Chapter 10
In Search of Math 2.0

What do I mean by Math 1.0? Since it's popular to label software upgrades with numbers, it makes sense to me that a term like Math 1.0 can be about the use of technology in math education.

For me, the buzz about technology in math really got going in 1989, when the National Council of Teachers of Mathematics (NCTM) announced the release of their "Curriculum and Evaluation Standards for School Mathematics." That was one of the first formally announced statements by NCTM that encouraged teachers to integrate technology as a tool in their teaching of math. However, it was considered just another tool to help teachers help students make sense of mathematics and make problem solving more doable. Since computers were only starting to become a noticeable part of the classroom landscape, NCTM supported calculators more than they did the more expensive desktop computers. The only mention of technology in 1989 was as part of instructional practice, where teachers should "use appropriate technology for computation and exploration." I called this Math 1.0 because *technology was noted as a player on the math education landscape but was not encouraged to be used to its fullest advantage.*

There was another major revision of the standards in 2000 when NCTM published "Principles and Standards for School Mathematics*"* and made technology a principle[1] (joining teaching, learning, assessing, curriculum, and equity). I was optimistic at the time that this would forge a new initiative into exploring what it means for technology to be a principle, but to date I'm disappointed that no such initiative has emerged. In fact, as late as 2009, NCTM's guidelines[2] did not even make mention of technology. It became clear to me that after almost fifteen years of holding technology as a principle, NCTM was not yet ready to embrace technology in a bold new way that includes the promise of what Web 2.0 offers. (However, with the publication of "Principles to Actions" in February 2014, attitudes may be changing.[3])

A New Paradigm for Teaching and Learning Math

There are three elements to Math 2.0:

    1. Dynamic math software

    2. Web 2.0 tools

    3. Hybrid communities of students and teachers who engage in mathematical adventures.[4]

Dynamic Math Software

Though I would argue that Logo was the first significant piece of dynamic software, origins of what's referred to today as dynamic software is usually associated with Geometer's Sketchpad, which was developed in the 1980s by Steve Rasmussen and Nick Jackiw at Key Curriculum Press.[5] Another example of dynamic math software (where the math is intrinsic to its DNA) was the spreadsheet. Dan Bricklin's daydreaming in a Harvard accounting class may be apocryphal, but his idea of putting the standard accounting sheet on a computer called Visicalc[6] sold thousands of expensive computers that were previously used only by hobbyists and pioneer classroom teachers.

KeyCurriculum (its current name) also made available Fathom and Tinkerplots for dynamic data analysis. Hollylynne Lee, a professor of mathematics education at North Carolina State University, writes that one way to help students become facile with technology in math is for them to collect and study sets of data from repeated trials within a simulated model. "Working within technology simulations can provide many opportunities for students to make sense of probability in meaningful and engaging ways. The real power of technology, with appropriate questions and opportunities designed by a teacher, is that students can critically analyze a problem, build a model of the problem with technology, and implement a data-collection approach to considering a solution."[7]

For algebra, the spreadsheet is a great example of dynamic software. Keith Devlin, professor at Stanford University, writes about using programming (macros) in a spreadsheet language like Excel.

> You have to use Algebraic thinking if you want to write macros to calculate the cells in a spreadsheet like Microsoft Excel. […] With a spreadsheet, you don't need to do the arithmetic; the computer does it, generally much faster and with greater accuracy than any human can. What you, the person, have to do is create that spreadsheet in the first place. The computer can't do that for you. Is mastery of algebra (i.e., algebraic thinking) worth the effort? You bet— though you'd be hard pressed to reach that conclusion based on what you will find in most school algebra textbooks. In today's world, [what] most of us really do need [is] to master algebraic thinking.[8]

Web 2.0

"I see utilizing Web 2.0 will increase math skills, math knowledge, and math understanding. Students can create, collaborate, and communicate … about math."

—Jennie Gibson

Web 1.0 was born when the first significant web browser, Netscape Navigator, arrived on the scene in the mid-1990s. This software made the reading of text from myriad web-based sources more engaging by including graphics and music. Commercial enterprise —buying and selling of goods—followed soon thereafter. With the advent of software developed by Amazon and eBay, the average Joe began to buy and sell items on the web. And most important for the education world, interactivity with the web (known as the read/write web) became commonplace and was referred to as Web 2.0. What followed was a boom in activities that encouraged students and teachers to interact with the web. News articles encouraged readers to respond with commentary, which then helped create a community of readers interested in the topic at hand. Web-based software that supported communication, collaboration, and creation of new websites began to emerge. Early pioneer software included blogs, wikis, and photo/video sharing software. Students could now post videos, photos, and blogs online. The popularity and

excitement of this kind of use of the web grew exponentially and encouraged educators to share their experiences online.

