Journal of Indian Research, Volume 1 No. 1, 2013, 105-110

Education

PEDAGOGY OF MATHEMATICS:
ROLE OF TECHNOLOGY IN TEACHING-LEARNING MATHEMATICS

Dr. Neetu Chawla*, Ashish Kumar Mittal**

ABSTRACT

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 National Council of Teachers of Mathematics (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). What kind of technologies can be used as tools for learning and communicating mathematics? The use of technology when studying mathematics is not a new issue, since humankind always has been looking for solutions to avoid time consuming routine work. Maybe the definition of routine work has changed, since the implementation of modern computers. Today we can not only get help with long and complicated calculations, we can also use computers and modern software to simulate and model complex situations described by mathematical structures. 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 pose a 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.

Key Words: *Technology in Mathematics, Attitude Of Teachers , Role Of Technology In Mathematics, Technology In Classroom, Barriers in The Way Of Mathematics.*

INTRODUCTION

Circa. September 1, 2056. Imagine the school atmosphere. And if one is entrusted with the responsibility to investigate the status of mathematics instruction in elementary, middle and high schools. What would one find? What kind of mathematics would be taught? How would be teachers teaching? How would students learn? Would the mathematical knowledge and skills imparted to students turn them into becoming mathematically more proficient? Can one estimate how much the National Council of Teachers of Mathematics' (NCTM) vision for school mathematics has been realized?

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

**** Dr. Neetu Chawla** [M.Sc., M.C.A., M.Ed., Ph.D.], Head, Department of Education, R.C.C.V. Girls Degree College, Ghaziabad.*

*****Ashish Kumar Mittal** ,Head, Department of Mathematics, Indirapuram Public School, Indirapuram, Ghaziabad*

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. (NCTM, 2000, p.3)

Can this vision of the National Research Council (NRC, 2001) be implemented so that all students can become mathematically proficient, a proficiency that involves an integration and balanced development of five key strands: *conceptual understanding, procedural fluency, strategic competence, adaptive reasoning*, and *productive disposition?* Can technology play a part in the development of mathematical proficiency? The National Education Technology Standards for Students *(International Society for Technology in Education, ISTE,* 2000) has observed that the technology is an integral component or tool for learning and communication within the context of mathematics . The students may be exposed to learning about various technologies once they learn begin to mathematics through the usage of technologies. Once students get actively engaged in mathematics using technologies , there may be quantum jump in productivity, communication, research and problem-solving and decision-making tools.

The challenge at hand is to make things happen to realize these visions by 2056. Perhaps one of the most critical respondents for actualizing this vision is the mathematics teacher. What will these teachers need to know and be able to do? As of now, most teachers have not learned mathematics using technology tools. The objective herein is to identify "what" and "how" to prepare mathematics teachers to teach in the 21st century. What do teachers need to know and be able to do and how do they need to develop this knowledge for teaching mathematics?

Technology: Pedagogical Content Knowledge

In 1986, Shulman proposed a more in-depth look at what teachers must know in order to teach, highlighting that future teachers need to be prepared to be able to transform that subject matter content through teaching strategies to make that knowledge accessible to learners. To teach, teachers need to have developed an integrated knowledge structure that incorporates knowledge about subject matter, learners, pedagogy, curriculum, and schools; they need to have developed a pedagogical content knowledge or PCK for teaching their subjects. But for technology to become an integral component or tool for learning the subject, teachers must also develop *"an overarching conception of their subject matter with respect to technology and what it means to teach with technology – technology pedagogical content knowledge (TPCK)*" (Niess, 2005, p. 510). To be prepared to teach mathematics then, teachers need an in-depth understanding of mathematics (the content), teaching and learning (the pedagogy), and technology. More importantly, however, they need an integrated knowledge of these different knowledge domains, the overlap and integration of these domains. TPCK for teaching with technology means that as they think about particular mathematics concepts, they are concurrently considering how they might teach the important ideas embodied in the mathematical concepts in such a way that the technology places the concept in a form understandable by their students. 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:

(a) an overarching conception of what it means to teach a particular subject such as mathematics **integrating technology** in the learning;

(b) knowledge of instructional strategies and representations for teaching particular mathematical topics **with technology**;

(c) knowledge of students' understandings, thinking, and learning **with technology** in a subject such as mathematics;

(d) knowledge of curriculum and curriculum materials that **integrates technology with learning mathematics**.

