Integrating Technology with Math and Science for an Enhanced Learning Space

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**Introduction**

In today’s educational climate of 21st century learning, the integration of technology in mathematics and sciences is essential in equipping students for interacting effectively in the world around them. The premise that technology is not a separate subject area to be taught, but rather an integral part of a student’s mathematical and science learning experience, is found throughout the video cases and interviews explored in Lesson 2 of the *ETEC 533: Technology in the Math and Science Classroom* course. Teacher T in Catherine Sverko’s interview states that “technology is not an inconvenience, or optional… [It]is part of our everyday learning” (Sverko, 2017). This holistic approach is evidenced also in the Video Cases, particularly in instances of successful and effective technology integration as viewed in Case 1 and Case 3.

One of the themes threaded throughout the discussion among the ETEC533 students focuses on the teacher’s responsibility to embrace the inclusion of technology and figure out how to implement it appropriately. In Daniel Bosse’s interview, Teacher A is reported as stating that “most of the effective technology learning happening in his context was a result of informal learning from colleagues” (Bosse, 2017). In Video Case 6, the general science teacher states that “to be on the cutting edge, you need to learn on your own.” As a result of this call to self-education, the collected resources in the following annotated bibliography are intended to provide insight and guidelines to the teacher who is interested in designing and implementing seamless and holistic technology integration into math and science learning.

The integration of technology is critical in the teaching and learning of mathematics and sciences as these subject areas “interact with one another in ways where each informs and challenges the other” (Sharkawy, Barlex, Welch, McDuff, & Craig, p. 13, 2009). As noted in Niess’s (2005) article, from the National Science Education Standards (1996) and the National Mathematics Education Standards (2000), the following statements can be found respectively supporting an integrated technology learning space for mathematics and sciences: ‘‘The relationship between science and technology is so close that any presentation of science without developing an understanding of technology would portray an inaccurate picture of science’’ (NRC, p. 190) and ‘‘[t]echnology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning’’ (NCTM, p. 11).

**Annotated Bibliography**

In selecting the articles for the following Annotated Bibliography, the ETEC533 resource folders located on CiteULike were initially browsed, specifically Resource Folder 3: Learning With Computers, Resource Folder 7: Teachers and Educational Technology, and Resource Folder 10: Learning Space Design. To narrow the search further, the following keywords were searched: math, science, technology, and integration. Initially, all of the articles that contained a title indicating technology integration in either math or science learning from grades K to 12 were gathered and then previewed. Some articles were difficult to access, while others did not focus directly on a technology integrated learning space as required for the purposes of this annotated bibliography, and hence were discarded. Both the articles by Niess (2005) and Sharkawy, Barlex, Welch, McDuff and Craig (2009) were accessed through CiteULike and contained applicable content. The UBC online Library was also searched using similar keywords. Again, several articles were gathered and then previewed. For this annotated bibliography, a recently published article by Clements and Sarama (2016) was selected through the UBC online Library because it focuses on a younger demographic of learners. This inclusion provides a rounding out of selected resources with insights on technology integration ranging from preschool to highschool learning spaces.

Clements, D., & Sarama, J. (2016). Math, Science, and Technology in the Early Grades. *The*

*Future of Children,* *26*(2), 75-94. Retrieved from <http://www.jstor.org.ezproxy.library.ubc.ca/stable/43940582>

This recently published article is informative as it focuses on a younger group of learners, those from preschool to grade three, and the effects of structured STEM-based learning. The premise of this writing is to address the appropriateness of STEM activities within this grade range. The authors examine this issue by reviewing research literature that explores the implementation of STEM activities within a learning space. One of the authors, Douglas H. Clements, is also the developer of a math program called Building Blocks ( [www.ubbuildingblocks.org/](http://www.ubbuildingblocks.org/) ). Studies observed with children using the Building Blocks program are largely considered throughout the article, leading to some concern of biases and promotional intents within the writing. That being said, other STEM related programs and instructional tools are mentioned and supported throughout the article as well.

The authors strongly favour the implementation of a structured math and science program at early grade levels with student achievement tests supporting this standpoint. As stated, “[t]eachers often believe they are ‘doing math’ through puzzles, blocks and songs. But even when such activities do include mathematics, it’s not the main focus; instead, math is embedded in reading or a fine-motor activity. Evidence suggests that such an approach is ineffective” (p.79). Using a learning trajectory model that includes goals (STEM content), developmental progression and instructional activities is promoted throughout the article to provide a structured approach to teaching all areas of STEM. As well, the implementation of what is called the TRIAD model (technology-enhanced, research-based instruction, assessment, and professional development) has proven to show a substantial increase in student achievement. As concluded by the authors, younger students are capable of learning and understanding more complex STEM concepts. As stated, “[s]tudents who have fluent and adaptive competencies can propose problems, make connections, and then work out solutions” (p.80). The biggest hurdle to overcome, as noted by the authors, is that there is still “much to learn about teaching certain topics in STEM and about the characteristics of curriculum development and professional development that will let children realize their full potential in these critical subjects” (p.91).

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology:

Developing a technology pedagogical content knowledge. 21(5):509–523.

