Security

Data privacy and security constitute major concerns in the use of AI and MOOCs for mathematics education. MOOCs that use AI to help determine users' interests and aid decisions about the next courses to take are highly data intensive. They consequently have to store plenty of detailed user interaction data and, in some cases, replicate it on multiple servers or share it with third-party providers. Losing control of such data or having it fall into the wrong hands has serious privacy implications, which adds to concerns users often have about government surveillance. Data-sensitive screenshots or spreadsheets uploaded during assessments further exacerbate this concern (Yu et al., 2017).

The most important security threats to AI- and MOOC-supported mathematics education are denial of service, extrusion of sensitive data, and manipulation of code or the training data of AI components. The first two commonly occur on web applications. The third, which can also cause extrusion of sensitive data, is less widely known but highly effective and difficult to counter, as AI components often use uncontrolled, publicly sourced training data.

The complex technical architecture of AI-, MOOC-, and mathematics-course integration creates a multi-faceted attack surface that starts at the AI and extends through various MOOC servers to mathematics-course content and then to the underlying mathematics institution. Integrity threats are particularly serious, as they enable manipulation of mathematics-course content or the results of AI-supported assessment and analysis.

The transparent, accountable, and fair deployment of AI in mathematics education requires a thorough analysis and resolution of systemic risks, as well as the incorporation of ethical AI standards into the overall AI design, development leading to deployment, and monitoring and maintenance processes (Radanliev et al., 2024). only a few such standards, however, currently exist beyond the well-documented AI principles published by many organizations.

Ethical AI preferably takes the form of a multi-modal, explainable human-in-the-loop system. In mathematics education, for example, student interaction models that dynamically update the student's competency level with respect to the topics covered by the course can provide personalized learning paths that reflect a student's strengths and shortcomings more accurately than manually specified alternatives. Modeling student sensibilities and detecting when intervention is necessary opens up ways for chatbots to act as learning companions that collaborate with a mentor instead of replacing one. Automated crackdowns on abusive language can also minimize the potential harm to sociable students or that caused by their inadvertent sharing of personal information. Aspects such as informed consent and information management must be made impossible to omit from any implementation—particularly when children are involved. Careful consideration of multi-modal inputs is necessary to ensure that audio, visual, and textual content does not facilitate either the generation or acceptance of inappropriate language (Lakkaraju et al., 2024).

10.2. Bias in AI Algorithms

Bias in AI and machine learning encompasses systematic preferences that extend beyond mere deviations from data consistency. It represents a predisposition favoring certain outcomes, which often manifests as systematic errors or prejudices (Englert and Muschiol, 2020). Google's facial recognition software exemplified harmful consequences of bias by misidentifying individuals owing to skewed training data. Identifying and addressing such biases is critical, especially within training datasets where missing features induce semantic bias and dependent features cause syntactic bias. Remedial countermeasures include root-out-bias processes requiring human oversight and data preprocessing through transformation techniques. In tandem with concerns about algorithmic bias, cognitive biases affecting users' interpretation of machine learning (ML) models are gaining attention. Base rate neglect—a failure to appropriately consider prior probabilities—leads to erroneous perceptions and irrational decisions, and remains prevalent among students learning ML concepts (Mike and Hazzan, 2022). Approximately one third of participants in an introductory ML course misjudged algorithmic performance because of this bias. Efforts to enhance model transparency have yielded interpretable architectures and explanation methods designed to mitigate misunderstanding. Since the manner in which humans perceive and comprehend ML models influences their susceptibility to cognitive biases, addressing these deficits is pivotal for education and technology development. Algorithmic bias within educational settings commands particular scrutiny owing to the risk of discriminatory treatment and attendant social, ethical, or legal ramifications. Investigations at a large Filipino university, involving seven million Canvas LMS access logs and binary grade prediction models, detected no unjust bias against any regional student group (Švábenský et al., 2024). Algorithmic bias may infiltrate any phase of the educational data mining pipeline and has been extensively examined in United States contexts; however, regional bias outside this domain has received limited evaluation.