In March 2008, Steve Hardagon described ten trends[9] proliferated by Web 2.0 that would directly impact the lives of students and teachers:

1. A new publishing revolution
2. A tidal wave of information
3. Everything is becoming participative
4. The new "pro-sumers"
5. The age of the collaborator
6. An explosion of innovation
7. The world gets even flatter and faster
8. Social learning moves toward center stage
9. The long tail (of the Internet)
10. Social networking really opens up the party

Gwen Solomon, in *Web 2.0—New Tools, New Schools*, writes,

> With Web 1.0, students can find information online and use it (with proper citations, of course) to write reports using a word processor or PowerPoint. They could show their work to peers in class and parents at home and store it in portfolios on the school server. Sometimes they could even create web pages that the district might allow to be posted. Now (with Web 2.0) they can write directly online in a blog and get immediate feedback from peers and others who could be anywhere. […] They can post photos, videos, podcasts, and other items online. The difference is that students can do the posting. They control the tools of production and publication. There are no more gatekeepers. With these tools people are changing the way that the real world works business practices as well as social activities. Why not use them to change schools?[10]

Learning Communities

Schools are changing as a result of the explosion of Web 2.0 tools. New learning communities are evolving as a result. New ways of teaching and learning math are now available. For example:

- Schools exist beyond networked brick-and-mortar. The four walls of a classroom no longer confine learning and teaching. Resources from everywhere are available on any connected computer or handheld device.
- Education in the clouds (online and virtual) is now commonplace.
- Classrooms can be flipped so that students can watch videos at home and discuss them online or in the classroom the following day.
- Math teachers blog about their experiences in the classroom and are followed by other teachers doing the same. They share activities and get involved in free-form professional development. Bloggers such as Dan Meyer,[11] who has a large following, creates ad hoc activities using creative Web 2.0 venues to explore math with other teachers.
- Homeschooling is now easier because of the proliferation of resources available to parents who form groups and organizations, both local and online, that support them in learning and sharing about various topics. Julie Brennan runs a website named "Living Math,"[12] expressly geared for adults interested in helping young people have better experiences with math.
- Dynamic math software communities and user groups, such as Logo, Geometer's Sketchpad, and Geogebra[13] inspire like-minded educators to learn about these very useful tools and their applications in the classroom. Web 2.0 tools have made all of this possible.

When CLIME (Council for Technology in Math Education) first started in 1988, we mailed newsletters, licked stamps, and charged a fee. But by the late 1990s, we shifted to e-mailing our newsletters in PDF format. It was not as effective, because e-mail addresses didn't guarantee communication in those days. Even members of CLIME didn't have e-mail addresses early on. Once the numbers were there, all of our print material was written in digital form and membership dues were dropped. (We didn't

have to buy stamps and lick envelopes anymore!) Our newsletter is now a blog.[14] Some members of the NCTM community didn't think it wise to drop membership fees, feeling, rather, that a fee would guarantee a commitment on the part of the member. As we move more and more toward open-source collaboration, that criticism is no longer valid, because we can thrive as a niche group on the long tail of the Internet.[15] Emerging, instead, is a new and highly innovative collaboration—open forums that encourage commitment through easy access and participation.

The same can be said for math communities in the business of helping students learn math. The communities come in all shapes and sizes. The one I'm most familiar with is CLIME, which is in its twenty-sixth year as an affiliate group of NCTM. For ninety dollars a year (affiliate dues), I keep it alive as an entity that works to inform "members" and NCTM on technology issues and trends. NCTM and technology are strange bedfellows, because NCTM always needs to keep the math needs in the forefront, particularly since the 1980s, when a lot of math teachers became huge proponents of programming environments like BASIC, Pascal, and Logo and as a result became computer teachers and left the math classroom. To slow this exodus and encourage teachers to use technology within the conventional math curriculum, NCTM coined the phrase "technology as a tool" to teach math, wanting to make sure that the distinction was clear to all. They felt that learning computer programming was not essential to math learning, and a teacher shouldn't use precious math time for that. Today, there is more pressure to mix the two by focusing on computational thinking, which is a kind of a euphemism for programming.

In summary, there are three components to what I consider Math 2.0:
1. The continuing emergence of dynamic math software
2. The collaborative and publishing power of Web 2.0 tools
3. The emergence of transformative learning environments that empower students to pursue their passions through project-based curriculums that unwrap to reveal interesting stories

When these three components merge synergistically, like the perfect storm, we have the necessary tipping point, and students will actually want to learn the math that is involved in project-based learning. Coming up with these projects is the real challenge for this millennium.