The availability of technology has changed enormously during the last 20-30 years. From the large and clumsy desk calculators of the 1970's over to the functional calculators in the 1980's and during the last two decades, we have got graphing calculators as well as symbolic calculators. There are also calculators which include software for geometrical constructions. If we shift to computers, the availability of software for all kinds of undergraduate mathematics is enormous, both commercial and freeware is easy to get. This significant change in availability naturally raise questions concerning mathematics education at all different levels, questions concerning content, teaching & learning, and assessment. Most curricula around the world probably include technology at different levels in some way. Here are some excerpts from the Swedish compulsory school:

> *The teaching of mathematics should strive for that students with familiarity and sound judgment can see and use the potentials of calculators and computers. Students should develop their knowledge about how mathematics is used within information technology, as well as how technology can be used in problem solving, in visualizing, and when investigating mathematical models.*

The use of technology in mathematics teaching at the college and university level today is harder to describe. Most university students at Gothenburg University seem to have calculators from their upper secondary studies, as well as easy access to computers and Internet both at campus and in their private environment. Many study halls at the universities include the possibility to make wireless network connections and since many students carry laptops with them in school, it is almost as if these students have instant access to tools for calculations and visualization. This is probably true for most university students in Sweden and in the Nordic countries.

Technology in the mathematics classroom

The use of technology when studying mathematics is not a new issue, since humankind always has been looking for solutions to avoid time consuming routine work. Today we not only get support of technology in long and complicated calculations, we can also use computers and modern software to simulate and model complex situations described by mathematical structures. The views on how information and communication technology can be used to support learning of mathematics have changed over time. When the new curriculum for the Swedish compulsory school was implemented in 1980, there was a new subject introduced called computer science. Mainly teachers of mathematics, Swedish and social science were involved in this work. Since the 1980's, the importance of computer support in the teaching and learning of mathematics has been emphasized more and more. It can be seen in the steering document for the curriculum for the present Swedish compulsory school. The view on how technology should be used in the mathematical classroom is also affected by other forces, as for instance strong expectations that present schools should mirror what goes on in the surrounding society in this respect.

In this context it is highly relevant to ask the question about how the teaching and learning of mathematics may be affected when modern technology is available. When it comes to computer support, Samuelsson (2003) addressed the role of the computer as an agent of change and focused on the following issues:

1. What new methods will be used by the teachers because of the technology?

a. When teachers use technology to introduce the concept of the equation of a straight line ($y = kx + m$), the teaching will be different compared to an ordinary introduction. The students will be able to easily investigate how different values for the parameters will affect the graph of the function.

b. The students learn more mathematics through visualization and models in the computer.

c. The students will learn effective procedures that help them to solve problems more efficiently, mainly due to the element of game and competition offered by the computer.

2. What new goals/results will be in focus for the teacher thanks to the possibilities offered by technology?

d. The students will be able to learn to handle technology in different mathematical situations.

e. Different aspects of knowledge can be acknowledged, for instance in statistics and algebra, if technology is used when students solve mathematical problems.

3. What in the everyday technology-enriched teaching of mathematics supports the overall visions that exist for school mathematics?

f. The student's views of mathematics may be affected in a positive way if the teaching is pursued with technology

g. Learning oriented teaching with utility programs seems to support the vision that the teacher should focus more on conceptual learning and less on the learning of skills and procedures.

h. See answers a, d, and e.

4. What kind of everyday technology-enriched teaching of mathematics interfere with the overall visions that exist for school mathematics?

i. To work with drill and practice software supports an old form of teaching mathematics, which the modern school is leaving behind. The technology could thus be assimilated into old traditions.

j. The students' possibilities to reflect over the content in the problems are reduced by the element of game and competition offered by the computer.

k. Technology offers a variety of different distractions, which results in students doing other things than mathematics in the classroom, surfing on the web, checking e-mail, and so forth. Technology becomes amusement.

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 profound envisioning that investigates and considers the impact of the tools for teaching mathematics. Niess, Lee and Kajder identified six important areas of questions that teachers must be prepared for:

1. **Curricular needs in mathematics in the 21st century.** Can the technology be used as a productivity, communication, research and or problem-solving and decision-making tool for learning in the subject area? Does the technology offer the capabilities to facilitate technology-enhanced experiences that address subject matter content standards and student technology standards? Does the technology offer capabilities that challenge the accepted standards, opening the possibility for a shift in what students need to know to be productive citizens in the 21st century?
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? Can the technology address the diverse needs of students in learning the subject? How must the instruction be scaffolded to guide student learning with and about the technology?
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? Do the capabilities challenge accepted ways of knowing and doing? What must be learned before incorporation of the tool as a learning tool?
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?