11. Comparative Analysis of Traditional vs. AI-MOOC Learning

Greater understanding of modular measures, relevance to applications and linkage with mathematics of complex systems were the main ejeds; also a comprehensive tutorial for meteorologists and modellers was amongst the planned outputs.A European Study Group with Industry (ESGI) involved a leading manufacturer of sealants (4del) and experts from several universities and met with them over a three-day period to examine ways of coupling acceleration with temperature to development of a new parameter that could better represent the ageing process of a sealant.Elastic rods were investigated in the context of cables undergoing snap-buckling during installation, with developments of the Elastica solution and some equations presented.

(Yu et al., 2017) attempt to answer why personalization is not widely adopted in MOOCs despite its benefits. In the definitions of personalization, the learner model played a vital role as it contained the information of individual learners that allowed teachers/instructors to adapt the courses accordingly. Personalization could be machine-driven or interaction-driven. Tele-immersive systems demonstrated the potential of AI to enrich learning experiences. Chatbots or human-computer patterned conversational techniques seized attention as a means to deliver personal lessons. A personalised reflection appraisal and recommendation system monitored discussions and guided the learners to reflect on their performance. One-to-one learning was the highest level of personalised tuition, but it was expensive and far from scalable.

Two individuals were involved in a MOOC with the aim of studying the effectiveness of such courses. The experience was novel. The impact of either underestimating the time to complete the course, the sense of isolation, the massive workload or the bounce rate was not taken into consideration.

11.1. Student Outcomes and Engagement

Student outcomes and engagement are important indicators of the effectiveness of courses (Yu et al., 2017). By analysing how learners respond to various types of pedagogy, instructors can better adjust courses for better results. Massive Open Online Courses (MOOCs) are making it ever easier to deploy experimental courses, with universities around the world offering sample courses for free with zero entry criteria. Still, many educational institutions are reluctant to invest, for fear of having unfilled lecture halls with empty seats. If MOOCs can yield similar student outcomes to more conventional classroom education, open access would become a viable alternative to traditional education.

Building on the expertise gained from her MOOC, Mona Diab, Director of the Natural Language Processing (NLP) lab at George Washington University, recently started examining the potential of Artificial Intelligence (AI) to provide solutions for many of the challenges of MOOCs, such as scalability, high dropout rates, content automation, and adaptive personalization. AI-enabled approaches are used widely to improve scalability and personalization in various online courses. Similar approaches can support other aspects of MOOC success. MOOCs already include some aspects of adaptive learning and personalization. Nevertheless, the inherent scale of MOOCs challenges manual approaches, e.g., course monitoring and student assessment operations require huge attempts. As such, these tasks must be automated to guarantee success. AI, already applied in areas of adaptive learning and personalization, constitutes a promising solution here.

11.2. Cost-effectiveness Analysis

Cost-effectiveness is a critical concern in the examination of AI and MOOCs applied to mathematics education. These approaches require significant resources, and novice teachers in particular need help evaluating their merits. AI and virtual learning environments are being explored to address these challenges.

The MOOC platform is an economically advantageous infrastructure for wide-area learning. It facilitates online access at low or no cost to university courses open to thousands of students; it is designed for use by an unlimited number of learners and in principle requires few human resources. These features correspond to “low input data” and “few extra activities,” which help minimize operating costs (Yu et al., 2017).

Introducing AI can enhance these virtues by enabling students to adopt learning styles most appropriate to their needs. AI emulates human reasoning and behavior, with applications ranging from personal-assistant systems such as Siri and Alexa to automatic translators and interpreters. AI learning systems promote efficient use of MOOC materials. Machine learning algorithms identify behaviour patterns and recognize students’ interest, which helps determine the appropriate offers. AI configures automatic personalized recommendations and error detections, generating the correct hints according to individual performance. Intelligent-learning systems automatically produce quizzes, exercises and tests tailored to the students’ progress (Azimi et al., 2020).

12. The Role of Instructors in AI and MOOC Environments

When mathematics is taught through AI and MOOCs, the role of an instructor changes. Lectures can be recorded, word problems can be constructed by AI, and tutorial services can be offered remotely by both AI and human instructors. The role of a human instructor shifts from disseminating information to providing targeted assistance and emotional support. An instructor, either in a typical class or in a MOOC, would be challenged to help a large group of heterogeneous students. The specialist can combine classroom and remote expertise, providing at least a temporary solution to the problem. Instructors need training to deploy their expertise through digital channels and to interact effectively with AI conversational agents that augment tutoring by responding to learner questions and providing personalized assistance and reinforcement of concepts (Yu et al., 2017)(E. August and Tsaima, 2021).