This case study focuses on observing five student teachers in middle school and high school practicums assigned to either a science or mathematics class. The teacher preparation program has incorporated a TPCK (technology-enhanced pedagogical content knowledge) approach for the purposes of encouraging technology integration into the student teachers’ mindset and teaching practices. The case study focuses on a single lesson that each student teacher is required to teach incorporating the use of technology. However, additional information is provided throughout the case study describing both prior and after experiences for each student teacher. Each of the five student teachers minimally holds a degree in mathematics or in one or more science areas, with one having a masters degree, and several having work experience. In spite of the TPCK approach in the teacher preparation program, only three out of the five student teachers approached their practicum lessons with a positive attitude toward the use of technology. Out of these three positive student teachers, one was distinguishably more enthusiastic and had a very supportive and involved overseeing teacher. When incorporating technology into their required technology integrated lesson plans, it should be noted that the student teachers were limited to using two data collecting tools: calculator-based ranger or calculator/computer-based laboratory probes. Due to this limitation of technology tools, possibly due to minimizing variables in the case study, considerations are raised as to whether or not the two more reluctant teachers would have had a more successful integration of technology had they been given more choice in the types of technology to use.

From this research, valuable insights on the characteristics of successful technology integration in science and math classrooms can be deciphered. Evident in all of the student teachers’ experiences is the critical need for students to be familiar with the technology to be used prior to conducting a lesson focused on math or science content. Content learning is diminished or completely negated when students are interacting with unknown technology. Teaching a lesson on learning the technology first and then implementing it into a content focused lesson is imperative to successful integration of technology in learning. As noted earlier, the most successful integration of technology occurred in the classroom with the very supportive overseeing teacher. Having a support team in place to help motivate and spur on new ideas is another essential aspect in successfully integrating technology as further indicated in the Sharkawy et al. (2009) article. A final characteristic of successful technology integration involves knowing the students, their strengths and weaknesses and carefully assigning cooperative groups based on this knowledge. Although not evident in each of the teacher’s experience, there was indication that careless group formation can lead to classroom management issues and lowering expectations of student learning.

Sharkawy, A., Barlex, D., Welch, M., McDuff, J., and Craig, N. (2009). Adapting a curriculum

unit to facilitate interaction between technology, mathematics and science in the elementary classroom: Identifying relevant criteria. Design and Technology Education, 14(1):7–20.

The authors of this article are engaging on the daunting task of rewriting a technology curriculum unit for the purposes of research on the integration of mathematics, science and technology. Phase 1 of their research consists of reviewing 77 relevant journal articles ranging from dates of 1975 to 2008. This article is a synthesis of their extensive literature review on the integration of science, mathematics and technology in the classroom. Interestingly, the integration of learning as described in the literature extended to other areas of learning including design, engineering and society influence. This article suggests that interaction of learning with society provides a strong argument for the support of integration. It is stated that “interaction centres on the nature of the disciplines themselves, the emergence of common procedures and concepts, and the way they interact in the world outside school” (p.13). This describes a seamless, holistic approach to integrated learning. Throughout the article, the authors offer specific findings on the characteristics of integrated learning, necessary supports at the micro, meso and macro levels, and considerations for the educator. These findings are evident in their conclusion of the seven criteria necessary to construct a successful integrated unit study:

1. Respect the integrity of the subjects
2. Utilize the commonalities of process and content shared by the interacting subjects
3. Reflect a constructivist theory of learning
4. The task set for pupils must be purposeful if it is to engage and motivate
5. The task must provide opportunities for pupils to use learning from mathematics and science to support learning in technology in such a way that learning in all three subjects is enhanced
6. Must enable students to recognize and use learning from mathematics and science to enhance their learning in technology
7. Must meet statutory requirements (pp.16-17)

Although the authors have derived comprehensive guidelines in developing an integrated technology curriculum unit, they do admit that “the evidence to support the view that interaction [integration] promotes enhanced motivation and engagement is sparse” (p.16). This is one area that will need to be further explored and documented as the authors’ research continues.

In pursuing the integration of technology in a learning space and considering the blurring of traditional subject boundaries, the literature review offers helpful insights into the starting points for planning and designing integrated learning. More helpful still are some of the cautions iterated, specifically that “success requires support at the national, state and local levels” (p.12) including coherence among educational policy makers, curriculum developers, school boards, administration and the classroom! This implies that with little support isolated or short-term success with integrated technology learning may occur in a classroom, but the long-term existence of a successful technology integrated learning space will remain undeveloped until support is established.

**Conclusion**

Recently, I read a quotation that describes teaching as an “outrageously complex activity” (Schulman, 1989, p.11). This statement could not be more true than when incorporating the integration of subject areas into a learning space. When “blurring the boundaries between subjects … it is essential to sharpen the focus” (Sharkawy et al., 2009). Sharkawy et al. (2009) describe this focus as clarity of subject content and an understanding of how this content can be applied in meaningful tasks to promote a holistic and rich learning space. This need of focus is also evident in Clement & Sarama’s (2016) promotion of a structured learning approach and the use of researched learning trajectories. The challenge for the educator is in keeping the authenticity of each content area in the midst of the merging of ideas and learning.Within each of the articles there is indication that professional development for all grade level teachers, including preservice teachers, is an ongoing challenge both to equip teachers with content knowledge and to diminish aversive attitudes towards the use of technology (Niess, 2005; Clement & Sarama, 2016; Sharkawy et al., 2009).

To further inquire about technology integration in mathematics and sciences, it would be interesting to follow the work of Dr. Azza Sharkawy as integrated technologies for mathematics and science classrooms are being designed. One example of such a design is The Knowledge Building International Project on Climate Change (http://educ.queensu.ca/research/spotlights/kbip).

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