MTH530 Technology in Mathematics Education

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Basic Aims

• To question what technology is in the 21st century and its role in Mathematics Education
• What different forms does it take and where does it belong in the student-teacher paradigm
• To explore its role in allowing us to explore and discover mathematical ideas in a deeper, more conceptual way (by that I mean that an understanding of the topic is seen within a broader spectrum of ideas, that it can be retained and used in later mathematical problem-solving and science)
• To explore the interplay between Technology and Mathematical Inquiry
• To observe where and what role Technology plays in the K-16 mathematics education spectrum
• To understand the potential of computational and communicative power inside and outside our learning environments (traditional).
• To envision the role of technology in Mathematics Education in the 21st Century (hypotheses and caveats)
General Schema of Events

- Presentations from prior week (problems solved, ideas generated, applications)
- An introductory lecture (30-40mins) which will include ideas, introduction to use and application of various technologies, problem-posing.
- Discussion
- Group Work
SH Expectations

• Active participation and group work
• Sharing of ideas, problem-solving, presentations (informal)
• Thinking and Reflecting (on each others’ ideas) - which should involve good note-taking
• Actively exploring the technology outside class (the C-minus caveat)
• This is not an Intro to Technology class
Major strands of Technology

• Software
• Hardware
• Infrastructure
• Communications
Software

• Some Basic Assumptions
  • Representationally Rich {do not make the base mathematical object more abstract}
  • Interactive {if we are not exploiting computational power, resolution, and color then why use such expensive systems?}
  • Cognitive {wrt to accessibility}
    o Visual in terms of interface and appreciative of theories of learning, activity theory and pedagogy
Hardware

• Needs to co-evolve with software & curricular development and applications
• Not just peripheral but deeply embedded in the surrounding environment
Example: Scaling Hardware

• 1. Light Pens – early pointing device where were used with a raster-display (electron beam scanned screen), photocells detected the beam and position were registered as coordinates [http://www.atariarchives.org/ecp/chapter_6.php](http://www.atariarchives.org/ecp/chapter_6.php)

• 2. Elementary and Sophisticated Mice ([www.keyalt.com/kpointer.htm](http://www.keyalt.com/kpointer.htm))

• 3. Key-stroke devices (hand-helds, mobile phones)

• 4. Scribable Tablet based device (e.g. Palm/Table PC)

• 5. Smartboards
Economy of Scales

• Does size matter?
• Scaling hardware leads to different marginal returns not just based upon immediate user feedback (click-click-do)
• Compare the use of a $10 mouse with a $3000 Smartboard
• Pointing is not necessarily peripheral but can be environmental which has huge impacts on Mathematical Education
Think

• Pointer as an environmentally constrained device (ink pen)
• Pointer as operating system-constrained device (mouse)
• Pointer as a user-constrained device (tablet)
• Pointer as an embodied, gestural, public action
• Things change as you get bigger but it does not mean more power per $
• Think about what it buys you educationally, environmentally, communicatively.
Communications

• Software and Hardware can co-evolve to enhance communication and dissemination
• Not just user-app but user-user; sharable, distributable
• Communication of ideas, participation
Infrastructure

• $S - H - C = \text{infrastructure}$
“Even though technology has provided new tools to design and discover mathematical ideas, these have not evolved at the same rate as communication infrastructure and have not deeply interplayed with their evolutions. {…} not only does technology constitute the materials, which they operate within but also the social conditions with which such operations occur. As technology becomes more infrastructural and exploits communication power, the interaction of learners and educators will change and the shift in mathematical discovery and problem-solving skills will take on a more natural sociological feel. Technology becoming infrastructural means a shift to a fundamental yet invisible role, such as which electricity, mains water, or telecommunications are given in most modern day homes when a device is turned on.”

Kaput & Hegedus, *Technology becoming Infrastructural in Mathematics Education*
K-16 Mathematics Education

• Principles and Standards – Technology Principle
• What does a Technology Principle look like for post grade 12?
• For students, what have you been exposed to? How has it been exposed? Are there any generalizable principles?
• How implementable is the Principle for K-12? For teachers, what do you do know? how does it attend to the Principle?
• Go to: http://standards.nctm.org/
AIM so far

• To contextualize what Technology means for us (me and you) and to create a baseline from which we will work from given the ubiquitous nature of technology. Expose our assumptions and beliefs

• BREAK
An introduction to dynamism – a major theme of the course

• Static Inert
  • cuneiform
  • graphs - historical note
  • clay
  • print outs

• Static Kinesthetic
  • pens, pencils, erasers
  • advance of color
  • difference between chalk and markers
• **Static Computational**
  - Graphing calculators
  - Smartboards

• **Discrete Dynamic**
  - Spreadsheets
  - Example in Excel
• Continuous Dynamic
  • Avitur’s Graphing Calculator
  • Programmable, Interactive
  • Dynamic visuals
  • Haptic, kinesthetic
  • Access invisible phenomenon (virtual)
  • 3D Maxwell, electromagnetism, force fields, oceanic visualization
Example: What is a graph?

- Maps, astronomical drawings: very old
- Modern forms: appeared in 1770, became common 1820
- Appeared in 3 places: Statistical atlases of William Playfair, Indicator diagrams of James Watt, writings of Johann Lambert (also descriptive geometry of Monge)
- Sylvester used it to describe analogies between chemical bonds in molecules and representations of mathematical invariants and covariants
• Peirce wrote: "by a graph (a word overworked of late years), I, for my part, following my friends Clifford and Sylvester, the introducers of the term, understand in general a diagram composed principally of spots and of lines connecting certain of the spots."

• Peirce called his logical diagrams “existential graphs” because of the spots and lines

• Graph has taken on an extended meaning in 20\textsuperscript{th} century
Let’s work in various environments

• Think about how a graph changes over these types of dynamism
• Calculator
• Excel
• Avitzur’s GC
Reflections:

• What are the role and purposes of such technologies both historically and in learning environments?
• List what features these various technologies have and how they are using in mathematics education (e.g. think about a graphing calculator affords, what and how a slider can be used, etc)
• Think of new activities that extend these uses of technology with other mathematical objects.
• Problem: What are the solutions of \( \sqrt{x} \), for all real \( x \)? How can you use technology to demonstrate general solutions, both graphically and algebraically, and to enable learners to understand the role of parameters? What happens if \( x \) becomes complex?