SHORT

reports

Technology in K-12 Mathematics Classrooms

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Technology integration in mathematics classrooms is important to the field of education, not only because today's society is becoming more and more advanced and reliant upon technology but also because schools are beginning to embrace technology as an essential part of their curricula. The *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000) and the *National Educational Technology Standards* (International Society of Technology in Education [ISTE], 2005) for both teachers and students emphasize the importance of technology in teaching and learning for K-12. There is a variety of technologies integrated into mathematics classrooms that support different teaching and learning strategies and objectives. Of particular interest here are the educational technologies used in K-12 mathematics classrooms and their effects on instruction and student learning.

Educational Technologies Used in Mathematics Classrooms

Calculators. Calculators are one of the essential technologies in mathematics classrooms that enhance student understanding (NCTM, 2000). Specifically, graphing calculators provide students and teachers with comprehensive ways to investigate, explore, and discover concepts (Harskamp, Suhre, & Van Streun, 2000). Graphing calculators are more prevalent in high schools (Dion, Harvey, Jackson, Klag, Liu, & Wright, 2001), and their use promotes deeper conceptual understanding by exposing students to multiple representations of mathematical concepts (Doerr & Zangor, 2000; Smith, 1998). Using calculators increases students' higher-order thinking skills and motivation (Phillips-Bey, 2004). These cumulative effects have been interpreted as helping to create an enhanced understanding of mathematics.

Interactive Whiteboard. While blackboards or whiteboards are universally used in every classroom, they are being replaced with interactive whiteboards. This new computer peripheral is attractive to both teachers and students (Kennewell & Beauchamp, 2007). The interactive whiteboard is a combination of computer, touch sensitive whiteboard, and a LCD projector integrated into a system that provides exponential benefits over any one component alone. One common advantage of interactive whiteboards is they increase student motivation (Beeland, 2002; Weimer, 2001). Through software applications, interactive whiteboards provide teachers the flexibility to design instruction that deepens student understanding (Edwards, Hartnell, & Martin, 2002; Miller, 2003). Interactive whiteboards have also been shown to reduce the time teachers spent as compared to writing on traditional boards (Ball, 2003; Miller).

Immediate response devices. This technology enables teachers and students interact via devices ranging from very durable simple keypads to intelligent multipurpose handheld computers. Although a number of researchers have studied immediate response devices (IRDs) in higher education, there is very little research at the K-12 level (e.g., Penuel, Boscardin, Masyn, & Crawford, 2007). Despite differences between the two groups in their expected level of knowledge and skills, K-12 teachers can use the same strategies shown to improve engagement and instructional experiences in post secondary education (Penuel et al.; Roschelle, Penuel, & Abrahamson, 2004).

These devices, IRDs, are also known as clickers, student response systems (SRS), audience response systems (ARS), or personal response systems (PRS). The IRDs can be integrated into classrooms to promote active learning in mathematics (Lowery, 2005; Martyn, 2007). Careful implementation of IRDs enables teachers to integrate questioning and class discussions with immediate response from every student. The uses can be expanded to "... elicitation of students' initial ideas, formative assessment, instructional decision making, polling students about preferences and interests, and quizzing" (p.216) (Penuel et al., 2007). Two key features, which distinguish IRDs from other active learning pedagogies such as traditional class discussions, are the mechanism that provides anonymity of responses and the game approach that engages students more than traditional class discussions (Martyn). These devices can help teachers to adapt their teaching to the needs of their students by providing immediate data about student learning (Draper & Brown, 2004; Wit, 2003). Students also benefit from the immediate feedback they get as they compare their answers with the correct answer provided by the teacher. In addition, IRDs reduce the paperwork associated with attendance taking, test administration, and grade recording, calculation and analysis (Johnson & McLeod, 2004; Lowery). K-12 teachers can use above mentioned strategies to improve teaching and student understanding and motivation.

Computers. Computer use in classrooms has been expanding, in part, due to the positive effects of computer-assisted learning in mathematics (Souter, 2002). Based on the analyses of National Educational Longitudinal data, there is a positive correlation between computer use and student achievement (Weaver, 2000). Types of computers in mathematics classrooms include desktop computers, laptops, hand-held computers, and personal digital assistants (PDAs). Desktop computers entered schools in the late 1980s; however, they haven't become an essential component of mathematics classrooms (Jacobsen, Clifford, & Friesen, 2002). One of the main reasons for the status quo may be because for many students, desktop computers have been only available in labs at prescheduled times for a limited period. However, with portable versions such as laptops, hand-held computers, and PDAs, computers are becoming more integrated into mathematics classrooms (Cwikla & Morse, 2005; Lewis, 2005). Handheld computers and PDAs are pocket-size mobile computing devices that include programs such as calculator, clock, calendar, address book, word processing, and spreadsheet. They also facilitate internet access, audio and video recording, survey response recording, and global positioning systems (GPS). The size, portability, mobility, and accessibility of these handheld devices differentiate them from desktop computers and laptops (Pownell & Bailey, 2000).

