Introduction

Aristotle says that “every art and inquiry, and similarly every action and pursuit, is thought to be some good.” (Aristotle 1) In the realm of mathematics, what, then, is the primary good? Some believe it might be utility, but some say it is understanding and process. Such a question matters more than ever, especially in the context of modern day debates surrounding mathematics education and the permissibility of Artificial Intelligence. Systems such as Large Language Models and Automated Proof Assistants have seen significant use and prominence not only in education, but also in academic research. In this paper, I will put forward the argument that mathematics is an art, and should be treated as such. If mathematics is an art, then, AI affects more than outcomes - it affects an artistic process. This challenges the ethical guidelines for proper AI use in mathematics, as it may impact the fundamental experience that mathematics affords beyond utility: the development of resilience, logical rigor, and the discipline of not knowing in a culture obsessed with certainty.

Mathematics and Metaphysics

To begin, it is important to establish what mathematics is, and what, if any, is the primary good(s) that it pursues? Mathematics can be thought of either as a philosophy, and to some degree, a language of reasoning. Initially, mathematics was a way of describing the physical world. It was a mostly empirical system. For instance, you might denote the amount of rocks by assigning a natural number to such a rock and counting the number of rocks in a set. Of course, this dips into a metaphysical quandary: does math exist in reality, is it a set of rules we can use to describe reality, or maybe something ideal or fictional, like a platonic form? These questions can be endless, so it is important to proceed with the least amount of assumptions possible.

Modern mathematics is constructed by a set of rules called *axioms*. Axioms can take many forms, and there is still fruitful discussion over the decision of what axioms to use or not given a certain mathematical problem. However, for all intents and purposes, most mathematicians abide by a set of axioms called the *Zermelo–Fraenkel set theory* including the so-called *Axiom of Choice.* This set of axioms is commonly abbreviated as ZFC theory, and was a hotspot in mathematics during the 20th century, when new papers discussing self-inconsistency issues in mathematics came into fruition. This ZFC theory was very controversial and has challenged the thought that mathematics is simply a system that constructs the real world. Whether it is developed through discourse, or is in some abstract realm we can not access is still debated, but it is safe to assume that mathematics is interfaced by the mind.

This process of construction continues by defining definitions (which themselves might be thought of as axioms) and then exploring their respective consequences. Of course, certain definitions might be constructed as the result of a priori knowledge, such as in the case of ZFC axioms. These definitions are generally constructed either with the idea of studying a new system, or might be implemented so as to make an already existing system self-consistent. AI

has already been implemented in some of these fields, with some researchers and mathematicians developing *Automated Proof Verifiers* to verify this self-consistency. To summarize: it is important to choose a consistent axiom system, and this consistency is thought to contain some beauty.

On the topic of beauty, one of the most beautiful theorems or formulas in mathematics is Euler's formula given by

$$e^{i\pi} + 1 = 0\,.$$

This formula, beyond its visual appeal, illustrates one of the chiefest goods in mathematics: the unification of seemingly disparate realms of mathematics. It relates irrational numbers, rational numbers, imaginary numbers; geometry, algebra, analysis into elegant, yet surprising harmony. This unification exemplifies why mathematics, like art, seeks more than utility; it seeks coherence, structure, and beauty itself.

This search for elegance corresponds to the Aristotelian definition of art, mathematics is an art itself because mathematics is a *mimesis,* that is, a representation of reality. It follows then that the qualifications of a great mathematician are in some way equivalent to that of a great artist: great artists are those that seek art for the sake of process rather than the final product. This, of course, is not to say that the end product is not laudable or beautiful per se. But, as Aristotle says, the object is sought for the sake of the process, so the process of creation is thought to be the chiefest end. Under the supposition that math is interfaced by the mind and is an art, it follows that using tools such as AI (or even tutors) can bypass the mind, leading to a diminished interaction with mathematics.

