Rare Events: Technology Throughout the History of ICMI

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Reflecting on the history of technology in mathematics education reminds me of a comment made by Richard Noss while answering a question after his opening keynote address to the 2005 Fields Symposium on Online Mathematical Investigation as a Narrative Experience, held at the University of Western Ontario, Canada. Noss described the wonderful mathematics experiences he has witnessed in classrooms using technology as *rare events*. I will return to this idea at the end of this paper.

Five pages cannot do justice to the topic of technology in the history of ICMI. To make the task manageable I will do the following: (1) I will address the historical component only partially by focusing on one point in time, on ICME-7 (1992). I have chosen to focus on ICME-7 for three reasons. First, ICME-7 was held in Quebec City, Canada, and it was a Congress that I attended. My paper in part represents a Canadian perspective, so it seems appropriate that I focus on an ICME that was held in Canada. Second, ICME-7 was the first ICME to focus intensely on technology in mathematics education. Third, as I will elaborate below, ICME-7 took place near a turning point in our view of technology in mathematics education. (2) Then, I will discuss changes from 1992 to the present in the context of the shifts in my own focus in mathematics education technology. Though my experience does not provide a comprehensive history, it does identify a number of important trends in mathematics education technology. (3) Lastly, I will return to the idea of *rare events* and offer some ideas about what they are and how current trends in technology may help us to make rare events public, to be shared as models for others and to serve as objects for reflection and critique.

A Look Back to ICME-7

ICME-7 was the first ICME to focus intensely on technology in mathematics education. For example:

- The first day of ICME-7 offered a 3.5 hour miniconference on calculators and computers with every participant invited to join one of five stands: students ages 5-11, students ages 11-16, students ages 15-18, mathematics undergraduate students, or teacher education. As Fey (1993, p.6) notes, “The miniconference made technology a prominent feature of the ICME-7 right from the start, and this attention was continued throughout the week-long Congress program.” Fey also notes that “Furthermore, it is evident from the program for other working groups that sessions of those groups devoted considerable attention to the impact of technology in all aspects of mathematics education” (p.7).
- There were three working groups on technology which met for four 1.5-hour sessions each: “Impact of Calculators on Elementary School Curricula”, “Technology in Service of the Mathematics Curriculum” and “TV in the Mathematics Classroom”.
- The Congress included important lectures by Celia Hoyles, Benoit Mandelbrot, and Seymour Papert.
- There were numerous software presentations at the poster displays and exhibits.

ICME-7 took place near a turning point in our view of technology in mathematics education. Shumway (1989), reflecting on ICME-6 observes that while the computer in education was in its initial uses (starting around 1965), it was valued as a tool for computations and programming, then later it was valued as a tool for drill and practice, teacher utility, information management, and tutorial uses. He notes that by 1988 the focus seemed to shift to computations, graphics, simulations, concept learning, and problem solving. Fey (1993), reflecting on ICME-7 adds that Shumway's summary also described the situation of ICME-7.

> In the miniconference, working groups, and special lectures there was very little evidence of interest in computer programming as a vehicle for learning mathematics, in computer tutors that control the learning environment as electronic instructors in drill-and-practice software, or in the variety of ways that computers can be used to assist with information management tasks of teaching. The strongest theme in most sessions was the search for powerful computer and calculator tools that would enable students to conduct mathematical investigations that solve important real problems and yield understanding of important concepts. (p.7)

The emergence of a view of technology as enabling mathematical investigation and facilitating the development of student mathematical thinking and understanding was an important turning point in the history of technology in mathematics education. Lichtenberg (1993), reporting on the ICME-7 working group dealing with the impact on the calculator, notes that "Common threads among the papers in this working group include encouraging mathematical thinking, exploration, mental work, having fun with mathematics, and posing questions like "What do you think will happen if …?"" (p. 19).

Fey (1993) notes in his reflective paper on ICME-7 that "the most frequently mentioned software was geometry drawing tools, especially the Geometric Supposer series, *Cabri-geometre*, and the Geometer's Sketchpad. From people who had experienced the software, I heard consistent reports that promised benefits in teaching and learning" (p.8). Fey also notes that "much of the most exciting development work applying calculators, computers, and video to mathematics education is occurring in North America. Also persisting was the idea of an immersive mathematical microword (pioneered by Seymour Papert). However, technology in then classroom was not a world-wide phenomenon. Mayo (1993), notes stories from delegates of Nigeria, the Dominican Republic, India and China where teachers not only lacked computers but also such things as chairs, desks, and other classroom resources that North Americans take for granted.