While billions of dollars have been spent on technologies for schools, access continues to be labeled 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. The lack of knowledge of integration acts as the barrier and the teachers' beliefs about how mathematics is to be learned becomes a pertinent issue. *Norton, McRobbie and Cooper* (2000) investigated this question by studying upon a mathematics staff in a technology – rich secondary school where the technology was rarely used in teaching mathematics. Their results suggested that these teachers' resistance was related to their beliefs about mathematics teaching and learning and their existing pedagogies. In essence, knowledge and beliefs may be the actual barriers. Perhaps these teachers are either uncomfortable with technology, or unsure about how to incorporate technology into their curricula, or have not seen examples of effective use. The result challenges teacher educators as they identify requirements to support the development of TPCK through the student teachers' program. While some programs simply make the requirement and provide access through classroom sets to be used during student teaching, others are more carefully investigating the classroom barriers. Garofalo and Bell (2005) at the University of Virginia provided their secondary mathematics and science student teachers with a laptop, projector and Smartboard for use during field practice with actual students. They studied the role of student teachers' beliefs and TPCK on classroom use of technology, when access is less of an issue. Continued research needs to be undertaken to expose real barriers so that the teacher preparation and professional development programs are able to deal with the issues.

Mathematics anxiety is certainly an issue in mathematics education. Does mathematics anxiety extend to technology anxiety? What about the discontinuity in the mathematics curriculum from pre-college to college level? Students at the precollege level have relatively few opportunities to use technology in learning mathematics. But, when they enter college, they are confronted with a ubiquitous incorporation of technology in learning mathematics. Calculators are expected. Students need to be able to readily use MATLAB as a tool for developing mathematical models for solving problems. But , students' mathematics technological toolkit cannot develop if teachers in the pre-college level are resistant to teaching mathematics with technology.

Another barrier that has been frequently pointed out is the knowledge base about how students learn and to design the curriculum that supports students in learning mathematics with technology. Everett Rogers (1995) explains how teachers need to progress through a five-step process in the process of facing the ultimate decision as to whether to accept or reject a particular innovation for teaching mathematics with technology:

1. **Knowledge** where teachers become aware of integrating technology with learning mathematics and has some idea of how it functions;
2. **Persuasion** where teachers form a favorable or unfavorable attitude toward teaching and learning mathematics with technology;
3. **Decision** where teachers engage in activities that lead to a choice to adopt or reject teaching and learning mathematics with technology;

4. **Implementation** where teachers actively integrate teaching and learning with technology;
5. **Confirmation** where teachers evaluate the results of the decision to integrate teaching and learning with technology.

Thus, as more and more teachers teach mathematics with technology as a tool, the shift must be towards 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 techno-rich environments in which they will study and work in the future. This might result in effective instructions in the mathematics classroom Circa. 2056!

References:

Association of Mathematics Teacher Educators' Technology Committee. (2005). *Draft position statement titled Preparing Teacher to Use Technology to Enhance the Learning of Mathematics.*

Beck, J. A. & Wynn, H. C. (1998). *Technology in teacher education: Progress along the continuum*. ERIC Document Reproduction No. ED 424 212.

Björk, L-E. & Brolin, H. (1995). *Using new technology as a tool to increase student understanding of calculus.* Proceedings of the International Conference on Technology in Mathematics Teaching, Edinburgh.

Grossman, P. L. (1989). *A study in contrast: Sources of pedagogical content knowledge for secondary English*. Journal of Teachers Education, 40(5), 24-31.

Grossman, P. L. (1991). *Overcoming the apprenticeship of observation in teacher education coursework*. Teaching and Teacher Education, 7, 245-257.

International Society for Technology in Education. (2000). *National educational technology standards for students: Connecting curriculum and technology.* Eugene, OR: ISTE.

International Society for Technology in Education. (2002). *National educational technology standards for teachers: Preparing teachers to use technology.* Eugene, OR: ISTE.

Margerum-Leys, J. & Marx, R. W. (2002). *Teacher knowledge of educational technology: A study of student teacher/mentor teacher pairs.* Journal of Educational Computing Research, 26(4), 427-462.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*, Reston, VA: NCTM.

National Research Council, (2000). *How people learn*. Washington D. C.: National Academy Press.

National Research Council, (2001). *Adding it up: Helping children learn mathematics.* Washington D. C.: National Academy Press.

Niess, M. L. (2005). *Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge,* Teaching and Teacher Education, *21*, 509-523.

Utbildningsdepartementet. (2000). *Kursplaner för grundskolan.* Stockholm, Fritzes.

Zhao, Y. (Ed) (2003). *What teachers should now about technology: Perspectives and practices.* Greenwich, Ct: Information Age Publishing.