

MATHPEN: ENVISIONING THE FUTURE

What can a handwriting recognition system like MathPen offer?

Mandy Lo discusses the ideas with a mathematics teacher in a secondary school.

Envisioning the Future

About a year ago, I was asked how I envisioned future internet technologies being utilised for mathematics education. As we all know, there is countless web-based mathematics software around. All the software suffers a common problem, though: while undoubtedly powerful and well appreciated by many, they are somewhat individualistic. Numerous research and classroom experiences have shown that students can, and usually do, learn from each other. Learning is not simply a personal pursuit independent of our social surroundings (Schoenfeld, 1992). The learning of mathematics, including intrinsic problem solving skills, is no different. If classroom-based group work can stimulate students' thinking ability and deepen their mathematical understanding, why not extend this online? So, in response to the question, I envisioned that students will be able to debate mathematical ideas *spontaneously* and *effortlessly* through the internet, in much the same way as students do on social networking sites for text-based communications today. The enabling technology is what I subsequently named *MathPen*.

MathPen

In its essence, *MathPen* is a web-based handwriting recognition system which allows students and teachers to write their mathematical expressions on a tablet computer and automatically convert the handwriting into internet compatible formats. Take the quadratic equation as an example. As simple as it is, it is not that easy to format electronically. The equation contains a plus or minus sign, a square root, superscripts - for indices, and is in the form of an algebraic fraction! Just think of the many hours mathematics teachers spend in designing worksheets for students. It takes forever! It is no wonder that STEM subjects are reported to be lagging behind in benefiting from online collaborative learning (Allen & Seaman, 2010). To illustrate, if a student encounters a problem with their homework after school, they may want to upload a copy of their present attempt and ask their friends for help. Figure 1 shows a

snapshot of what it might look like online. While this may seem to be a trivial matter for text-based subjects, the handling of the mathematical notations can prove to be very challenging for many. For one thing, expressing $\frac{2x+3}{x-1} - \frac{x+2}{x+1}$ as $(2x+3)/(x-1) - (x+2)/(x+1)$ is neither easy to comprehend or straightforward to work on.

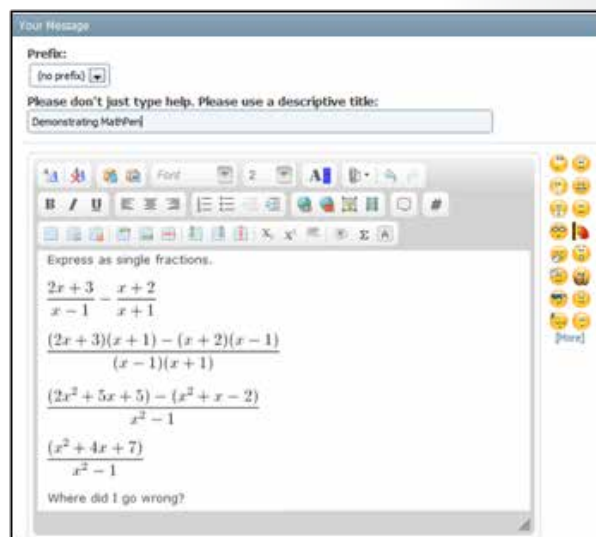


Figure 1: Posting a question online

Of course, when the expressions are properly formatted, the presentation is much more engaging. And, if you are one of the friends who have spotted the error, it is only natural to want to post a quick response to help your friend out. But what is involved in generating the pretty text that captures the attention in the first place? For internet-based communication, the current method is Latex, a programming language for professional typesetting. Figure 2 shows how Latex can be used to generate the pretty text. Perhaps, as well-qualified professionals, it is not too difficult for us to decipher the Latex code as shown in Figure 2. Yet, how many of us would be comfortable with communicating mathematics in this format? Worse still, how many of our students would be

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\frac{2x+3}{x-1}-\frac{x+2}{x+1}
\frac{(2x+3)(x+1)-(x+2)(x-1)}{(x-1)(x+1)}
\frac{(2x^2+5x+5)-(x^2+2x-2)}{x^2-1}
\frac{x^2+4x+7}{x^2-1}
    
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Figure 2: The required Latex code to generate the correct mathematical formatting

with this? Looking into the future, I envisage students will be able to simply write their work on a tablet computer, then a piece of software will magically interpret the handwriting and insert the formatted mathematical expressions on the students' behalf. Only then can the vision of *spontaneous* mathematical discussions take place.

Figure 3 shows how I envisioned students' ability to write and make notes on a tablet, while Figure 4 shows the converted mathematical expressions. At a click of a button, students should be able to send the formatted mathematical expressions along with a snapshot of their handwritten work online. Instead of overcoming the challenges of mathematical *coding* online, students can focus on their mathematical *discussions*. It should be quick, easy, and natural. This piece of software I have called *MathPen* - a programme that allows us to write mathematics in the way we would with a pen.

