

Integrating Technology into the Mathematics Classroom: Instructional Design and Lesson Conversion

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Abstract

The use of technology in Kindergarten to grade 12 classrooms provides opportunities for teachers to employ mathematical rigor, to integrate problem solving strategies and to extend mathematical ways of knowing (Drier, Dawson, & Garofalo, 1999). The presentation consists of two parts. One investigation maps secondary mathematics technology lessons and materials to the elementary school mathematics standards and converts the mathematics concepts to manageable elementary school lessons. The other investigation analyzes pre-service teacher lessons written using ASSURE instructional design format. The major aims of this paper are to present two teacher preparation practices, one for secondary mathematics pre-service teachers (converting secondary materials to elementary materials) and the other for elementary mathematics pre-service teachers (writing lessons using the ASSURE model).

Introduction

The researchers intended to increase the use of technology integration in pre-service mathematics methods courses. Two processes were undertaken. The first process involved a graduate student adapting materials and lessons for the secondary classroom to the elementary classroom setting. This process required that the graduate student review a variety of software and hardware such as Autograph, Geometer's Sketchpad, National Library of Mathematics manipulatives. The investigation included looking at the materials, mapping the materials to the New York State mathematics standards and then writing objectives for the elementary classroom.

The second process involved elementary teachers writing a lesson for the grade level classroom that integrated technology. The integration used the ASSURE instructional design model to ensure the proper use of technology. The design model was used by every student in the elementary mathematics methods class, and each of the lessons was presented in methods class for critique using the Lesson Study model (Takahashi, Watanabe, and Yoshida, 2006). The ASSURE model stands for analyze the audience, state the objectives, select the methods, materials, and media, utimize the methods, materials and media, require participation, and evaluate what happened upon instruction.

Adapting Materials for Integrating Technology

After one semester of reviewing lessons written by pre-service teachers taking a mathematics methods course, the researcher realized that assigned technology based lessons lacked the characteristics expected. The researcher had expected as with Chaney-Cullen and Duffy (2001) that integrating technology into mathematics lessons would provide pre-service teachers with opportunities to investigate problem based constructivist mathematics lessons. Given adequate time, teacher attitudes about technology often begin to adapt towards a more constructivist perspective (Derry & DuRussel, 2000; Richardson, 2003; Thomas et al., 1994), where "constructivist goals focus on students ability to solve real-life practical problems, and its methods call for students to construct knowledge themselves rather than simply receiving it from knowledgeable teachers" (Roblyer & Edwards, 2000, p. 67). It was hoped that the pre-service teachers would exhibit qualities of constructivism in their lesson delivery and write ups. While the pre-service teachers delivered their lessons to their peers, there were gaps in their constructivist thinking, gaps in the types of objectives they were attempting to assess, and gaps in the types of activities that seemed to fit under a problem based methodology.

As a response to the concerns about the lessons mounted, the researchers investigated using the Teaching Secondary Mathematics (TSM) resources and other secondary technology based resources as a means to more problem based (more constructivist) set of materials that were mathematically rigorous and integrated technology. It was hoped that by investigating the objectives, standards and possible assessment goals using the TSM materials that elementary mathematics methods students could improve

the types of lessons created. In response to these educational imperatives, the U.K.-based technology for secondary /college mathematics (TSM) group serves as clearinghouse for software-based technological enablers for math instruction at the secondary and college levels in order to encourage the integration of technology with mathematics instruction.

The researchers provide elementary mathematics teachers with variants of TSM activities, modified for use with elementary students that aid in the introduction to probability in the first and fifth grades. The technology-based activities, in conjunction with the sample lessons plans, have the potential to cover a wide range of New York State performance indicators for each grade level. The graduate student researcher investigated technology-enhanced lessons in the first grade and fifth grade in order to represent both the lower and upper elementary grades, choosing fifth grade as the benchmark for the upper elementary grades in the probability module because it is in this grade that the New York State performance indicators require experiments using the formal language and methodology of probability & statistics.

Model Lessons

In integrating technological resources into elementary probability lessons, the graduate student researcher began with a spinner activity, an activity not included in the TSM resources but nevertheless recommended by education researcher Marilyn Burns as a “good beginning probability and statistics experience for children of all ages,” an opinion that was supported anecdotally by several sample lessons available online (Burns, 1992, p. 61). The elementary teacher can introduce the spinner activity in the context of a simple board game or an arts and crafts project in order to avoid introducing the mathematical experience of the spinner activity as an arbitrary and irrelevant activity divorced from “real life.” By constructing their own spinners, as described by Burns, grade level students can explore performance indicator 1.G.2 (Recognize, name, describe, create, sort, and compare two-dimensional and three-dimensional shapes) while addressing possible Individual Evaluation Plans (IEP) goals for students with modified curricula such as improving manual dexterity and following directions (Burns, 1992, p. 62).

