Artificial Intelligence: Challenges and Opportunities in Postsecondary Mathematics Education

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The introduction and widespread adoption of generative AI tools pose new challenges and present new opportunities in various fields, including Mathematics Education. This paper reflects on these opportunities and challenges through the lens of the Postsecondary Mathematics classroom and curricular development and urges the Mathematics Community to be prepared for the implications and embrace generative AI tools in postsecondary mathematics education.

Classroom Challenges

Ethical Uses by Students

Since the unveiling of generative large language models, perhaps the most broadly discussed concern in the classroom setting is cheating. This issue affects all academic disciplines to varying degrees. Some institutions have already issued broad guidelines for setting classroom standards on the use of AI (see references 1,2,3). Mostly, these guidelines repeat the common practices for the ethical use of any reference material and apply to mathematics as much as any other discipline. For several decades now, mathematics instructors have learned to set clear classroom standards on using technology tools for homework and exams. Until now, these measures have mostly been needed at the introductory level, where a significant portion of learning goals are numerical or symbolic computation. However, the new AI tools threaten to broaden the courses for which guidance is necessary. At this point, AI tools do not seem to be adept at providing correct mathematical proofs, even at the introductory level. Still, it is conceivable, and likely, that this will be an issue in the near future (see reference 5). Setting clear guidelines on using AI on homework and exams in "proof-based" courses at this early time will help establish norms that will be useful as these tools improve. At a minimum, guidelines should expect attribution when AI is used to assist in solving a problem, along with the expectation that the student is responsible for checking the accuracy of the AI-assisted work.

Ethical Uses by Instructors
As students should be taught and required to give proper attribution for the use of AI in their work, so should faculty learn and use best practices in attribution for the use of AI in their own public-facing material, both in research and teaching.

Furthermore, generative artificial intelligence (GAI) models raise questions about students' right to privacy. (See reference 6 for a broader discussion of this issue.) Generally, it should be assumed that work entered into the cloud of searchable material may be used for training material in these models. Uploading a student’s work to a website (perhaps to check for plagiarism) could make that work available to a public platform. Faculty who plan to use such tools should clearly inform their students in the course syllabus.

Finally, as faculty begin to develop assignments and exercises requiring the use of GAI models, they should pay attention to questions of accessibility and equity, as they would with all course materials.

Other Concerns

The present pervasiveness of technology in our classrooms and the incipient addition of AI models to this presence raise new concerns for our students. Perhaps the most important of these is the possibility of student isolation from human interaction. More and more, students, faculty, and administrators are finding it convenient and comfortable to replace the standard classroom experience with online learning. Unfortunately, the resulting lack of human interaction can lead to depression and social anxiety (see reference 7). Although working with technology and online materials can provide accessibility, faculty must be attuned to the possible hazards that can arise.

A similar concern is that overuse of these tools might make students too reliant on technology. Students must be reminded that although these tools may be valuable for exploring a mathematical concept, they are no substitute for understanding. More than ever, students will need to learn to be responsible for checking their own understanding of a concept.

Classroom Opportunities

While it is advisable to proceed cautiously, generative AI provides many opportunities in the classroom. In the past few decades, many mathematicians have found great success in adopting the use of technology such as symbolic manipulation and computer visualization to give a richer context to difficult mathematical concepts, especially at the introductory level. Generative AI promises to bring a new set of computational tools to mathematics education.
These tools can range from developing worksheets, homework, and assessment tools for traditional mathematics tasks to introducing new learning opportunities based on direct student interaction with generative AI tools. We strongly encourage the mathematics community to explore these opportunities and to develop forums for sharing insights and materials. The AMS may have a role to play in supporting this process by maintaining a list of resources for mathematicians.

The fact that the presently available generative AI models are not currently adept at mathematical reasoning can provide opportunities for students to practice critical reading and mathematical reasoning skills. A student can be asked to prompt ChatGPT to provide a proof and then to critique this proof. Is it correct? Are there “skipped steps”? If incorrect, how can it be corrected? A variation on this is to ask the student to explore and critique a general mathematical topic using ChatGPT. (Reference 8 describes the experience of a historian using such a teaching method.) These types of problems can bring a research aspect into the undergraduate curriculum that can be difficult to incorporate in a traditional classroom, teaching students how to take responsibility for their own learning.

Finally, the depth of ethical issues that are becoming evident in the widespread use of AI provides a unique opportunity to discuss these issues in the mathematics classroom. Students can learn that developing sophisticated mathematical tools can have societal effects, good or bad, and be aware of the complexities surrounding equitable, ethical use of these tools.

**Curriculum development**

As the utility of mathematics applications has taken hold across many disciplines beyond physics and engineering, there has been much discussion of adjusting the standard STEM pathway in undergraduate programs. The emergence of AI underscores the necessity of continuing this discussion.

Concepts from calculus, such as optimization, approximation, and gradient flow, are certainly fundamental to understanding the inner workings of modern machine learning. However, many other mathematical fields, including linear algebra, numerical analysis, combinatorics, and probability, also play a crucial role. The mathematics community is encouraged to continue developing innovative course materials at the introductory level to deliver the necessary tools to students interested in modern applications, including AI. Again the AMS may have a role to play here by creating forums for sharing such materials.

In the future, GAI may create new career tracks for mathematics majors, requiring different technical competencies. Ideally, course offerings will adapt to serve these changing needs.

Similarly, understanding the deeper theoretical issues that abound in GAI and large language models will require researchers with a strong foundation in advanced mathematics.
Departments should consider developing courses, pathways, and programs at the graduate level that prepare students for careers in research and development in both industry and academia.

The abilities of AI tools to solve routine college-level mathematics problems is already significant, and is progressing rapidly. Students may benefit by learning how AI can be used as a tool for the subject matter and clarify current technology's limitations. Learning goals for courses may evolve accordingly. These principles apply equally at the graduate level; all graduate students should be exposed to modern AI as part of their training, even in pure disciplines.

References

4. University of Maine, Learn With AI: https://umaine.edu/learnwithai/