When integrated properly into the teaching and learning process, computers improve student proficiency in mathematics. Through different software applications computers reduce the cognitive load of mathematical learning (Kozma, 1987; Liu & Bera, 2005). Interactive mathematics computer programs such as *Geometer's Sketchpad* (Jackiw, 1995) and virtual modeling and visualization tools provide students with dynamic multiple representations and support their understanding as they interact with concepts in a variety of ways (Flores, Knaupp, Middleton, & Staley, 2002; Garofalo, Drier, Harper, Timmerman, & Shockey, 2000). In addition, computers offer students immediate access to the web, where they can find additional resources and use interactive sites to investigate mathematical concepts.

Web-based applications. Web-based applications are available to teachers and students in classes with internet access. Web-based practice and assessments can produce practical and flexible approaches for teaching and learning mathematics because these applications are easy to use given students' familiarity with personal computers and web browsers. Web-based technologies offer radical improvements and innovative methods for assessment (Bennett, 1999). This technology provides interactive applications or programs with immediate scoring and feedback, makes the assessments more authentic and engaging by incorporating audio, video, and animation into the assessment tasks, and allows for individualized assessments by engaging different students with different interactions simultaneously (Bennett, 2001).

Implication

The realized positive effects of technology integration in mathematics education include improved attitudes toward learning, increased student achievement and conceptual understanding, and engagement with mathematics. However, these positive effects of technology on mathematics teaching and learning are mediated by how well the technology is used (Guerrero, Walker, & Dugdale, 2004; Lowther, Ross, & Morrison, 2003). For successful implementation of technology in mathematics classrooms, Masalski and Elliott (2002) recommend that schools provide students and teachers with access to appropriate instructional technology, both pre-service and in-service teachers receive proper professional development in the use and integration of educational technology, and technology is integrated in curricula, course objectives, and assessment. However, in many schools the available technology lay unused, or teachers are not provided with adequate professional development or technology-based curriculum materials (Muir, 2007).

Although many schools have technologies available, they are not woven into the teaching and learning process. One of the factors that determine the use of the technology is its location for equitable access. For example, computers are commonly located in computer labs, and it is difficult to schedule the lab when it is needed. Alternative strategies to this practice have been suggested such as making computers available through mobile computer labs. Another factor in the effective integration of technology is technical support. Many teachers experience technology failures in classrooms. Frequent technical problems that are not resolved in a timely manner cause teachers abandon their efforts to implement technology (US Department of Education, n.d.). Schools need to provide staff with technological expertise such as that of an instructional technology specialist who can assist teachers in the resolution of technological problems. Further, instructional technology specialists can provide professional development for teachers to integrate diverse technologies into the classrooms and to utilize technology as an integral curriculum component.

Unfortunately, many teachers do not know how to incorporate technology into classroom instruction (Weaver, 2000). The primary function of technology in classrooms has been to automate traditional education (Muir, 2007). However, as emphasized by Dede, using technology to simply automate traditional methods of teaching and learning will not have a substantive impact on teaching and learning (Brandt, 1995). An effective implementation of technology augments the learning of every student by providing diversity in instructional models, developing a student-centered learning environment, and restructuring the teaching and learning process to make it more intellectually rigorous. Driscoll (2002) offers four guidelines as a framework for appropriate use of technology:

Learning occurs in context, so teachers can include technologies that provide real world context such as computer simulations, information from current web resources, or videos related to current events.

Learning is active, so teachers can use brainstorming, concept mapping, or visualization software.

Learning is social, so teachers can include software that supports a networked multimedia environment.

Learning is reflective, so teachers can include technologies that promote communication within and outside the classroom.