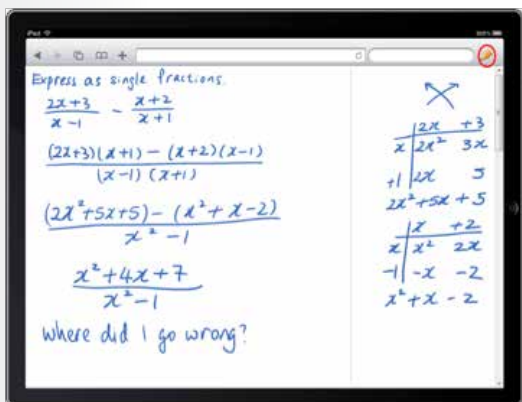


Figure 3: A student's handwritten work on a tablet computer

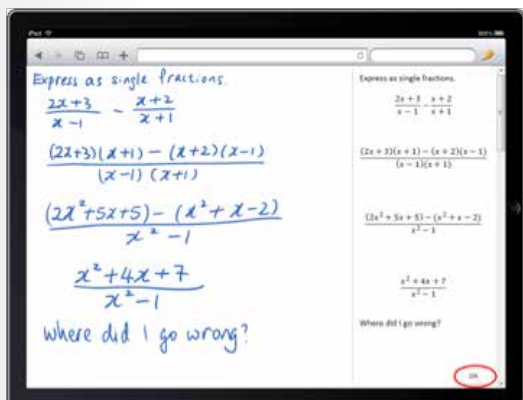


Figure 4: The converted expressions

Within a school-setting

More recently, I had the privilege of meeting with an experienced mathematics teacher in a local 11-18 school. Like many other educational institutions, Moodle is used as a virtual learning environment. On a regular basis, teaching material, homework sheets, and quizzes are made available through this platform. Students are encouraged to ask questions, discuss possible solutions, and to form a constructive learning community. Up to 50% of mathematics homework is set online. With this in mind, I met up with this teacher to find out what he thinks of *MathPen*. Below is an excerpt of the conversation.

Mandy: Why are you interested in MathPen?

Teacher: At the moment, our school uses Moodle as a learning platform. It is generally working well and I do tend to set a lot of homework on it. But as you know, mathematical notations are not exactly easy for our students. More often than not, if the appropriate homework requires non-numerical answers, I would have to resort to pen-and-paper methods. That means collecting books or loose pieces of paper etc. The thing is, I can't risk losing the students' interest by having them battle with technology. In order to do their maths homework online, they will have to learn how to 'type' square roots, use the correct brackets and even then the expressions don't always come out right. It's so frustrating. Sometimes I think mathematics students have it tough when it comes to online learning. I saw your video online and thought, if it works well, it could save students a lot of time and I can use it for writing out questions for the students too. I see a lot of potential in it.

Mandy: How often do you set homework online?

Teacher: It depends. I tend to do it more with students in the lower school. As they progress through the curriculum, the demand for mathematical notations also increases. But even then, to make life easier, I can still find ways to have at least some of the work done online. For example, I can ask students to do indefinite integrals by hand and the evaluated numerical answers online.

Mandy: With the concept of online handwriting recognition, it has an inherent assumption that both handwriting inputs and the internet are available. Do you think it would be a problem?

Teacher: For us? No! In fact, as the ICT co-ordinator of the school, I can tell you we are quite behind in our IT facilities when compared to other schools and colleges. We've discussed making tablets available to all students as part

of our school policy for a number of years. There are many educational apps out there that would really improve the quality of our teaching and we believe our students should benefit from that. What's more, the prices of these tablets are dropping so quickly that it is no longer prohibitive to students' use. These things definitely provide a more personalised interactive environment for learning.

Mandy: You seem to like the idea of MathPen. Any concerns?

Teacher: I have spent so much time battling with Latex and I simply don't have the time for it. My main concern is the recognition accuracy, and of course, the price.

At that, I demonstrated the capabilities of several current handwriting recognition technologies to give him the reassurance that what I envisage is absolutely achievable. Of course, while commercial companies would like to charge thousands of pounds each year for their products, there is no reason why I cannot spend some time in developing such a device and make it accessible as freeware to schools.

Reflecting on the visit

Reflecting on the conversation, I have learnt two vital points, a) the fast-growing role and dominance of tablet computers in education, and b) the tremendous frustrations of teachers and students when it comes to representing mathematics online.

There was a time when education technologists had to worry about access to equipment in schools. Very soon, classroom teachers began to find themselves confiscating mobile phones as students were sending text messages to each other instead of paying attention in lessons. Today, no longer are we battling with mobile phones, but smartphones, not text messages, but internet-based social networks. Whether the tablets are to be provided by schools or brought in by students, it is not difficult to see the growing prevalence of such devices. In view of the many successful student engagements through these devices, it is clear that tablet computers will become an increasingly important educational tool in the near future.

Recalling the days of my undergraduate years, it was hugely frustrating when literally any ideas could be communicated and discussed through the university's email system, except mathematics. How were we supposed to discuss our group work when most of our modules involved so many mathematical notations? We had no choice but to meet up in the library to complete our work. That was ten years ago and, while the internet has moved on to the so-called interactive web (also known as Web

2.0), things have not changed much for us as mathematicians.

I often hear people say: "*It's time for a change*". It certainly is! It is time this world-changing internet caters for the needs of mathematicians. It is time for the world-wide-web to provide a truly world-wide coverage by including our students in the many internet-based discussions during this interactive age of Web 2.0. It is actually high time that we engineer something user-friendly in order to support mathematics learning.

What will the future bring?

I remember, just over a year ago, when I was asked to envision the future, not only was I met with scepticism by some, I was also not one hundred per cent confident that my ideas would meet the needs of teachers and students.

Yet, now, having come to know so many individuals like the mathematics teacher mentioned in this article and, with the support of my supervisors at the University of Southampton, I was able to conduct research into the feasibility of such developments and the needs of mathematics education. I am absolutely confident that *MathPen* can fulfill the current needs and will be accessible to many.

A note about MathPen

Although still under development, *MathPen* is intended to be a free, W3C-compliant web-based handwriting recognition system designed for mathematics education. It is part of an educational research project with a goal to open the way for online collaborative learning especially for mathematics. This research is funded by the Research Councils UK Digital Economy Programme, Web Science Doctoral Training Centre, University of Southampton. EP/G036926/1.



About the author

Mandy Lo is a PhD student at the University of Southampton working in both mathematics education and web-based learning. An early version of *MathPen* is available at www.mathpen.co.uk. If you would like more information, please contact Mandy at cmml100@ecs.soton.ac.uk.

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