The disruptive AlphaGeometry: Is it the beginning of the end of mathematics education?

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Geometric thinking in primary education is a significant step for children. This transition is crucial as it exposes children to a completely different mode of thinking compared to repeating the logic of elementary arithmetic, including addition, subtraction, multiplication, and division.

In practice, middle school students are first introduced to these new concepts through geometry: "proof", "rigorous", "beautiful results", "misconceptions", "creativity", and more.

AlphaGeometry demonstrates the power of AI in inheriting precise and creative logical thinking in geometric proof at the most challenging level: International Mathematical Olympiad (IMO) problems [1].

The strength of AI, as shown with AG in this case, can be outlined as follows:

- AI can inherit human-level logical thinking in geometric proof to reach "discoveries" in challenging problems, which inherently involve non-linear thinking.
- This strength exponentially increases as the algorithm continues to be involved, exploring multiple solution approaches simultaneously (without waiting for sequential processing, as in human-focused thinking).
- The serendipitous nature of AI [2, 3] will further enhance its "thinking" power once the cycle of "problem-solving requests" is eliminated, and AI, like AlphaGeometry, reaches a level capable of generating new problems equivalent to IMO difficulty.

Now, let's discuss the disruptive nature of that could be the beginning of the end in mathematical thinking education.

Firstly, a significant portion of children's time and effort in mathematics education is devoted to solving problems (similar to what AI is assigned) and challenging each other to demonstrate flexibility within a limited time frame, for example, 60 or 90 minutes.

Secondly, due to the substantial time spent on this activity and the diverse nature of problem types, thinking styles, and difficulty levels, the keywords are predominantly "solving" and "proving" under specific assumptions, with almost an absence of the keyword "questioning."

Thus, the emergence of AG and potentially other AIs in the future, with improved computational capabilities, puts learners in two opposing disadvantages:

- Slower computational abilities compared to AI.
- Limited creative thinking in exploring new problems, based on profound, self-driven questioning.
- Learners may struggle to find the true meaning of learning mathematics, as, for example, in elementary geometry, if learning for proof, the non-linear evolution of AI could make finding a solution costly, time-consuming, and prone to misconceptions.

Clearly, we are in an uncharted territory and a distinct approach is needed for mathematics education. For example, consider the fact that Vietnam, a nation with a strong mathematical foundation highlighted by figures like Prof. Ngo Bao Chau or the co-authors of AlphaGeometry, is yet struggling with high school mathematics textbooks. Prolonged discussions on whether to reprint these textbooks every year, the associated printing costs, and the feasibility of students writing directly into the provided spaces in the books are all menial yet unresolvable issues. It becomes evident that AlphaGeometry serves as a symbol, indicating a forewarning of the beginning of the end.

Now, let's explore the imagination as follows (as per Albert Einstein, imagination is extremely important as it stimulates curiosity):

A large company, for example, Microsoft, integrates a more advanced version of AlphaGeometry and provides widespread usage rights. Teachers present a geometric proposition

for proof. How would a student feel if they could choose between spending 5 hours proving unsuccessfully and spending 10 minutes working with AG to get a solution, and then spending 4 hours and 50 minutes reading, contemplating, and understanding in a different way?

Next, after 4 hours and 50 minutes, the student could ask AG for a problem equivalent to IMO difficulty, then analyze the solution to understand it thoroughly. The next morning, the student suggests to the teacher to solve a new IMO-level problem, challenging the teacher in class. Who can guarantee that the teacher will solve it? Suppose the teacher at this point needs to use AG to solve the problem assigned by the student. In this case, the difference between the teacher and the student in the specific context of geometry would be significantly shortened at a staggering pace.

The imagined scenario shows we are clearly at an uncharted territory. As human's abilities to learn and do math as well as many other tasks are augmented with AI [4], technologies such as AlphaGeometry are redefining a number of concepts and institutions such as learning, schools, education, teacher-student relationship, etc, which are so fundamental for what we've thought of as modern society, economy, and culture [5, 6]. What are we preparing for in mathematics education in the face of the possibility of the continued emergence of disruptive technologies, signaling the beginning of the end, if a new reality of mathematics is not taken into account?

References

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