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ABSTRACT

Mathematical literacy has become a 'buzz word' for describing those mathematical abilities, which are essential for any individual to function in our increasingly technological world. Despite the widespread use of the term, there is no real consensus about what being mathematically literate entails. A working group met during this AMTE conference to explore the issue of how technological literacy supports mathematical literacy. Considering a proposed model of mathematical literacy, which included processes (problem solving, reasoning, representing, and manipulating), and enablers (values, technology, and communication), the working group raised questions and discussed perspectives about the relationship between technology and mathematics. While the working group raised questions about the complexity of the construct and the difficulty in identifying common standards for all students, the group did provide important perspectives on the role of technology in providing rich mathematical environments which promote exploration and analysis of mathematical concepts. The members agreed that technology provides a tool for looking at problems in new ways. Further, the working group indicated that there is not an adequate framework, which promotes understanding and application of technology in the mathematics classroom. Too frequently teachers are left to define for themselves what the 'appropriate use' of technology is in their classrooms; therefore, mathematics teacher educators and others in the mathematics and education communities must continue to define the issues and provide perspectives so that all students can have equal opportunities to develop mathematical literacy. (Author)

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Mathematical and Technological Literacy: Developing an Integrated 21st Century Model

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ABSTRACT. Mathematical literacy has become a 'buzz word' for describing those mathematical abilities, which are essential for any individual to function in our increasingly technological world. Despite the widespread use of the term, there is no real consensus about what being mathematically literate entails. A working group met during this AMTE conference to explore the issue of how technological literacy supports mathematical literacy. Considering a proposed model of mathematical literacy, which included processes (problem solving, reasoning, representing, and manipulating), and enablers (values, technology, and communication), the working group raised questions and discussed perspectives about the relationship between technology and mathematics. While the working group raised questions about the complexity of the construct and the difficulty in identifying common standards for all students, the group did provide important perspectives on the role of technology in providing rich mathematical environments which promote exploration and analysis of mathematical concepts. The members agreed that technology provides a tool for looking at problems in new ways. Further, the working group indicated that there is not an adequate framework, which promotes understanding and application of technology in the mathematics classroom. Too frequently teachers are left to define for themselves what the 'appropriate use' of

technology is in their classrooms; therefore, mathematics teacher educators and others in the mathematics and education communities must continue to define the issues and provide perspectives so that all students can have equal opportunities to develop mathematical literacy.

Introduction

Mathematical literacy is necessary for today's students to competently approach current challenges. The development of mathematical literacy is critical in providing our students with the unrestricted access to the school curriculum and to a full range of opportunities in their vocational and personal lives. The National Council of Teachers of Mathematics (1989) in recognition of the significance of mathematical literacy called for the creation of " a coherent vision of what it means to be mathematically literate both in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied in diverse fields." In the current working draft of the Standards 2000 document, NCTM (1998) reaffirms the critical need for mathematical literacy in our increasingly mathematical and technological world that requires informed decisions requiring quantitative understanding. As evident in these references, technology is a cornerstone in the development of mathematical literacy. Being both technologically and mathematically literate is vital for the application and understanding of mathematics.

Some feel that the charge to create a coherent vision of what it means to be mathematically literate has not been adequately realized. One problem is that

conceptions of what it means to be mathematically literate are diverse and efforts to find commonalties have been minimal. The construct of mathematical literacy is multifaceted and our perceptions for what is necessary for learners today is continuing to evolve. This paper provides some perspectives on the nature of technology in the development of mathematical literacy.

Constructing a Model of Mathematical Literacy

In order to facilitate discussion of the interrelationship between mathematical and technological literacy, participants of this working group were presented with a basic model of mathematical literacy (Pugalee, 1999). The model represents those processes that are central in using mathematical knowledge. The center of this model is content. Students must have an adequate foundation in the mathematics content in order to extend their skills at applying that knowledge in order to 'do mathematics'. The five processes appear in the outside circle of the model: representing, manipulating, reasoning, and problem solving. The inner circle identifies three enablers that facilitate the student's ability to engage in mathematics: communication, technology, and values. The model utilizes two concentric circles enclosing a core labeled as content. Concentric circles depict the interrelated nature of the processes and enablers as they interact with the content of mathematics in the development of mathematical literacy.