12.1. Facilitation vs. Traditional Teaching

The Massive Open Online Course (MOOC) offers free and unlimited online access to lectures and teaching materials (Yu et al., 2017). The lecture videos are usually self-recorded by university lecturers, sometimes by academic mass organizations. Classical areas of Mathematics have generated a library of such classical lectures and textbooks. The MOOC platform acts as a service platform to disseminate the mathematical knowledge worldwide and train the teachership, on the condition that the classical lectures can meet the didactic requirement to System Mathematics. Simply reproducing the classical lectures is deadlocked in a pedagogical point of view. The classical concepts and ideas must be fused with modern communication; research and education combined in a pedagogical model. Otherwise, the classical lectures that attest the holy writ of the Mathematical tradition remain bold that cannot enter into the System Mathematics. A thousand lectures do not replace good learning events.

Mathematical knowledge sets foresight concepts and ideas that have to be exposed and whether the theoretical courses can be done within the Mathematical Framework. They constitute the logical basis from which the supplementary sciences—terminating study for example—can be developed. Within the didactic requirements some shifts have to be operated, at the Mathematical level, as the emphasis on groups for example (rather than ring, vector space, field) since the notion of structure plays a decisive role in research, mostly for theoretical physics, but also analysis. While in the science learning (which is at the origin of the system) usually linear methods set a bias and smoothing on the complex phenomena, working through groups cover the whole Mathematical: objects, structures, theories and which cannot be bypassed. Mathematics is at the centre that iterates the teaching and works through the principles of relations and cognitions. If Biology or Physics involve a part of probality theory or partly Statistics (which in principle are applied Science rather than Mathematics), Mathematics have the primary role. Mathematics can be investigated through social theory; thus determine the foundation of Medical biology-Raymond Grand's lecture towards a philosophy of physics.

12.2. Professional Development for Educators

The majority of teachers feel inadequately prepared to meet the needs of their students, a situation particularly acute among educators working with disadvantaged youth (Laurillard, 2016). The limited opportunities for continuing professional development in many countries compound this challenge. Massive Open Online Courses (MOOCs) can help fill the gap, as shown by evidence from a highly successful pilot MOOC for teachers of primary-school mathematics in the Caribbean. The course convinced 87% of respondents to change their teaching practice and significantly increased teachers' confidence and their understanding of how to use Information and Communication Technologies (ICT) in education. The co-learning model, in which teachers engaged as learners, was instrumental in this success. The potential of MOOCs for professional development also extends to emerging economies where informal or private-sector schools are filling the gaps left by weak or insufficient national provision.

13. Student Perspectives on AI and MOOCs

Modern educational innovations remain insufficiently embraced by many students, teachers, and institutions. According to a survey of more than 1,500 respondents, 20 % report having neither used artificial intelligence nor online mathematics courses in their learning activities. In contrast, 60 % have used both artificial intelligence and Massive Open Online Courses (MOOCs) (Yu et al., 2017). This disparity in adoption suggests that AI and MOOCs require greater exposure and public endorsement to facilitate widespread integration.

Although MOOCs lack the tangible contact of traditional classroom environments, the majority of learners acknowledge that the convenience afforded by access to lecture videos, forums, quizzes, and supplementary resources adequately addresses their desire for student-teacher engagement. Furthermore, emphasis on learning at an individual pace mitigates concerns about instructor attentiveness, fostering a suitable environment for gradual and dialectical understanding of mathematical concepts and problems. Nonetheless, challenges within MOOC platforms persist, notably the limited opportunities for real-time peer support, which some students find critically lacking in the educational process.

Underpinning the educational framework is a clear appreciation for self-regulation and time management. Most respondents indicate that positive experiences with these attributes motivate continued engagement with digital learning modalities. In contrast, struggles with self-discipline precipitate frustration, often culminating in withdrawal from the educational program. Consequently, while educators endeavour to generate interactive tools and course materials conducive to learning, student proclivities toward interactive games, evaluative challenges, and peer collaboration remain influential determinants of sustained participation. These observations underscore the necessity for MOOC developers to incorporate self-assessment toolkits and to foster collaborative interfaces that address motivational factors and facilitate persistent engagement.

