Journal of Applied and Advanced Research, 2018: 3(Suppl. 1) S26–S28
https://dx.doi.org/10.21839/jaar.2018.v3S1.163
ISSN 2519-9412 / © 2018 Phoenix Research Publishers

Teachers to teach Mathematics with ICT

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(Received: 20-03-2018; Accepted 18-04-2018; Published Online 21-04-2018)
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Abstract

The challenge for mathematics teacher educators is to identify teacher preparation and professional development programs that lead toward the development of technology pedagogical content knowledge. TPCK is an important body of knowledge for teaching mathematics that must be developed in the coursework in teaching and learning, as well as within the coursework directed at developing mathematical knowledge. Preparing teachers to teach mathematics is highlighted by its complexities. What technologies are adequate tools for learning mathematics? What about teacher attitudes and beliefs about teaching mathematics with technology? What are the barriers? These questions and more frame the challenge for the development of a research agenda for mathematics education that is directed toward assuring that all teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology in the context of teaching and learning mathematics.

Keywords: ICT, teacher educators, professional development programs

Introduction

Imagine a classroom, a school, or a school district where all students have access to high-quality, engaging mathematics instruction. There are ambitious expectations for all, with accommodation for those who need it. Knowledgeable teachers have adequate resources to support their work and are continually growing as professionals. The curriculum is mathematically rich, offering students opportunities to learn important mathematical concepts and procedures with understanding. Technology is an essential component of the environment. Will the vision of the National Research Council (NRC, 2001) be implemented in a way that all students can become mathematically proficient, a proficiency that is an integration and balanced development of five key strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition? Will technology play a role in the development of this mathematical proficiency? Will the technology be an integral component or tool for learning and communication within the context of mathematics, as called for by the *National Education Technology Standards for Students* (International Society for Technology in Education [ISTE], 2000)? Will students be learning about various technologies as they learn mathematics with the technologies? Will students be actively engaged in mathematics using technologies as productivity, communication, research and problem-solving and decision-making tools?

Technology Pedagogical Content Knowledge

The challenge is to identify teacher preparation programs that lead toward the development of TPCK for teaching mathematics. Grossman (1989, 1991) developed four central components as a means of thinking about PCK; Niess (2005) extended these components as a means of clarifying TPCK development for teacher preparation programs:

1. An overarching conception of what it means to teach a particular subject such as mathematics integrating technology in the learning.
2. Knowledge of instructional strategies and representations for teaching particular mathematical topics with technology.
3. Knowledge of students' understandings, thinking, and learning with technology in a subject such as mathematics.
4. Knowledge of curriculum and curriculum materials that integrates technology with learning mathematics.

Teacher Preparation and Professional Development

Teacher preparation programs need to focus on strengthening the pre-service teachers' knowledge of how to incorporate technology to facilitate student learning of mathematics through experiences that:

- Allow teacher candidates to explore and learn mathematics using technology in ways that build confidence and understanding of the technology and mathematics.
- Model appropriate uses of a variety of established and new applications of technology as tools to develop a deep understanding of mathematics in varied contexts.
- Help teacher candidates make informed decisions about appropriate and effective uses of technology in the teaching and learning of mathematics.
- Provide opportunities for teacher candidates to develop and practice teaching lessons that take advantage of the ability of technology to enrich and enhance the learning of mathematics.

Unravelling the Complexities: Challenging Research Areas and Questions

Preparing teachers to teach mathematics with

technology is far more complex than identifying TPCK as an important knowledge base for teachers. Several areas highlight the complexities and the challenges for mathematics education researchers.

What Technologies are Tools for Learning Mathematics?

Technology has become an essential tool for doing mathematics in today's world. It can be used in a variety of ways to improve and enhance the learning of mathematics. As NCTM (2000) highlights in its standards, technology can facilitate mathematical problem solving, communication, reasoning, and proof; moreover, technology can provide students with opportunities to explore different representations of mathematical ideas and support them in making connections both within and outside of mathematics (NRC, 2000). Which technologies make useful tools for learning and communicating mathematics?

Spreadsheets are often described as a mathematical tool. They offer access to advanced functions for exploration of problems. But should students understand the mathematics behind the functions before making use of the functions? How can students' development of mathematics be supported by an integration of the development of their knowledge of designing spreadsheets? Designing solutions to problems with spreadsheets seems to mirror the issues that surround the development of programming in computer science. If teachers do not guide students in the design of spreadsheets, students are more apt to create spreadsheets that are not reliable when changes are made in some of the cell values. Thus, the result is a spreadsheet that only solves one problem reliably. Can spreadsheets be designed to dependably and reliably solve more than one problem? What mathematics can students learn as they learn to design spreadsheets to generalize problems?

Geometer's Sketchpad and some applets provide students with wide-ranging opportunities for mathematical exploration and sense-making. With these tools students are encouraged to make mathematical conjectures and use the dynamic capabilities to visualize an idea under a wide variety of situations. Do students develop the idea that they are proving their conjecture? Is their conception of mathematical proof influenced by these explorations? What mathematics are students learning as they use these tools for exploration and problem solving?

What about Teacher Attitudes and Beliefs about Teaching Mathematics with Technology?

These technologies are only examples. What other technologies are available or are emerging that might support learning mathematics? Teachers need to be prepared for exploring the current and emerging possibilities. They need to develop a professional attitude of evaluation and reflection about tools for teaching mathematics – a thoughtful visioning that investigates and considers the impact of the tools for teaching mathematics. Niess, Lee, and Kajder (in press) identified six important areas of questions for which teachers must be prepared:

1. *Curricular needs in mathematics in the 21st century*. Can the technology be used as a productivity, communication, research or problem-solving and decision-making tool for learning in the subject area?
2. *Instructional needs in mathematics in the 21st century*. Can the technology support learner-center strategies for learning the subject? Can use of the technology as a learning tool help students develop a more robust understanding of the content?
3. *Student learning in the 21st century*. Can the technology engage students in important experiences that support their learning? Can the technology provide multiple perspectives for the students to view of mathematics? Can the technology be applied to developing students' higher order thinking and reasoning skills? Can the technology maximize student learning?
4. *Unique capabilities of the new tool*. What are the capabilities of the tool? How are these capabilities useful in accomplishing 21st century skills?
5. *Student knowledge, access, and management concerns*. Will inclusion of the new tool create student access issues? What preparation must be provided for students working with the technology as a tool for learning? What management issues need consideration if the tool is incorporated in the classroom situation?
6. *Assessment and evaluation with the new tool*. How will assessment of students' learning of mathematics be affected by the incorporation of the new tool? Will performance assessments be important to demonstrate students' knowledge of the content with use of the new tool?

What are the Barriers?

Although billions of dollars have been spent on technologies for schools, access continues to be labelled a major barrier. Many studies have documented this barrier, but on the other hand, in some situations where technology is readily available, some teachers do not know how to take advantage of it and still others are against it.

Continued research needs to be undertaken to expose real barriers so that teacher preparation and professional development programs are to be able to deal with the issues

Another barrier is the knowledge base about how students learn and how to design the curriculum that supports students in learning mathematics with technology.

Conclusion

Thus, as more and more teachers teach mathematics with technology as a tool, the shift must be toward the evolving issues more directly focused on student learning of mathematics – evaluating the results of the decision and its impact on the mathematics curriculum and instructional strategies needed so that all students are able to learn mathematics. Ultimately, if technology is used to improve the learning of mathematics at all levels, students will be better prepared to use technology appropriately, fluently, and efficiently to do mathematics in technology rich environments in which they will study and work in the future.

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