Math Snacks: Using innovative media to address conceptual gaps in mathematics understanding

Abstract

"Math Snacks" are clever, engaging and focused resources designed to help learners "get" the concepts behind frequently misunderstood mathematics skills and knowledge. Based on research and thorough assessment of existing gaps in knowledge, the final tools are developed by math educators and mathematicians partnering with game developers and animators. Participants will be able to review gaps in mathematical understanding of middle school learners that are used in "Math Snacks" development and compare to gaps with their students, and identify ways in which completed games and animations are relevant to their learners. Teachers will review developed games and animations, and provide feedback to developers on ways to make future "Math Snacks" more relevant and usable for their classrooms. Finally, users of "Math Snacks" integrate technology (web, animation, video, iPhone and iPod) into their math curriculum by using developed tools as pre- and post- class activities, as part of a lecture and as homework. Workshop attendees will understand how these are utilized, and identify ways in which the same strategies could be incorporated in their work. All completed materials are available for free at mathsnacks.org.

This project addresses middle grades mathematics learning with a focus on basic conceptual understandings of mathematics that are a foundation for further advanced learning. Research supports fundamental mathematics education in order to improve student learning in mathematics, a critical concept needed for students to take advanced courses in the STEM field and eventually become knowledgeable citizens and workers in the 21st century. One of the reasons mid-school students lack a conceptual understanding of mathematics may be the relatively undefined and unstructured U.S. curriculum, poor assessments, and the low level of mathematics knowledge required for teachers. As Ginsburg, Leinwand, Anstrom, and Pollock, (2005) suggest in a book comparing the Singapore and U.S. curricula, the U.S. lacks a centrally identified core of mathematical content which could help focus the country's various curricula and teaching systems. National assessments are not utilized as formative assessments for teaching. These authors state that the U.S. "textbooks emphasize definitions and formulas, not mathematical understanding*"* (p. ix). The same authors continue, "The Singapore texts are rich with problem-based development in contrast to traditional U.S. texts that rarely get much beyond exposing students to the mechanics of mathematics… the Singapore illustrations also feature a concrete to pictorial to abstract approach. "*Many students who have difficulty grasping abstract mathematical concepts would benefit from visual representations of mathematical ideas"* (p. xii). Multimedia supports learning by providing additional graphical illustrations (Moreno & Mayer, 2007).

Math Snacks materials are created to evaluate the potential of short animations and games in helping learners understand concepts before engaging in more formal classroom learning. In a preliminary study carried out by the NMSU Learning Games

Lab, 20 mid-school youth were loaned iPods with only educational content on them — they were not allowed to put their own music or games on them. Content included educational videos, such as documentaries, and age-appropriate animations. Researchers found that youth spent approximately 10 minutes a day with the material in the first week. When they found an animation or video they especially enjoyed, they shared it with their peers, and often with their parents as well. This study was the impetus for creating short, entertaining animations. The six resulting pilot animations are popular with students and teachers. Team members created print companion materials to guide teachers and students in applying the conceptual understanding to math skills. Pilot animations and materials are available at http://www.mathsnacks.com.

If U.S. students are to be more successful in life, they must begin with a strong foundation in core mathematics concepts and skills, which, by international standards they presently lack. Singapore, whose students ranked first in the international comparison of student mathematics performance at the 8th grade (TIMMS, 2008), has such a foundation. Other high-scoring countries, such as Japan, also have clear national systems that define what topics are to be covered in depth at each grade level (Takahashi, Watanabe, & Yoshida, 2004). In the U.S. there are current efforts to develop a focus on core understandings at specific grade levels. Two examples are the *Focal Points* proposed by the National Council for Teachers of Mathematics and work at the University of Georgia's MSP project, *Partnership for Reform in Science and Mathematics* (PRISM) to provide such a framework for their state schools. The *Math Snacks* project provides a key set of topics to be explored and understood within a developmental framework of conceptual understanding that moves from the 6th- 8th grade levels.

New Mexico's Standards-Based Assessment *(NM*SBA) has been shown to correlate well with the NAEP national assessment (Aligning mathematics assessment standards, 2008). The test is given yearly to all students in grades 3 through 8, and again in 11th grade. Fifty percent of the points on this test are reserved for short-answer or open-ended questions. In other words, students must write about their understanding of the mathematics they are doing, draw or interpret tables or graphs, or explain their thinking in answering a problem. In every district in the state, students score lower on the half of the test that includes open-ended items than they do on the multiple-choice section of the test. While students can generally use procedures correctly, they don't demonstrate an understanding of the reasons for doing them. In additional their lack of understanding of the reasonableness of an answer, based on estimation, can lead students to perform incorrect computations.

An analysis of over 11,000 student scores in 6th-8th grade in high-need NM districts showed consistent areas of weakness. In addition to receiving lower scores with the open-ended questions, students had trouble with multiple-choice questions demonstrating understanding (as opposed to just choosing a numerical answer) (Korn &Wiburg, 2008). For example, while students can measure, they don't score as well in the section on understanding measurement. Overall, student scores were weak in demonstrating an understanding of number systems and operations, fractions and decimals, areas of geometry, (in particular: differentiating between area, perimeter, and volume); and moving between numerical, tabular, and graphical data describing linear

relationships.

As Gee argues, games and newer electronic learning environments provide opportunities that both engage students and require a demanding kind of "reading and writing" that builds literacy and thinking skills (2004). A recent synthesis of research (Heid and Blume, 2008) describes how technology can be used for the teaching and learning of mathematics. Within this research series, Olive and Lobato (2008) describe how the use of technology aides students in understanding rational number concepts. They present six research studies in which students gained understanding of rational numbers through the use of technologies from virtual manipulatives to videos and game environments. Students were able to understand the concepts of equal parts to whole and the use of multiplicative reasoning when using computer-based environments that allowed them to take apart and rebuild representational pieces of objects. Clements, who has done extensive work with young children and computers, suggests that for children, representational objects on a computer are seen as a manipulative. They find such representational objects as easy to use at an early age as blocks and chips. He and colleagues (Clements, Sarama, Yeilland, & Glass, 2008) describe the use of modified LOGO environments to help students learn geometry. Interactions with media around mathematical topics have the potential to help students fill their conceptual gaps in understanding. As Atkinson (2005) states, "Creating multimedia presentations that encourage learners to build coherent mental representations enhances learning."

Researchers (Hill, Rowan, & Ball,, 2005) have found that teacher mathematics knowledge is positively related to student achievement. Many middle school teachers had very little opportunity to learn deep mathematics in their teacher education programs in the U.S. Unlike teachers in other countries, they have not been required to pass high levels of mathematics as part of teacher preparation, nor do they receive continued professional development in learning mathematics for teaching (Ginsberg, *et. al*, 2008). According to the cognitive theory of multimedia learning (CTML), combining spoken text with dynamic graphics should promote learning with understanding (Atkinson, 2005). *Math Snacks* modules allow best practices of a guest expert to virtually come into the classroom in order to share mathematics with the teachers and the students via media.

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