RESEARCH ON TEACHING AND LEARNING MATHEMATICS WITH TECHNOLOGY: WHERE DO WE GO FROM HERE?

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The NCTM Standards (2000) state, "In mathematics-instruction programs, technology should be used widely and responsibly, with the goal of enriching students' learning of mathematics" (p. 25). Although many mathematics educators believe in this vision, the research base we have for justifying such a belief is incomplete. Much of what we know about the use of technology in the teaching and learning of mathematics is anecdotal and might be referred to as "possibility" research. We believe there is significant interest in research regarding the use of technology in mathematics teaching and learning and propose the formation of a PME-NA discussion group to investigate frameworks which can move this work beyond "possibility" research. The overall purpose of the discussion group is to address the following questions: What do we really know regarding teaching and learning mathematics with technology? What questions do we ask from here (what more do we want/need to know)? What frameworks, methodologies and collaborations will support the research that will produce this knowledge?

In 1991, the National Council of Teachers of Mathematics (NCTM) stated in their *Professional Standards for Teaching Mathematics* that mathematics teachers should "help students learn to use calculators, computers, and other technological devices as tools for mathematical discourse" (p. 52). This position was a weak though admirable endorsement for the use of technology in the teaching of mathematics. By contrast, the NCTM's *Principles and Standards for School Mathematics* (2000) devoted one of its six overarching principles wholly to technology. The four principles addressing curriculum, teaching, learning, and assessment have long been pillars of their recommendations for educational reform (e.g., NCTM, 1961, 1980, 1989, 1991, 1995). The other two, addressing equity and technology, are not new to NCTM's vision, but their prominence is. The Technology Principle states: "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (NCTM, 2000, p. 11). The statement "technology is essential" is strong language. That technology can enhance learning is commonly accepted, although less commonly translated into practice; the claims that technology might influence the very mathematics that is taught is not mainstream thinking in U.S. mathematics classrooms.

The following excerpt further illustrates NCTM's (2000) strong commitment to a reform-oriented approach to teaching with technology:

> Students can learn more mathematics more deeply with appropriate use of technology (Dunham and Dick 1994; Sheets 1993; Boers-van Oosterum 1990; Rojano 1996; Groves 1994).[1] Technology should not be used as a replacement for basic understandings and intuitions; rather, it can and should be used to foster those understandings and intuitions. In

[1] Note that the five sources cited in support of these statements were published since the release of the 1989 NCTM *Standards*.

Lloyd, G. M., Wilson, M., Wilkins, J. L. M., & Behm, S. L. (Eds.). (2005). *Proceedings of the 27th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.*

> mathematics-instruction programs, technology should be used widely and responsibly, with the goal of enriching students' learning of mathematics. (p. 25)

Although many mathematics educators believe in this vision, the research base we have for justifying such a belief is far from complete. Although some research (as cited above) has made a case for the positive impact technology can have on the learning of mathematics, much of what we know about the use of technology in the teaching and learning of mathematics is anecdotal. That is, we have seen incredible ways technology *can* be used, but "the effects are not yet visible to many" (Kelly, 2003, p. 1038). Thus, we might refer to much of what has been written about technology and mathematics as "possibility" research.

Based on experiences at previous PME-NA conferences, we believe there is significant interest in research regarding the use of technology in mathematics teaching and learning. We propose the formation of a PME-NA discussion group to investigate frameworks which can move research on the teaching and learning of mathematics with technology beyond "possibility" research. The overall purpose of the discussion group is to address the following questions:

> What do we really know regarding teaching and learning mathematics with technology?
>
> What questions do we ask from here (what more do we want/need to know)? What frameworks, methodologies and collaborations will support the research that will produce this knowledge?

What follows is an outline of the agenda for the proposed discussion group. This agenda is based on the past pattern of meeting three different days for between 1.5 and 2.5 hours, but could be adjusted as needed.

Day 1

Purpose

To introduce the overall purpose of the discussion group and facilitate an initial discussion surrounding that purpose.

Plan

The organizers of the group will begin the discussion group with a brief presentation, in which they will introduce the proposed purpose and vision of the group. Group participants will then be formed into small groups, in which they will discuss several questions, including those outlined in the purpose statement above and prepare to share the results of their discussion with the full group. The remainder of the time will be spent sharing, comparing and contrasting the small group reports. In a broad sense we hope to address questions such as the following:

- How important is it that research on the use of technology in the mathematics classroom focus time and effort on justifying such use?
- How do varying degrees of access to technology effect the learning that occurs?
- How can we assess the learning that occurs in a technology environment?
- What experiences do teachers need in order to be prepared and motivated for andsupported in productive use of technology in their teaching?
- When considering the NCTM principles, why should technology be given such a prominent position?

Day 2

Purpose

To discuss researchable questions that can move the field forward in the directions outlined on day 1, and to discuss what frameworks exist or need to be developed in order to carry out such research.

Plan

The organizers of the group will begin the discussion by summarizing the results of the previous day's discussion. Group participants will then again be formed into small groups. Each group will be given an area of possible research interest and several related articles (e.g., Burrill et al., 2002; Cadiero-Kaplan, 1999; Doerr & Zangor, 2000; Goos, Galbraith, Renshaw, & Geiger, 2000; Heid, 1997; Kaput & Thompson, 1994; Pierce & Stacey, 2004; Schwarz & Hershkowitz, 1999; Zbiek, 1998) on teaching and learning mathematics with technology, from which they will be asked to extract "where do we go from here?" questions. These sample research areas will focus on the differences that are available (also probable, possible, desirable or undesirable) when one compares learning a given mathematical concept with or without the influence of technology. Examples include the following:

- The geometric understanding (of construction, proof, circles, loci, etc…) that is facilitated using a compass and straightedge versus using dynamic geometry software.
- The algebraic reasoning facilitated by manual versus technological manipulation of algebraic expressions and equations.
- The statistical understanding (of randomness, variability, sampling, etc…) that is facilitated by tactile manipulatives versus computer applets or dynamic statistics software.

As groups consider these questions, they will be encouraged also to discuss the frameworks that might be used, adapted, or created in order to conduct the research that is designed to answer these questions.

Day 3

Purpose

To discuss and plan how the discussion group, as an eventual PME-NA working group, could productively organize and collaborate so as to begin to produce research that will contribute to the research base we have on teaching and learning mathematics with technology?

Plan

Much of this day's activity will be an outgrowth of what is accomplished on the previous two days. Based on those discussions, the group will collaborate in articulating an agenda for the continuation of the group. We hope to encourage members of the group to consider ways in which they might pool resources throughout the coming year in order to move toward the goals of this agenda.

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