Once the classroom students have constructed the spinners, the teacher should ask students which number is more likely to come up more than any other number and why, addressing the reasoning and proof, communication, and problem-solving performance indicators (Burns, 1992). After explaining and demonstrating how to record the results of the spinner experiments on a pictogram or bar graph, addressing performance indicators 1.S.2 – 1.S.8, the teacher should ask students which number will reach the top of the graph first and what the graph will look like once one number reaches the top of the graph (Burns, 1992). The teacher can address the number sense and operations performance indicators by asking well-placed questions about the graphs, requiring students to count and make judgments of greater than, less than, or equal to. By using this questioning methodology, the teacher allows students to formulate conjectures, using their intuition to sense what should happen, and subsequently conducting experiments to collect data to support or refute those conjectures, allowing for the “continuous interaction between a child’s mind and concrete experiences with mathematics” which forms the basis of a constructivist approach to mathematics (Burns, 1992, p. 24).

After the completion of the conjecture-based activity using the cardboard spinner, the introduction of technology is useful in extending the spinner activity by enabling students to explore different spinner configurations and large numbers of spins without necessitating the use of the additional time required to manually construct additional spinners and graph large numbers of trials. Although complete generality and theoretical probability are beyond the grasp of elementary age students still in the concrete operational stage of cognitive development, encouraging students to begin constructing these higher-order concepts using concrete experiences as a conduit can serve as a valuable introduction upon which additional knowledge can be constructed as students mature (Owens, 2002).

Linking Activities to Curriculum Objectives

The Microsoft excel document (exercise) is undertaken to give pre-service teachers (students in the mathematics methods course) an opportunity to analyze problems and activities that are of interest in the classroom. The Excel chart which serves as a single place for information regarding the activity includes title, grade level, mathematical processes and content, and a place to document specific objectives that can be taught based on the original problem. Teachers may use the excel file to analyze

information and to discover gaps in teaching standards within grade level, and across particular mathematical processes and content.

Pre-service Teacher Lessons using the ASSURE Model

Organizations such as NCTM (2000) and TPACK (2008) speak of designing digital age learning environments and experiences for students in mathematics. These organizations provide information for pre-service and in-service teachers to gather exemplars of these lessons, but the process of developing and delivering these lessons around student higher order cognitive thinking described by TIMMS (Keene, 2008) is a difficult and dynamic process. When pre-service teachers are asked to create these lessons or move these created lessons into a design template for presentation, there are difficulties. One of these lessons will be analyzed in order to discuss the intricacies of the technology integrated lesson and to provide some feedback for how to better integrate these lessons into a typical childhood mathematics lesson.

Pre-service teachers are asked to create a problem based lesson that integrates technology. The lesson creation activity provides an opportunity for students to translate the theory about good lessons, as described earlier, into a workable, usable lesson that could be used in any classroom. All of the lessons should have evidence of how students are collecting evidence around mathematical ways of knowing. The acronym ARRCC is used to help remind pre-service teachers that mathematical ways of knowing should include Accuracy, Reasoning, Representation, Communication and Connections. Pre-service teachers are asked to create lessons and think about the mathematical ways of knowing that are connected to ARRCC as they integrate technology.

Convincing teachers to change their practice has much to do with systematic activities with technology and the interactions with a variety of vehicles that move teachers along a continuum for making changes in their thinking (Barnett, Walsh, Orletsky, and Sattes, 1995), and that change should take place via experiences in the college classroom first. These technology based lessons are used to help teachers create learning environments for teachers to help negotiate individual needs for learning and teaching (Hung, 2001; Ross et al., 2002; Flake 2001).

Discussion

These lesson plan samples provide a glimpse to pre-service thinking about technology based lessons in the mathematics classroom. Each of the students was shown the materials created by the graduate student, technology integrated materials, and then students were asked to create lessons that use of a problem based methodology. The lessons cannot fully provide evidence related to the criteria as defined earlier, but the lessons reinforce that the process for creating the lessons is a difficult process that requires much research.

