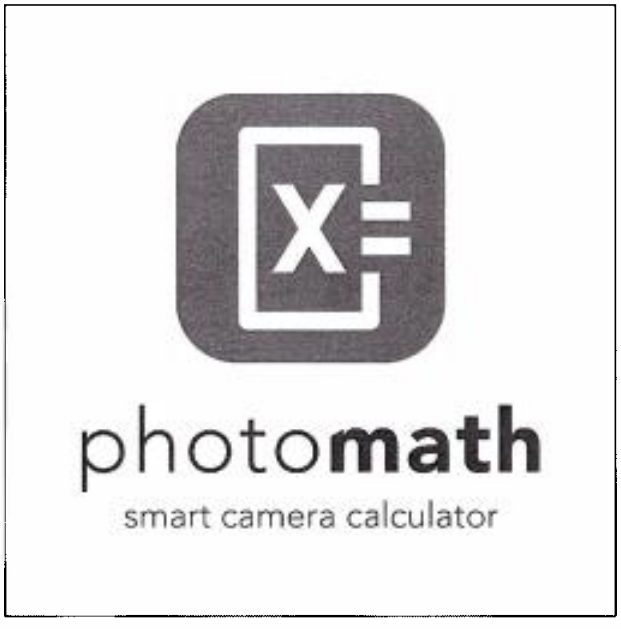
Well, This Changes Everything, Or It Should

Chris Reed



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This week in ECI 831, we were tasked with finding a tool or an app that we had not regularly used for education and reviewing it. The next day, I was talking with an amazing math teacher at my school and he said, "Check out this app, Chris. You take a photo of your math question and it solves it." I was impressed, and then he said, "Just wait. You cannot even get around this by telling the students to show their work, because this app shows it step by step. I am going to have to change how I do assignments." The bell rang and we both went to class. I knew immediately that I was going to have to review this app.

The App

The app in question is Photomath, available for free download for both Android and iPhone. To download it, go to the Google Play store or the App store for Apple.

Does It Work as Claimed?

The first thing I wanted to do was test whether the app worked as it claimed. I strongly recommend that you take a moment to watch the demonstration video that the developer produced (https://vimeo.com/147764920). The video shows a student using the calculator to verify that the work that she has done on paper is correct. It also shows her scrolling through the step-by-step process to check to see if what she did step by step matches. So now we know what to expect.

I tested this by printing off some math worksheets for multistep equations. I also went to the Photomath website (https://photomath.net/en/), where they have a list of equation examples that you can print. I also wanted to test it on handwritten samples to see how good it was at picking up printing. Here is how it did on each of these hurdles.

The Examples from Its Own Website

- Addition and subtraction—It had no problems at all and showed really detailed step-by-step instructions.
- Multiplication and division—Again, it had no problems, and that includes testing it with fractions. The step-by-step instructions also could be expanded to include more detail if needed.
- Complex arithmetic operations—It worked perfectly again.
- Factorization and algebraic fractions—It worked through complex problems without issue.

- Linear equations with restrictions—Again, no problem, and it graphed the solutions as well.
- Systems of linear equations—Here, it did a couple of things: it solved the equation using multiple methods, and it gave you options about which method you wanted to look at. It also, of course, graphed the solution.
- Integrals and derivatives—No issues. Also, the step-by-step illustration was really helpful to me, since it has been a few years and my calculus is rusty.

So yeah, it had no problems with the questions they provide as an example, but that makes sense. It better have no problems with their own stuff.

A Third-Party Worksheet

- I ran it through a selection of worksheets from a program that I had purchased years ago. It did not matter that the questions were laid out in a different format, that the variables used were different letters other than x, y, a, b, and c, or that the font was different. It did just fine.

Handwritten

- I did not do an exhaustive test of the app's handwriting detection. I just wanted to see if reasonably neat handwriting would be recognized. It did pretty well. Some things that I noticed were that you need to remember the little things like putting the degrees sign on your trigonometric functions. It liked *sin* (30°) but treated *sin* (30) as a different question. Also, it handled both forms of 4 (with the closed and open top), it handled curved 9 and straight 9, and it handled normal 7 and crossed (drafting) 7. It thought a crossed (drafting) zero was a theta, which to be honest looks exactly like a theta and more often than not *is* a theta.

For any mistake that the photo part made, there was a manual equation editor that you could use to fix it, and then it would solve the new fixed equation.

Verdict

Photomath works as stated. While there are some math questions that it could not handle yet, like graphing systems of inequalities, the app is continually being revised, and I would be very surprised if within a couple of years it couldn't do every kind of math equation that any high school student would ever face (minus the word problems, maybe).