In addition, the Technology Integration Planning (TIP) model provides teachers five phases for effective technology integration to address educational standards and to satisfy their students' needs (See Figure 1) (Roblyer, 2006). In the first phase, teachers determine the relative advantage of technology integration. Teachers need to identify the benefits of technology implementation compared to their current practice and assess if these benefits are worth the additional time, cost, and effort. In phase 2, the focus is to evaluate if the advantages of technology integration have taken place. To this end teachers adopt objectives and assessments to evaluate and revise integration strategies. Teachers can specify the expected outcomes of technology implementation and develop means to assess how well these outcomes have been met. Phase 3 involves designing integration and teaching strategies. These strategies are guided by content objectives and student characteristics. Teachers can utilize technology to accommodate differentiated instruction, which is necessary for students with different learning levels and styles to be successful in heterogeneous classrooms. In phase 4, teachers prepare all aspects of the instructional environment, including the setting, instructional activities, acceptable use policy, and tasks that specifically require computer use. The availability and the quantity of necessary equipment such as computers and software, access to these technological tools, and back-up plans for technology failure should be considered in this phase. In the last phase teachers reflect on products of the previous stages to determine what worked well and which aspects need improvement. Applying Roblyer's model may help to provide appropriate technology integration (Cifuentes & Ozel, 2008).

Discussion

Instructional technology has been found to have positive effects on both students' achievement in mathematics and their attitudes toward mathematics (e.g., Beeland, 2002; Weaver, 2000). However, these positive effects are mediated by how it is integrated into the teaching and learning process. As emphasized by US Department of Education's (n.d.) report on technology and education, to effectively integrate technology into mathematics classrooms three prerequisites are necessary: a) students and teachers must have equitable access to technology, b) teachers must receive adequate training in the use and implementation of technology within their curricula, and c) teachers must be provided with timely access to technical support so that they are comfortable with integrating technology in their classrooms.

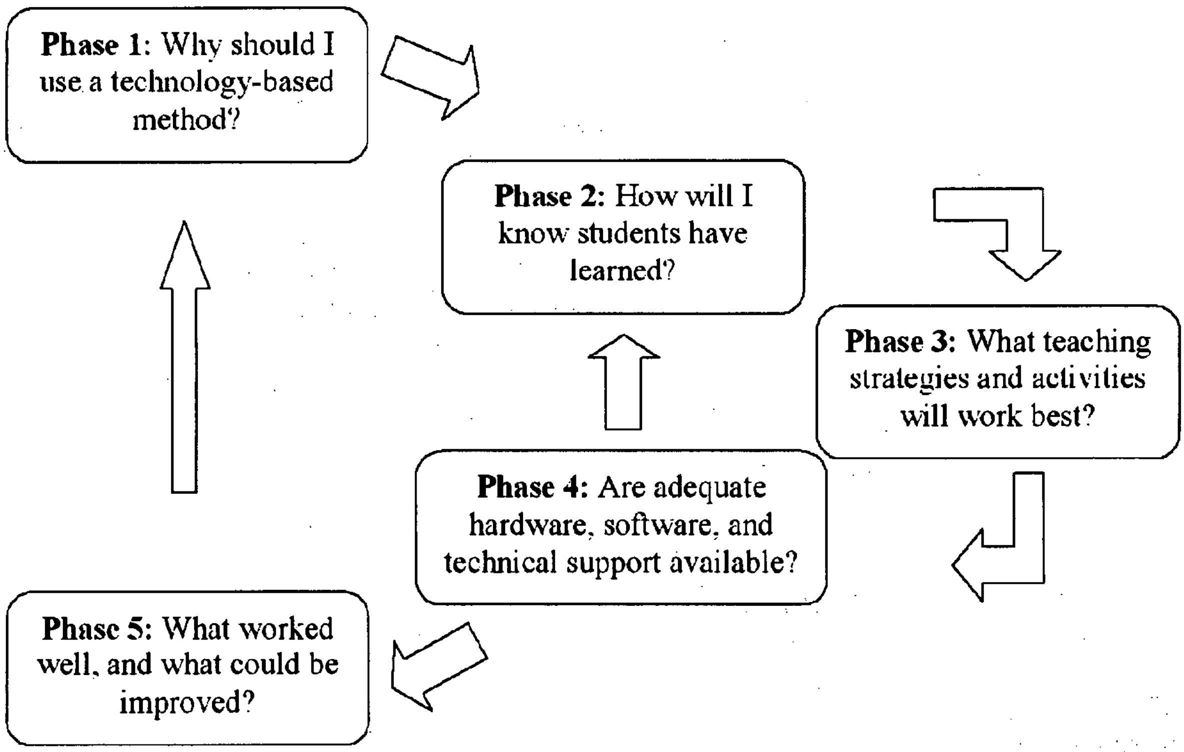

Figure 1. The technology integration planning.

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