[Insert Figure 1 about here]

Students must obtain the ability to construct and alternate between various representations of mathematical models. Representing involves process skills which include equations, matrices, graphs, and other symbolic or graphical forms. Multiple

representations of concepts such as numerical, algebraic, graphical, and verbal are necessary if one is to denote mathematical information and ideas in order to facilitate communication and to successfully solve mathematics problems.

The mathematically literate student must be able to successfully perform manipulations involving various calculations and the use of algorithms and procedures. The ability to manipulate extends beyond actions to include the development of a deeper or conceptual understanding of mathematics. Students must understand the complexity and nature of mathematical computations, algorithms, and procedures. This process includes the ability of students to use calculators, computers, and other devices to explore mathematical ideas and solve problems.

Making conjectures, gathering evidence and building arguments is part of being able to reason mathematically. Reasoning involves informal and formal thinking about mathematics which promotes sense making as students draw logical conclusions; use models, facts, properties and relationships to explain thinking; justify answers and solution processes; and use patterns and relationships to analyze situations.

Problem solving continues to be recognized as the fundamental objective for mathematical study. Problem solving depends upon the utilization of prior knowledge and skills in developing a plan to resolve a problem, monitor the progress of that plan, and evaluate the reasonableness of the outcomes. The ability to engage in problem solving is at the core of becoming mathematically literate.

Mathematical literacy involves the intricate interaction of these four processes. While an individual possesses varying levels of proficiency, each of these processes must

be nurtured and developed to move toward mathematical literacy. In addition to these processes are some factors which enable students to develop as mathematical thinkers. These "enablers" include technology, communication, and values.

Communication, spoken and written, is a necessary tool in assisting student to extend and develop mathematical understanding. Communicating mathematically is essential in providing opportunities for the formation of associations between informal and intuitive ideas in mathematics involving the use of abstract language, symbolism, and multiple representations. Values include emotions, beliefs and attitudes toward the actual doing of mathematics as well as the nature of mathematics. The affective domain interacts with cognitive processes in ways that impact the development of mathematical understanding. Students must be provided with opportunities to develop positive values toward mathematics in order to truly be empowered to succeed in mathematics. Technology is the third enabler. The remainder of this paper will explore the issues related to technological and mathematical literacy. The background information given thus far provides a context for understanding the complexity of the use of technology as a tool in the development of mathematical literacy.

Technology and Mathematical Literacy

Technology continues to shape our lives in remarkable ways including transforming our approach to mathematics. Technological tools must be a domain of the mathematically literate as he or she investigates mathematical ideas and seeks solutions to mathematical problems. Apprehension about the impact of technology use, especially hand held calculators, on the development of mathematical skills is unfounded. Research

fails to substantiate concerns that students who use technology experience any lack of progress in mathematical abilities, including computational skills. To the contrary, the research literature shows that calculators use promotes the development of higher order thinking particularly during mathematical problem solving (Nohda, 1996). This means that technology has the potential to change the nature of the problems, which are viewed as important in the study of mathematics. Additionally, technology provides new tools for changing the approaches and methods used to study mathematics and solve problems. NCTM (1989) recognized the vitality of technology's role that they advocated that calculators should be made available to all students at all times, that a computer be available in every classroom for demonstration, every student have access to a computer for individual and group work, and that students learn to use the computer as a tool for processing information and performing calculations in investigating and solving mathematical problems (page 8). The ability to use technology in mathematics will continue to play a significant role in the advancement of mathematical understanding and consequently in obtaining mathematical literacy.

Technology plays an important role in the evolution of algebraic thinking. Technology provides students with opportunities to visualize graphs and generate data; thus, there are more opportunities to focus on real world applications, abstract concepts, and mathematical relationships. The learner has increased opportunities to manipulate information in ways that enrich his/her mathematical experiences and encourages thinking mathematically about problems and concepts in more conceptual terms.

Considering the potential of technology raises an important question, "How does technology become a tool?" Our schools need assistance in moving from a non-technology curriculum to a technology-oriented curriculum. There must be clearer articulation of how technology promotes and fosters mathematical understanding. In this rich technology oriented environment, teachers must extend their mathematical knowledge in order to understand the entire curriculum. Knowing what concepts come next is vital if technology is to become a powerful tool in connecting concepts and providing a powerful means for exploring relationships and constructing knowledge. We have a long way to go. We will not reach this goal if we fail to develop models for the integration of technology into mathematics.