A Look at Today and Tomorrow

What has changed since ICME-7? One way to answer this question is to look back on the last 15 years and identify the shifts in my own focus in mathematics education technology.

From computer-based to the Web-based. In the last 15 years, my focus has shifted from computer-based software to Web-based learning objects and the design of online mathematics learning experiences. Before 1992 and continuing until about 2000, I used and trained other teachers to use graphic calculators and a variety of computer-based software that offer students opportunities for exploring mathematical concepts and relationships in a non-scripted fashion (such as, the Geometric Supposer, Geometer's SketchPad, and spreadsheets). However, in the late nineties my interest in computer-based software was waning as I was drawn to attend to the potential of web-based mathematics experiences.

From Web 1.0 to Web 2.0. The Web 2.0 paradigm views a website not as a static read-only page but as a dynamic read/write environment (such as a wiki) where users interact and co-generate content and experiences. With the steady growth of bandwidth, the mode of Web 2.0 interaction and the content generated are increasingly multimodal (as in YouTube). In the last three years, I have been focusing on Web 2.0 affordances, especially (1) collaborative knowledge building environments (like wikis) that entrust users as co-authors or co-developers and potentially tap into their collective intelligence and (2) the increasing support for multimodal/performative communication. This shift is reflected in the projects I am now working on:

Read/Write learning objects. We are developing mathematical learning objects (Gadanidis, Jardine & Sedig, 2007) that allow users to annotate a given state of a learning object and to share the state and the annotations with others (as a url that is sent in an email or posted on a website). The annotations currently are text only, however, we are in the process of developing video annotations (captured by the learning object using a webcam) and drawing annotations (using a drawing tool built into the learning object).

The Web as a performative medium. Marcelo Borba and I are working to develop a conceptualization of digital mathematical performance (Gadanidis & Borba, forthcoming). Hughes (2007) suggests that the Web is fast becoming a "performative medium". This is evident in the multimedia authoring tools used to create online content, such as Flash, which often use performance metaphors in their programming environment. For example, you program on what is referred to as the "stage", you use "scenes" to organise "actors" or "objects" and their relationships, and you control the performance using "scripts". The Web as a performative medium is evident in the success of portals like YouTube. Hughes suggests that the new media that is infusing the Web draws us into performative relationships with and representations of our "content". To use new media is to in part adopt a performative paradigm. In this context we ask ourselves, what mathematics experience is worthy of performance and how might such a performance be created and shared digitally?

The affordances of wikis. The idea of a wiki has 'stained' my thinking about almost everything I do in my development and research projects and in my teaching. For example, we are at the moment developing a new website for sharing mathematical performances, which will allow visitors to edit its content in a number of ways: by recording/posting their own performances; by selecting and re-combining website content in ways they see fit, and sharing these new 'view' with others; and, by annotating existing performances (using text, audio and video). Also, in my online teaching, I can no longer imagine using a discussion tool that is not wiki-based. In 2004 I designed an online discussion platform called Idea Construction Zone (ICZ) which allowed for wiki postings (postings that can be edited by others in the discussion), synthesis postings (where a number of postings can be selected and their content merged into a single posting that the user can edit, with all authors credited), embedded drawings within postings using a built-in drawing tool (see example in Figure 1), embedded video (or audio) captured using a webcam within a posting, embedding other multimedia within postings (like jpeg, animated gif, and Flash swf) or hyperlinking to external resources. Since 2005, ICZ has been used to teach graduate, preservice and continuing teacher education courses. It has also been used in research projects between Canada and Brazil and Canada and Tanzania, involving

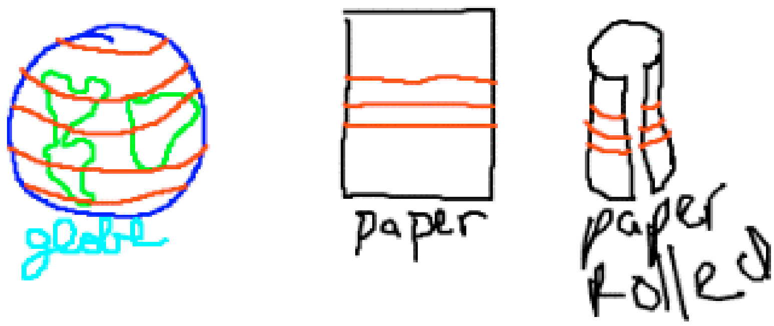

Figure 1. An elementary preservice teacher uses the Draw Tool to show three representations of 'parallel' lines.

students, teachers and researchers.