Teacher Reaction

I wanted to know if my math colleagues thought this was a good or a bad thing. Also, I was curious how the existence of this app was affecting the math class that my colleague teaches. So on Friday, during lunch, I tracked him down and asked him about it. The first thing he asked was if I had shown [it to] any students. I hadn't. That calmed him. He said that he knows that students are going to come across this app likely sooner rather than later so he is trying to figure out what he is going to do. He already has his gradebook set up and is halfway through the semester. There is work that he expects to be done at home, and for at least this semester, some of that work counts for marks. He said that he already suspects that there are some students that might be using it because their homework is so much better done than their in class work, but he does not think it is widespread yet. He thinks this since so many students are still doing poor quality homework (a good thing in this case?).

When he said all of this, I became curious about how *he* had heard about the app. He said that he was searching for math apps to create practice quizzes and focused study help for students that were struggling. He uses a lot of the kinds of programs that we have talked about in class, things like Kahoot, an interactive quiz website (https://kahoot.it/), Socrative, a learning management system (www.socrative.com/), and more, so I am not surprised that he found this app before many others have.

He also said that while it is causing him to rethink how homework works, this was more of a wake-up call than an all-out crisis. He says you already have no guarantee that the student is the one doing the homework, and that spotting plagiarism in math is next to impossible, whereas in other subjects you at least have a chance of spotting it. The homework portion of his mark setup is relatively low, with in-class work and tests making up 80 per cent of the students' mark at this time. He was already leaning toward removing any mark for work done at home, but now he knows that this is the last semester he will ever give marks for homework.

So Now What?

If you are a math teacher, this kind of uncomfortable truce with technology is nothing new. Many of us grew up with teachers telling us to put away the calculators and to learn things by rote. Most of the current generation is growing up with a calculator that they literally carry everywhere with them. There is a lot of debate/soul searching happening about math curriculums in Canada and the world right now. The *National Post* recently ran an editorial about discovery math and why people want to get rid of it in Canada (Csanady 2016). It is not just Canada asking this question, either. The

BBC wrote an article that asks if every country should use the Shanghai method (Low 2017).

So what is the solution? If you asked this question in a coffee shop, everyone would have an opinion, and many of them would focus on the idea of back to basics, or doing more practice. This was certainly the opinion of the ministry of education in Saskatchewan in the October 2017 throne speech (Yard 2017). You would even hear a lot of the phrase "Back in my day, we ..." The problem is that we are not back in anyone's day. The tools available to students now make earlier approaches impractical and unreliable, especially since students are unlikely to avoid the use of these new tools. So how do we work with the tools available?

I know that Photomath is too new to have any studies done on it, but I remembered that Wolfram Alpha was a computational search engine that could do similar things, and I remembered that the creator of it felt that math education needed to change. So I went looking for what he had to say because I knew that he would be thinking about the issue. Was he ever! In fact, he gave a TED talk about this way back in 2010 (www.ted.com/talks/conrad_wolfram_teaching_kids_real_math_with_computers?utm_campaign=tedspread--a&utm_medium=referral&utm_source=tedcomshare).

There is a lot to process in this talk, and I strongly recommend that you watch it. His presentation boils down to the idea that we are emphasizing the wrong part of math. He sees math as a four-step process: first, posing the right questions, then converting the real-world problem into a math problem, doing the computation and, finally, converting the math answer back to a real-world application. He argues that we are spending 80 per cent of our time doing step three, which he points out is the only step that computers can do perfectly. He argues that we should be teaching students to do steps one, two and four better. In fact, he did more than just give a talk about this—he started an organization, Computer-Based Maths (http://computerbasedmath.org/), which looks at how to teach math better using computers. Teaching computer-based math was an option in 2010, when he gave this talk; in 2018, it is essential.

I recommend that you watch the TED talk if you teach anything like math or science. I also suggest that you download the Photomath app, because you are going to want to start to understand how students could use this as a positive thing. I know that I am already thinking that next semester's physics class is going to look a lot different from last spring's physics class because of the existence of this kind of stuff. I am only one person in a whole school, though. I need to make sure that what I do is not going to cause huge headaches for others. So, in the next month, I need to talk with all the math and science people in my school and figure out "Now what?" I think that Conrad Wolfram might just have a possible path forward for us.

Let me know how this affects you. I foresee good things potentially, but it will require us to change. Continuing as we are is definitely not the correct option.

References

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