Integrating the perspectives and motivation of mathematics students plays an influential, if often overlooked, role in the successful implementation of AI and MOOCs. Evaluation of student feedback on forms of support, interactivity, and independent learning offers guidance in developing digital course design and technological development. Balancing instructor autonomy with student input, AI platforms can respond in a supportive yet non-intrusive manner that encourages progress through difficult material. Moving forward, the integration of Artificial Intelligence and MOOCs facilitates robust, scalable instruction especially suitable to STEM education. Authoring courses of this nature alleviates pressure on educational infrastructure while maintaining equivalent value to traditional classroom settings.

13.1. Surveys and Feedback Analysis

Surveys and academic feedback are essential to improving learning. Feedback strategies can increase motivation and fostering tutoring feedback and other forms of information that help learners understand the course content can contribute to higher achievement in multimedia learning. Understanding or predicting MOOC completion in terms of student intent, situational interest, and engagement is critical to improving MOOCs. Designing feedback in new and more informative ways that keeps students attending courses is crucial and the effectiveness of that feedback and of the actual learning is also highly important.

Surveys and academic feedback have been used to assess what learners find attractive and unattractive in STEM MOOCs and which specific aspects of the courses can be improved. This analysis was based on the open-ended feedback of the three post-course survey questions: which part of the course did you like the most and why? Which part of the course did you dislike the most and why? How could the course be improved? A total of 133,000 answers from 12 different STEM MOOCs offered by FutureLearn were then analysed by means of a text mining technique called latent Dirichlet allocation (LDA) topic modelling coupled with qualitative analysis.

Mathematics is a core aspect of many fields in Science, Technology, Engineering and Maths (STEM) education and, therefore, most STEM MOOCs have a strong mathematical component. Student attitudes to substantive online assessments requiring mathematical answers can provide valuable insights. These students have access to detailed online feedback and the effect of formative feedback plays a significant role in their perception of educational technology. Online feedback is considered more enjoyable and useful than traditional methods. Attitude and enjoyment emerge as the primary factors influencing the intention to use online assessment tools. Additionally, confidence in using computers and the available support for Information Technology remain vital, even for digitally native generations, in effectively leveraging online assessments to enhance mathematical learning.

Better understanding of what learners like and dislike about the courses they take and about their attitude to the way they are assessed contributes to design better courses. Increasing motivation and fostering more engaging feedback can contribute to higher achievement and towards improving learner retention (Gentry, 2019).

13.2. Case Studies of Student Experiences

Research into Massive Open Online Courses (MOOCs) has produced several case studies, which reveal a significant divergence in the success and failure of various initiatives. Some attempts have been highly successful, while others have not.

It is illustrative to consider the contrasting experiences of two M.Sc. programmes in mathematics: one in the Middle East and one in Africa. Both programmes emphasise the role of Massive Open Online Courses (MOOCs), but student experiences differ materially despite the novelty of the MOOCs.

Instructors find themselves not merely disseminators of knowledge but also facilitators and motivators. Pedagogical techniques evolve, with MOOC-centred syllabi increasingly encouraging students to develop selective and critical study strategies (Betteridge et al., 2020).

14. Collaborative Learning in AI-MOOC Settings

Massive Open Online Course (MOOC) providers have made various attempts to scale collaborative learning, which appears intrinsically counter to the widespread MOOC paradigm of individualized instruction and assessment. Collaborative activities can, nevertheless, be effective in handling the hundreds of thousands of users that the largest MOOCs have attracted, enabling more sophisticated interactions between small subsets of students than can be coherently administered by instructors or TAs, and relying on a decentralised distribution of work. In this light, collaborative learning can be considered a key mechanism for distributing and reducing the provision of direct instruction across large populations. Further, given the role that a dialogue between student and tutor plays in the development of a comprehensive understanding, collaborative learning in AI-MOOC settings offers an alternative means of establishing this dialogue and reinforcing its benefits (Yu et al., 2017).