Conclusion

While it might be unfeasible to define mathematical literacy in terms of the same standards for everyone, there are common processes which interact with the content of mathematics to bring about mathematical understanding. These processes along with tools, which facilitate the development of mathematical thinking, are vital components in the suggested model of mathematical literacy offered here. Mathematical literacy is necessary if our students are to learn to adapt new technologies, identify mathematical problems, reason about the problems and content of mathematics, and communicate using various representations (NCTM, 1997). The four processes and three enablers in this model are part of a dynamic and inter-related system. These components provide a background for understanding the intricacy of mathematical literacy.

Beginning discussions in describing the interaction of mathematical and technological literacy is a commanding task. One of our goals in engaging in this discussion is to promote additional discourse to enhance our perspectives and ideas about mathematical literacy. Subsequently, the role of technology in this process must be clearly articulated. The current rhetoric characterized by phrases such as the "appropriate use of technology" is inadequate in formulating both methods and models for enriching the mathematics curriculum. The use of such terms as "appropriate and acceptable" does not provide substantive direction for teachers and educators. We must continue to address the issues and define how technology becomes a tool. The concept of mathematical literacy is incomplete without any of the components offered in the present model. We must engage in hard and focused discussion on how to best communicate how technology functions as a tool (enabler). Only in bringing this discussion to the forefront can we progress in providing those experiences which will assist our students in developing mathematical literacy.

The Working Group: David Pugalee, University of North Carolina at Charlotte and Gregory Chamblee, Georgia Southern University served as facilitators. Other members included Susan Beal, Saint Xavier University; Fred Flener, Northeastern Illinois University; Marty Larkin, Southern Utah University; Mary McMahon, North Central College; S. Marie Elizabeth Pink, Alverno College; Susan Pustejovsky, Alverno College; Ken Simms, University of Missouri; David Slavit, Washington State University; Melissa

Sheparh, University of St. Thomas; Linda Taylor, University of Cincinatti; and W. Virginia Williams, National Council of Teachers of Mathematics.

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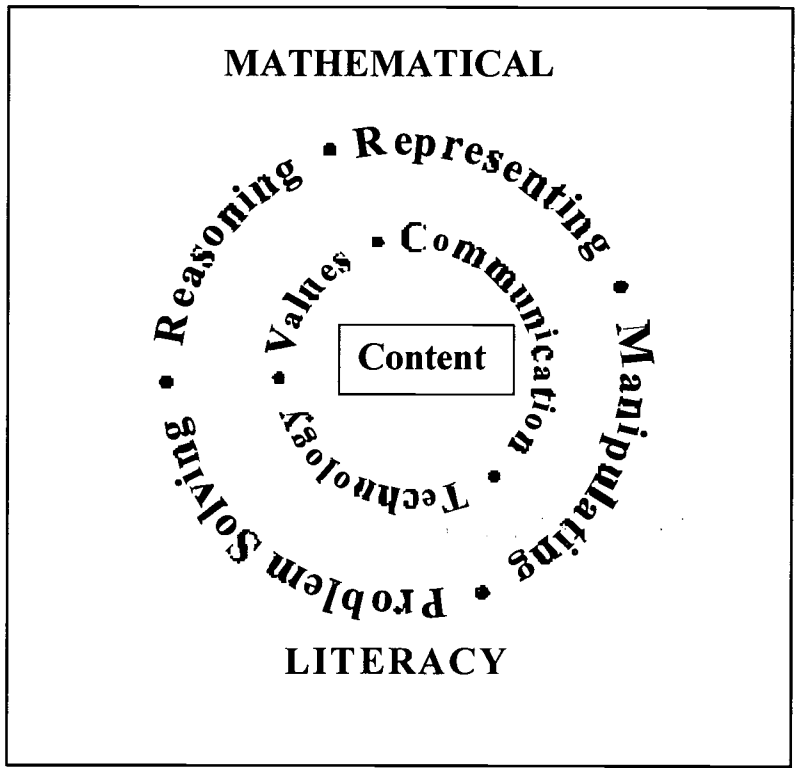
Figure 1. Model of Mathematical Literacy



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