The lessons demonstrate enormous effort around interaction, but the interaction and the objectives appear to be disconnected. For example the objectives from lesson one are from a variety of learning levels, but the evaluation activity, does not map very well to the learning objectives listed. The second lesson also fails in that area. The activities are dynamic and make use of the smartboard, but the objectives, assessment, and activity are often disjointed. For example in the assessment with theoretical probability and the like, the objectives speak to reflecting on the thinking, but the assessment examples do not demonstrate any assessment. It is also difficult to read the lesson and understand how the smartboard moved the objectives forward, but the difficulty in creating lessons and then observing behaviors that bring out the appropriate mathematical thinking is not easy to document.

The comments made by the students in their evaluation phase are of interest too. Their comments reveal a sense of the difficult nature of the task and the learning process required of the teacher as they develop lessons and reflect on their teaching. There is a lot of good information in the words of the students as they grow beyond just delivering information and reflect on their role in the classroom. As teachers rethink their roles to meet the diverse needs of their changing, inclusive classrooms, technology provides a concrete instrument for teachers to step back and observe classroom interactions. As the students use the technology the teacher is able to observe the understandings via the student interaction with the computer technology, the interaction with peers and of course the interaction with the actual content of interest.

Observations about pre-service teacher understandings must be carefully parsed so that what the teachers observe is based on teacher perceptions about what student behaviors are supposed to look like when students understand. So, pre-service teacher perceptions, teacher observations opportunities and skills must be carefully developed in order to ensure teacher interpretations that are accurate and reliable over time. The assumption here is that during a constructivist organized lesson, the teacher is making observations about student understandings based on a variety of sources of evidence, but those observations are connected to teacher perceptions of him or herself and are further clouded by issues of race, socio-economic status, administrator expectations, disability and ability status, curriculum constraints and other factors that affect learning and the assessment structure in schools. These factors play a part in how the teacher will make inferences in the classroom about student thinking, behaviors, successes and failures, etc. The teacher observations which are conducted during classroom interactions and are part of the teaching process can be facilitated via the use of technology in the classroom. The technology provides a space for students to interact with the material, whatever that content may be and for the student interaction with their peer, so that the teacher can spend more time observing and for assessment purposes so that the instruction and assessment cycle (formative assessment) is seamless.

Paradigm Shifts in Mathematics Education and Their Implications on Mathematics Education

The researchers believe that teachers, when given the opportunity to convert technology based materials for the elementary classroom, both the secondary and elementary pre-service teachers gain. One, the pre-service teacher learns about the technology deeply enough to think about how he or she might use that technology in a future secondary setting. Two, the conversion process of mapping the technology materials to the elementary mathematics standards provides useable materials for perspective elementary teachers who may (or may not) have the mathematical background to create and write materials for use in their own classroom. The assumption is that the work of adapting the technology for the elementary classroom is done by those who may be more mathematically confident, and therefore better able to map the mathematics to usable lessons in the classroom (Math Tools).

We assumed that requiring pre-service teachers to integrate technology would be straightforward. It was assumed that using technology could move forward the teaching of diverse learners (Math Tools). However, the preliminary results of the study show that elementary pre-teachers mostly see the technology integration as a superfluous add-on and not a potentially integral part of the instructional process. Students work hard at using the technology to create their lessons, but often the qualities of a constructivist lesson are lost in the process. Evidence of proper questioning was lacking in both lessons presented in this paper. The assessment was connected to the objectives, but the original objectives rarely map to higher order thinking skills required or expected in a constructivist lesson (Burrell, 2008). The lessons use technology but the technology may not enhance the instructional process.

The lessons were created by the graduate student as an instructional tool to prepare pre-service teachers to implement technology into Kindergarten to Grade 6 classrooms. Unfortunately the researchers learned that the process of introducing technology into the classroom requires more time. The time would be used to observe the lessons in the real K-6 classroom, as opposed to only observing the lesson in the higher education classroom with adult peers. The evaluations (from the E part of the ASSURE model) reveal pre-service teacher perceptions about their instructional process in a good way, but also reveal to all who observed the lesson the inadequacies of measuring mathematical gains in the instructional process. The work by the graduate student was useful and profitable, in that pre-service teachers viewed a variety of elementary lessons with rigorous levels of mathematics and technology. The final step in the process was for pre-service teachers to use the sample lessons that the graduate student created, to create their own, based on the mappings in Microsoft Excel, and based on a topic of interest. The instructional design template does not ensure, in itself, that teachers will integrate technology properly, but provides a lens by which technology based lessons may mechanically include the parts of the lesson that demonstrate some constructivist thinking.

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