**Wes Maciejewski**

I recently purchased a couple of rolls of 35mm film for my old camera. My son wants to learn photography, partly to explore his burgeoning interest in photographing *liminal spaces*, spaces intended for humans in transit, spaces inhabited by humans only temporarily. He's fascinated by the camera, just how *manual* it is, and constantly tinkers with the aperture size, F-stop, and focal length, bringing some objects in focus, and leaving others a part of the supporting blur. All this exploring will undoubtedly make him a better photographer, but also does not inhibit him from taking hundreds of pictures on his cellphone, when the time calls. He has it out now as I write this, taking pictures of the Drumheller Valley, a liminal space in its own way, formed by millennia of shifting landscapes.

A few weeks ago from the time of this writing, a Large Language Model form of Artificial Intelligence (AI) effectively won a gold medal at the International Mathematics Olympiad (IMO). The significance of this event—and it must be emphasized that this is *one* event in a whole chain of victories for AI starting in the last decade, with many more unforeseen victories to come—should be underscored. Artificial intelligence is born out of mathematics. In a sense, AI is new mathematics, or at least new tools, or old tools re-arranged in profound new ways. Seldom does the Nobel Prize go to a mathematician or a mathematical result, but one just did in 2024, to a Canadian, Geoffrey Hinton for at least his very profound, yet mathematically basic application of the backpropagation algorithm. So basic is this result, a simple use of gradient descent, that I have taught it to my first semester calculus students. And this is the significance of the AI IMO win: the student is turning on the master, to test them, to feel their own weaknesses, to grow, to progress, and to eventually succeed in besting its master.

And that's the good news. We are also facing the runoff effects of AI, or mathematics used in high technology more generally. The immense waste of resources burned through for ChatGPT to generate answers to your assignment problems, the widening societal divide through left/right algorithmic content pushing on social media, the wealth gap exacerbated further through mathematically-charged "fintech", the severe erosion of reasoning or logic in any public sphere. Mathematicians are being called on—right now, as you read this—to reflect on the destruction wrought by applications of mathematics, and to what extent mathematics ought to be held accountable.

ChatGPT came out not too long ago—I remember hearing about it on Reddit or some podcast, and, staying true to my ethos of "contemporary education includes contemporary technology", I allowed my students that semester to use it live during our calculus exam. As I paced the exam hall, one student caught my eye. They looked puzzled at their tablet and I walked up to take a look; ChatGPT output lit up the screen. They turned to me with eyes expressing both pride and betrayal, "this is...just...simply incorrect!" Yes, dear student, that is the lesson.

Answer this, what skills did that student use in that moment? They were able to read and understand a mathematical argument, which is an act which requires a depth of previous experience, and more importantly, they possessed the courage to be critical of and challenge the resource they were interacting with. To me, those evaluative skills, of being capable of knowing when a solution, or an argument more generally, is correct subsumes the skill of crafting the solution. Properly supported by technology, among many, many more influences and affordances, the student above attained a new-to-them level of mathematical mastery. I am convinced any reflective, thoughtful mathematician would place more value on this stroke of mastery than on any sort of demonstration of routinized skills.

The story above took place in a first-semester calculus course, a subject which has completely ossified its place in the general education cannon, but has always appeared to me as more of a historical note—modern mathematics is done with computers, why are calculus students doing all this by *hand*? All those lists and lists and lists of trigonometric integrals out of Stewart I solved decades ago in Rutherford South, or you did in Robarts or Osler, seem quaint to me now. Perhaps I did get something out of those exercises, insofar as I learned some neat tricks and generally liked winning so many successive small battles, but I would have rather spent my time doing deeper work.

That was calculus, but Mathematics is not so much a singular subject, rather a glorious landscape of ideas, each with their own fine details, and just as diverse as our beloved country: the rolling rising and falling foothills of stochastic processes, the smooth cool green-blue rivulets of partial differential equations, the craggy texture of the Langlands programme, the vast multi-coloured pastures of graph theory. A single picture could not feasibly present all of it; in any picture, some regions are in sharp focus, whereas others remain fuzzy, on the supporting periphery. Move the camera, adjust the depth of vision, and other areas are brought into focus, whereas those previously at the centre are out of frame. But it's all there, all of mathematics, no matter if a combinatorialist and an analyst struggle to find a common language, they share an identity—all are part of the bigger picture. The evolving, liminal landscapes of mathematics.

Artificial intelligence, created out of mathematics, and widely, and perniciously available, has turned its lens on mathematics. It has grown and evolved to make all of our routinized procedures and calculations automatic, completely doing away with the need to perform any of that manually, and is closing in rapidly on deeper problem solving abilities. It calls on us now as it zooms out from the aspects of our field we hold on to closely, tightly, calling on us to let go of those antiquated practices we endured, just as countless generations before us had let go of theirs, calling on us to do what is necessary, what is needed: a shift of focus.