14.1. Peer Interaction and Support

Collaborative learning enriches students' educational experience through social interaction, joint effort, and peer review; it has been a fundamental component of in-person education for centuries, and one would expect that the inherently social environment of MOOCs would be conducive to such collaboration (Martin and Pease, 2013). Broadly defined, collaborative learning occurs when learners work together towards a common goal or purpose (Tegos et al., 2021). While many of the major platforms host well-attended discussion forums, collaborative learning through group engagement is less common; even when participants have the opportunity to collectively pool knowledge and reflect on materials, they do not always do so (Yu et al., 2017). For smaller groups, the problem of establishing synchronous collaboration is even more pronounced; a lack of coordination among distributed learners may prevent groups from discussing critical ideas in real time, or from generating authentic engagement altogether.

In conventional learning environments, instructors may serve as moderators for participating groups and can nudge conversations towards productive lines of enquiry; the high student-to-staff ratio commonly seen in MOOCs, however, means that providing discussion oversight at scale is an unattainable goal. Agents may offer an alternative by acting as proxies and conversational partners for extroverted members of the group, and by nudging and engaging quieter participants during periods of prolonged inactivity. By guiding the collaborative discussion towards critical pedagogical objectives, agent-supported peer collaboration can satisfy the popular call for more meaningful peer engagement while simultaneously reducing attrition and dropout from the course.

14.2. Group Projects and Assessments

Group assignments constitute a major component of many MOOCs and a number of assessment methods have been proposed and implemented to investigate learners' behaviours and patterns during collaborative learning (Yu et al., 2017). The role that a student plays in group projects and the project mark allocated to a student can be computed by analyzing the interaction data logs with the e-learning platform. However, these methods usually examine only a single property of the collaboration process. For example, algorithms such as text clustering focus on the linguistic patterns of collaboration, while social network analysis methods investigate the topology of the network but do not consider features such as project content and information flow. Collaborative learning is argued to be a form of knowledge building in which members build upon each other's contributions. Many current collaboration systems support collaborative knowledge building through the use of explicit, structured and multimodal representations such as concept-maps, diagrams and models.

15. Global Perspectives on AI and MOOCs in Mathematics

Geographical, cultural, and social factors combine to shape the global adoption of AI and MOOCs for mathematics. In some areas, robust digital infrastructure and positive governmental policy have enabled full integration of MOOCs into broader learning approaches. Elsewhere, lack of infrastructure and low digital literacy inhibit effective use. Variations in culture, pedagogy, traditions, and language also create barriers to worldwide implementation and acceptance of these online resources (Yu et al., 2017). Global partnerships can help overcome these barriers and increase access to course materials, while also producing new strategic and operational insights for organizations (Betteridge et al., 2020).

15.1. Regional Variations in Adoption

The advantages of artificial intelligence (AI) and massive open online courses (MOOCs) in mathematics education play out on a broad regional scale. For example, in many parts of the world widespread disparities in secondary-school mathematics attainment limit educational opportunities in affected areas. Massive open online courses can provide a flexible, cost-effective platform for delivering adapted courses to help alleviate these variations.

The widespread availability of high-quality free online mathematics courses makes it possible to support remote areas where educational standards fall short, safeguarding academic progress and mobility. The IPP MOOC platform OpenED, launched in 2013, extended its platform to mathematics programmes and launched its first mathematics MOOCs, offering courses in Probability and Combinatorics, and Differential Calculus in 2014. MOOC provision has now been extended to a wide range of other scientific disciplines.

The flexibility of delivery and collaborative approach provided by MOOCs has led to a region-specific programme, Math Without STRESS, launched in 2015. This initiative targets regions with high dropout rates due to insufficient mathematical background, delivering a structured mathematics programme that can be taken alongside a regular course. It directly supports university graduates as well as current secondary-school pupils. IPP, in close collaboration with the Ministry of Higher Education and Scientific Research, has taken the fee and admission barriers as well as the widespread student dropout into consideration, aiming to provide a free of charge widespread access to quality learning. The goal of this open platform is to develop a backbone of courses and learning materials addressing the needs of learners with significantly different educational backgrounds, enabling the careful placement of students onto higher-level courses and supporting structured skill acquisition for either dropout or direct academic progression. (Yu et al., 2017)(Soares and Paula Lopes, 2016)

15.2. International Collaborations and Partnerships

The global nature of both MOOCs and AI naturally leads to international collaboration. In the USA, Europe, and Asia, organizations and individual lecturers share open access courses and resources. Institutions with a tradition of working at a distance, such as the Open University UK, are extending teaching areas and student numbers by making course material available more widely. However, access to courses and examinations alone is not the full solution to a shortage of expertise and course availability (Yu et al., 2017). A realistic alternative makes use of AI to help design and support an intelligent, replicated, and personalised system. AI techniques have been used for many years to support mathematics teaching and research. With the availability of MOOCs and e-assessment, in principle it is possible to have a system where the student gains knowledge on demand, can have tutorials and modelling to determine what help they need, work throughout the year with test feedback and advice on improvement, and then take degree examinations.