Is one thought to be a good mathematician if they know the most beautiful formulas? I would argue that this is not the case, for then anyone could become a great mathematician without needing what are thought to be the components of a great one: creativity, vision, and effective mathematical communication. These ideas are in alignment with the artist, but the canvas might be thought of as the rules of mathematics.

Mathematics as an Art

It is an immediate corollary, then, that a great mathematician is a mathematician who has some sort of vision - a way of understanding and generating mathematics from their mind.

It is now important to investigate how LLMs might impact this vision and consequently their art. LLMs may impede mathematicians to the same degree as it might impede artists, that is, blocking creativity and critical thinking skills. Artists are known for implementing creativity and exploring some representation of reality, which is usually nurtured by large amounts of practice and consumption of other art.

Like the artist, mathematics requires creativity and, above all, consistency. This combination can be nurtured by effective mentors and good teachers, but more than anything else, mathematics is about truly understanding each step that you make . Proofs and mathematical constructions require intense work and understanding, which may be useful to supplement with AI in the short term, but will negatively impact general understanding in the long run. Proofs are profound ways of acquiring deep understanding of mathematics, but also logic and thinking itself.

It is no surprise then that the most effective way to learn mathematics is to prove theorems and to understand your definitions, and then put pen to paper. Sometimes what you write is complete and utter nonsense, but understanding follows suit. If something does not work, you know more than when you started. Terrence Tao, one of the most famous mathematicians in the world likens mathematics to “Playing Chess with the Devil.” He learned this idea from fellow mathematician Charles Fefferman, and goes onto explain that Devil’s chess has “special” rules: “The devil is vastly superior at chess, but, Fefferman explained, you may take back as many moves as you like, and the devil may not. You play a first game, and, of course, ’he crushes you.’ So you take back moves and try something different, and he crushes you again, ‘in much the same way.’ If you are sufficiently wily, you will eventually discover a move that forces the devil to shift strategy; you still lose, but — aha! — you have your first clue.” (Cook)

There is an analogy that can be drawn here: AI is known to cheat in chess. According to some research, modern LLMs will actually cheat in chess matches when the models are close to losing. (Barlow) LLMs in particular are known for their tendency to “hallucinate” results, and will on occasion generate incorrect results or statements, challenging the validity of a work. It follows then, that using AI can be potentially incompatible with the vision of mathematics as an art if not used properly. If AI is willing to bend the rules in chess, it can be seen that LLMs in particular may be prone to bending the rules of mathematics.

Of course, this reluctance to receive help could be interpreted as borderline sado-masochism, which would very aptly characterize many mathematicians. The idea is simple: success in mathematics requires hundreds of thousands of failures and deadends. Mathematics is cold and unforgiving, but such circumstances have the proclivity to breed beauty and meaning in the face of adversity, which can be a component of happiness. AI’s affordances and limitations in this context are then clear: AI can be useful, and perhaps necessary in contexts where you can not make the first move, but it’s in wrestling with the devil where we truly learn to think, to adapt, to understand the underlying patterns. The LLM might make the move for you, but cannot teach you to see the board.

Utility, and Modern Consequences of AI Use in Mathematics

The use of AI in mathematics at the surface level presents the following problem: will people use AI to encourage the process of learning mathematics, or will people use AI to solve mathematics itself without understanding it themselves? The answer to this question has many variable dependencies: how dense course workload might be, external factors, and even

frustration or burnout, all of which are reasons for general use of AI in academic contexts. Some of these reasons can be boiled down to the following reason: people treat mathematics as a tool rather than as an art.

This proposes a few caveats to the artistic perspective: there might be people who use mathematics as a means of achieving some societal good, like developing frameworks for new technologies, to apply to real world problems or may simply do it because they are told to. There have always been challenges to my idealized form of learning mathematics, such as time constraints and difficulty hurdles, and as time has gone on, students have found better ways to avoid these barriers to completion such as through the use of the internet, textbooks and AI. Though AI is thought to be terrible at math, AI can be a very effective guide or mentor when there are none available. AI, then, can actually be a very useful tool for solving mathematical problems and inducing deep understanding, but should not be the main means of solving a problem.

