

Chapter 66

Fostering Mathematical Competence through Technology–Enhanced Interactive Environments

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ABSTRACT

In this longitudinal research project, the authors traced the impact of a mathematics enrichment program on a group of approximately 80 middle and high school students as they worked on mathematical explorations using interactive computer software for three years. The results indicate that learning environments designed for children supported their development of mathematical practices emphasized by the CCSSMP while increasing their exposure to and understanding of content standards.

INTRODUCTION

Common Core Standards of Mathematical Practices (CCSSMP) propose that all students of mathematics must be nurtured so to:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning (CCSS, p. 5).

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The central idea embodied in the CCSSMP is the view that mathematical competence entails not just acquisition of factual information about various concepts covered in the curriculum, but also the attainment of dispositions and the reasoning tools crucial both to authentic mathematical thinking and the mathematizing (Schoenfeld, 1994) process. Inherently, the ultimate vision of CCSSMP is for all children to develop a mathematical point of view (Schoenfeld, 2005); build an inclination to view and interpret what is encountered using mathematical tools and using those tools in the service of finding/describing structurally important features and/or relationships in and among phenomena observed or experienced. The particular emphasis that CCSS place on using mathematics to model phenomenon capitalizes the need to increase the children's capacity to think and engage in practices common among mathematicians: search for patterns and generalities, use patterns to predict the behavior of the phenomenon under study, and test and validate results systemically. Therefore, the mathematical practices provide a platform for considering mathematics as a mode of thinking and a particular type of intellectual disposition that needs to be supported throughout all mathematical experiences designed for children. As such, these practices and content standards cannot and should not be treated as mutually exclusive, but as deeply intertwined and reflexive domains. Mathematical content provides a context for development of desired mathematical practices. Inversely, mathematical practices provide a structure for designing curriculum and instruction around the content. Therefore, the design of instructional tasks as well the media used to engage children in those tasks serve as two vital instructional ingredients since they provide the means for the type of mathematical thinking and dispositions children learn to develop. The presence of interactive technologies (mathematical software), and its use as an instructional medium, further punctuates the need for careful selection of instructional tasks since together they can form

venues for engaging children in mathematics and mathematical thinking that are not accessible in traditional static environments of the past. We will elaborate on this point more fully later. Lastly, the primary postulate in our work is the notion that the development of mathematical dispositions desired by the CCSS is less likely to be achieved through episodic exposure to quality resources and is instead fostered through deliberate, regular, and continuing interactions with quality interrelated resources and tasks. Therefore, in our work we aimed to go beyond illustrating or examining children's practices on isolated tasks,¹ and instead trace the students' growth overtime.

GENERATIVE TASKS

In mathematics education literature and professional journals, a number of terms have been coined to describe quality tasks conducive to advancing mathematical cognition of learners. Among many include: rich, authentic, open-ended, cognitively demanding, exploratory and investigative. Despite some minor differences in structure, these labels share several common characteristics: they allow rooms for multiplicity of entries and responses, provide opportunities for practice of communication, reasoning, and problem solving, and engage students in understanding of mathematical concepts while eliciting justifying and explaining of answers. We fully endorse the importance of these characteristics and believe they are necessary conditions for nurturing mathematical abilities of learners and strengthening their conceptual understandings. However, we argue that these attributes are not sufficient to characterize the types of tasks that foster the mathematical practices described in the common core standards. We view mathematics as a structure-finding activity and so we propose the construct *Generative*, to suggest three additional features of tasks that aim to move students towards generalizing: extendibility, coherence, and

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