From thinking about technology to thinking *with* technology. When we immerse ourselves in using a technology – and this immersion is a critical component – we naturally think *with* that technology, whether it is the technology of the printed text, or the technology of the word processor I am using to author this paper, or the technology of a wiki I use to design and teach an online course on mathematics for teachers. Levy (1997) suggests that technology is itself an actor in the collaborative process, and not simply a tool used for human intentions. When we immerse ourselves in using a technology, either individually or in collaboration with others, the technology becomes an integral component of the cognitive ecology that is formed. Borba & Villareal (2005) add that humans-with-media form a collective where new media also serve to disrupt and reorganize human thinking. What has changed for me – for us – in the last few years is that the technology of the Web has become an pervasive environment, and its various affordances have become tools I increasingly and naturally think with. There is a qualitative difference here between immersion in a computer-based software like Geometer's SketchPad, which has a narrow application, and Web-based tool like a wiki, which is infused in various layers of my life (teaching mathematics courses for teachers, teaching graduate courses, conducting international research where the wiki is used to bring together students for different countries, or creating a family wiki where pictures, videos and news are posted and discussed by family members overseas).

The mathematics education technology that I thought about in the ICME-7 era was computer-based and mathematics-specific. The mathematics education technology I think with today is Web-based and it is not domain-specific. My thinking about mathematics education has been disrupted and reorganizated as I use and think *with* the technology of the Web. For example, using a wiki in my online teaching is a very different experience than teaching the same groups in a physical classroom. It is also very different from using Web 1.0 tools like WebCT. Using a wiki does not only disrupt and reorganize my thinking about how I organize classroom interaction: it also becomes a lens that changes how I see other aspects of my online teaching, such as course content, evaluation practices, my role as instructor, and generally what constitutes knowledge and how it is or should be constructed in an online environment.

The Web's shift from text-based, read-only communication to multimodal, read/write communication is not simply a quantitative change: it is not just a case of having more communication modes. It is a qualitative change, analogous to the change that occurred when we moved from an oral to a print culture. However, our understanding of what this change implies for mathematics education (and education in general) is emergent and not fully conceptualized or articulated.

Rare Events

It would be interesting for us to share in our working group wonderful mathematics experiences we have witnessed in classrooms using technology, with various tools and at different historical periods, and to consider whether or not these are rare events. It would also be interesting to consider what it is that makes such events wonderful mathematics experiences. Marcelo Borba and I have been looking at the performing arts for guidance, in part because of the performative affordances of the new media that permeates our work in mathematics education (Gadanidis & Borba, forthcoming). For example, if a mathematics classroom experience was to be judged as we might judge a film, then Boorstin (1990) would say that it would 'work' if it offered us opportunities to experience the following pleasures: the pleasure of seeing the new and the wonderful in mathematics; the pleasure of being surprised mathematically; the pleasure of feeling emotional moments in doing and learning mathematics; the pleasure of sensing mathematical beauty. Our mathematics education culture does promote helping students experience the 'new and the wonderful' to the extent that our curriculum documents promote the making of connections and exploring relationships and getting a sense of the big ideas of mathematics. However, an emphasis on surprise, on emotional moments, or on beauty would be a rare find in a curriculum document.

If, as it has been suggested, the Web, and new media in general, is increasingly a performative medium, then perhaps we have something to learn from the performing arts about how to structure wonderful mathematics experiences with technology. The arts, and especially the story arts, capture the whole of human experience. I would suggest that even if we did our best to help students use technology to experience the new and the wonderful in mathematics, without an explicit focus on surprise, emotional moments, and beauty, mathematics would not be a wholly human experience. I would also suggest that new technology may help us to make *rare events* public, to be shared as models for others and to serve as objects for reflection and critique.

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