These concerns are not present for just students. In the realms of academia, AI simultaneously threatens yet creates hope for improved academic integrity. It might be a solution to its own problem through the use of automated proof assistants, which if implemented correctly, could actually strengthen the integrity of mathematics. Papers that are submitted to journals must undergo refereeing and massive amounts of rewriting and planning. If possible, referees who have prior background in these topics could use automated proof assistants to verify these mathematical papers to ensure they are correct. However, the proofs that are correct could certainly still be generated by AI. For instance, Argonne's Automated Deduction Software has proved several theorems since the 1970s (Argonne National Laboratory), and AI proof assistants are only getting better.

The primary problem we see, as demonstrated, is that AI is commonly used in the creation of the end product rather than being of assistance in deepening the learning process (though, it certainly can be used in service of this too.) This also creates a competitive environment in which mathematicians (and students) who are unwilling to adapt and use these tools may be left behind by those who do - a very similar problem faced by authors, other artists alike, and other fields being affected by the dominance of AI as a tool. Though the end goals may be slightly different in nature, the artistic merits of mathematics may decline.

This begs the question then: does AI have any place in the realm of preserving mathematics as an art? The evidence seems to suggest no, and in fact, academia seems to already be tainted by the degradation of mathematics as an art, and is not actually the fault of AI. Mathematics, by merit of it being considered a science (though it is not) is that it falls victim to the same shortcomings that other sciences do: corruption, publish-or-perish cycles, prestige hierarchy, and gatekeeping which have in some capacity diminished the integrity of these artists. AI only exposes these problematic foundations on which mathematics research lies upon.

So now what?

So, what can be done? Unfortunately, unless there are some major changes to society's attitude with regards to education, the solutions might be more philosophical in nature. In the section before, it was mentioned that AI can devalue mathematics as an art. Though there is beauty in the struggle of mathematics, there are times where you can get genuinely stuck in a problem to the point where no progress is possible. This is why advisors and teachers are so important in these contexts - they can help generate new inspiration or insight you never would have thought of previously. People tend to think that mathematics is a solitary activity. However, this is not true in practice. Mathematics flourishes under community and the peer review process.

There have been many times where I have been utterly stuck on some problems, and I would try to explain my research to someone who was outside of my field. This process would afford new perspectives on problems that I probably never would have had. Or, in the middle of a problem, I might ask for help and someone might criticize my work. It is oftentimes difficult to not take such criticism personally, but it is a necessity to be impartial and receptive to people's feedback. Unfortunately, not every person is in a circumstance where this is a possibility. AI (if used correctly) can be a supplement, though not a replacement for this vital component of this process. This can be said of tutoring in general as well - it is useful but should not be used in place of reasoning.

This problem is not unique to mathematics. People have been cheating on assignments for years, which in turn might cheat people out of their education. The necessity of AI use, however, is widely predicated upon faulty time management, and a fear of losing the finite amount of time and attention where it is constantly being competed for. Coupling this with a deficiency of learning in a society which necessitates college education is strikingly problematic; people treat classes or degrees as a means to an end, rather than a partial end itself. People are more stressed than ever about how they spend their time and whether it's being used meaningfully, and courses in mathematics can be seemingly useless. So why is irresponsible use of AI for mathematics bad? You may be cheating yourself out of a difficult, yet beautiful experience worth having.

A reframing of why people do mathematics here is necessary. Yes, there are your stereotypical mathematics professors with crazy hair, wild ideas, and enjoy staying inside on Fridays to compute Jacobian matrices, but Mathematics is not simply moving symbols and drawing arrows - It can be used as a means of developing mental resilience and reinforcing the necessity of logical thinking, which are some of the most applicable and important skills a human being can have, and are the foundation of one of our most beautiful intellectual arts.

Works Cited

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