16. Conclusion

This paper has surveyed recent work on the use of artificial intelligence (AI) and Massive Open Online Courses (MOOCs) in higher education, with a specific focus on mathematics. As digital platforms for the delivery of degree-level mathematical science education continue to expand and diversify, AI and MOOCs are central to innovation in distance learning and teaching. MOOCs are sweeping the post-secondary sector (Soares and Paula Lopes, 2016) , while AI tools pervade numerous aspects of modern life (Betteridge et al., 2020) and have the potential to transform mathematics learning opportunities for students globally (Yu et al., 2017). Further developments and research in this area will therefore be crucial to future sustainable growth in the discipline.

References:

1. Yu, H., Miao, C., Leung, C., and John White, T. "Towards AI-powered personalization in MOOC learning." 2017. ncbi.nlm.nih.gov

2. Soares, F. and Paula Lopes, A. "Teaching mathematics using massive open online courses." 2016.

3. Betteridge, J., Y. S. Chan, E., M. Corless, R., H. Davenport, J., and Grant, J. "Teaching Programming for Mathematical Scientists." 2020.

4. Ling Lim, S. and Sing Goh, O. "Intelligent Conversational Bot for Massive Online Open Courses (MOOCs)." 2016.

5. Iniesto, F., McAndrew, P., Minocha, S., and Coughlan, T. "An investigation into the perspectives of providers and learners on MOOC accessibility." 2017.

6. Azimi, S., Popa, C. G., and Cucić, T. "Improving Students Performance in Small-Scale Online Courses - A Machine Learning-Based Intervention." 2020.

7. E. August, S. and Tsaima, A. "Artificial Intelligence and Machine Learning: An Instructor's Exoskeleton in the Future of Education." 2021. ncbi.nlm.nih.gov

8. Yu, L. and Yu, Z. "Qualitative and quantitative analyses of artificial intelligence ethics in education using VOSviewer and CitNetExplorer." 2023. ncbi.nlm.nih.gov

9. Franco D'Souza, R., Mathew, M., Mishra, V., and Mohan Surapaneni, K. "Twelve tips for addressing ethical concerns in the implementation of artificial intelligence in medical education." 2024. ncbi.nlm.nih.gov

10. Radanliev, P., Santos, O., Brandon-Jones, A., and Joinson, A. "Ethics and responsible AI deployment." 2024. ncbi.nlm.nih.gov

11. Lakkaraju, K., Khandelwal, V., Srivastava, B., Agostinelli, F., Tang, H., Singh, P., Wu, D., Irvin, M., and Kundu, A. "Trust and ethical considerations in a multi-modal, explainable AI-driven chatbot tutoring system: The case of collaboratively solving Rubik's Cube." 2024.

12. Englert, R. and Muschiol, J. "Syntactic and Semantic Bias Detection and Countermeasures." 2020. ncbi.nlm.nih.gov

13. Mike, K. and Hazzan, O. "Base rate neglect in computer science education." 2022.

14. Švábenský, V., Verger, M., Mercedes T. Rodrigo, M., James G. Monterozo, C., S. Baker, R., Zenon Nicanor Lerias Saavedra, M., Lallé, S., and Shimada, A. "Evaluating Algorithmic Bias in Models for Predicting Academic Performance of Filipino Students." 2024.

15. Laurillard, D. "The educational problem that MOOCs could solve: professional development for teachers of disadvantaged students." 2016.

Gentry, A. "(POSTER) A Birdu27s-Eye View of What Learners Like and Dislike about STEM MOOCs Using Topic Modeling." 2019.

Martin, U. and Pease, A. "What does mathoverflow tell us about the production of mathematics?." 2013.

Tegos, S., Mavridis, A., and Demetriadis, S. "Agent-Supported Peer Collaboration in MOOCs." 2021. ncbi.nlm.nih.gov