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"When I hear literacy": Using pre-service teachers' perceptions of mathematical literacy to inform program changes in teacher education

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HIGHLIGHTS

- We examined pre-service teachers' (PSTs) perceptions about literacy in mathematics.
- PSTs perceived communication, application, and vocabulary as literacy in math.
- PSTs valued organizational strategies in content area literacy (CAL) coursework.
- Yet, PSTs felt CAL strategies were mostly disconnected from math instruction goals.
- PSTs regarded self-knowledge and student ability as barriers to math literacy.

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ABSTRACT

This case study investigated pre-service teachers' (PSTs) perceptions of disciplinary, or mathematical, literacy and factors related to their teacher education program at a public research university that influenced these perceptions. Seven PSTs volunteered to participate in individual and focus group interviews. Analysis indicated that PSTs considered certain elements of literacy (i.e., communication, application, vocabulary) to be important in mathematics education, but PSTs felt that literacy coursework did little to support their understanding of mathematical literacy. PSTs also discussed barriers present in mathematics methods coursework that hindered their understanding of mathematical literacy instruction and their ability to incorporate such instruction.

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1. Introduction

Integrating literacy instruction into content areas, such as mathematics, at the secondary level has been a standing focus in the field of education (Draper, 2002; Siebert & Draper, 2008) and one that has historically been met with resistance from teachers (Hall, 2005; O'Brien, Stewart, & Moje, 1995; Siebert & Draper, 2008). Resistance is particularly high in mathematics where reading and writing can become challenging for teachers to consider, much less integrate (Siebert & Draper, 2008). A promising perspective to alleviating this resistance is disciplinary literacy (Moje, 2008; Shanahan & Shanahan, 2008; 2012), which situates literacy as an integral part of disciplinary instruction. This perspective holds that literacy in each discipline can be defined by the particular practices that disciplinary experts use to engage in study of that discipline (Moje, 2008; Shanahan & Shanahan, 2008; 2012). For example, disciplinary literacy in history may entail students practicing sourcing, contextualization, and corroboration of primary sources, in a similar manner as historians as they interpret events from the past (Wineburg, 1991). In science, disciplinary literacy may involve students understanding and participating in the specific language of scientists (Lemke, 1990) and engaging in inquiry-based processes to address questions derived from curiosity about the world (National Academy of Sciences, 1996). Disciplinary literacy in mathematics, also referred to as *mathematical*

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literacy (the term adopted and used throughout this manuscript), would entail comprehension and application of mathematics through reasoning, thinking, and interpreting through problem solving so that students engage in application of mathematical knowledge rather than rote learning (De Lange, 2003). This perspective stands in opposition to a content area literacy (CAL) standpoint, a historically more traditional approach to integrating literacy in the content areas, which incorporates general literacy strategies that may work in any content area to help students read and write information (Moore, Readence, & Rickelman, 1983). Although research indicates CAL strategies and instruction may certainly be beneficial to students by helping them organize and comprehend information (Hall, 2005), studies also suggest that this type of literacy is often in conflict with the broad goals of mathematics instruction (Friedland, McMillen, & del Prado Hill, 2011).

In mathematics, varying, yet overlapping, definitions of mathematical literacy exist (Jablonka, 2003; Pugalee, 1999), but holistically those definitions summarize mathematical literacy as a person's ability to engage in higher-order thinking skills specific to mathematics, such as analysis, reasoning, and communication of mathematical concepts in real-life, everyday situations (Kramarski & Mizrachi, 2004; Meaney, 2007; National Council of Teachers of Mathematics (NCTM), 2000; National Governors Association Center for Best Practices (NGACBP), 2010). These characteristics reflect the overarching objectives of instruction and guidelines by which pre-service teachers will be educated in a newly revised mathematics teacher education program at a U.S. public research university that is the setting of this study. The adoption of Common Core State Standards (CCSS), which promotes mathematical literacy, has prompted a new generation of mathematics teachers to prepare students with 21st century skills. To align with this prompt, this study sought to review the university's program of study for future mathematics teachers that has recently removed CAL coursework from the program and aims to instead integrate literacy, in a manner yet to be determined, into mathematics education coursework to promote mathematical literacy. Although the research describing mathematical literacy is promising for promoting higher-order thinking in mathematics instruction in schools, more research is needed to understand how to prepare mathematics teachers to implement mathematical literacy into their instruction (see Draper, Broomhead, Jensen, & Nokes, 2012 for an example of existing research) and a favorable place to start is in pre-service teacher education (Moje, 2008), which this study targeted.

Noting the importance of teacher perspectives and perceptions in the successful implementation of literacy in content areas (Hall, 2005; O'Brien et al., 1995), the purpose of this research was to understand how mathematics pre-service teachers (PSTs), who had completed the former mathematics teacher education program that separated CAL coursework from mathematics methods coursework, perceived literacy in mathematics instruction to inform systematic program changes in a mathematics education program currently being revised to more fluidly integrate the two areas to promote mathematical literacy. Particularly, these perceptions were valued as pre-service mathematics teachers' perspectives have been found to play a critical role in how they acquire and enact knowledge from their teacher preparation programs in classroom instruction (Ng, Nicholas, & Williams, 2010). Although much is historically known regarding PSTs' beliefs and perspectives related to CAL (e.g., O'Brien & Stewart, 1990; Stewart & O'Brien, 1989), less is known about their perspectives toward mathematical literacy and how their perceived experiences in CAL coursework may incite and influence programmatic changes in teacher education. Consequently, we sought to add PST voices to the data considered as program changes were being made in a mathematics teacher education program. Thus, the purpose of this study was to understand PSTs' perceptions of both CAL and mathematical literacy and to use these findings in the planning and execution of a revised mathematics teacher education program.

2. Factors that influenced the study

The catalyst for this study was the implementation of a revised mathematics and science teacher education program at a large, public research university in the United States. With the adoption of an innovative mathematics and science teacher preparation program, a diverse set of nine STEM education courses, typically beginning in the first semester of students' freshman year, designed for mathematics and science PSTs will integrate various competencies typically found in professional education coursework. One such course, Reading and Writing in the Content Areas, will no longer be part of the secondary mathematics teacher education program. This course typically involves promoting an understanding and use of questioning strategies, summarizing and retelling strategies, and strategies in literal, interpretative, critical and evaluative comprehension/composing across the curriculum at the secondary levels. In lieu of this course, mathematical literacy techniques will be incorporated into several courses and taught by mathematics education experts. Ideas and strategies will be steeped in the discipline and allow PSTs to think more deeply about ways to incorporate literacy practices into their classroom instruction. This requires greater collaboration between literacy and mathematics education experts (Draper, Broomhead, Jensen, & Siebert, 2010). While this type of change will alter the objectives of traditional mathematics education coursework, the program's aim is to advance the type of instruction PSTs receive prior to entering the field and to prepare PSTs to engage diverse types of learners in mathematical practices that move beyond rote learning. A report published by the National Research Council (2012) states that research universities should invest in efforts to improve teacher education and preparation for K-12 STEM education and this program revision proposed to accomplish this point. By incorporating mathematical literacy more seamlessly into several mathematics and science teaching and learning courses, rather than one mathematics methods course, PSTs will receive training in mathematics pedagogies that emphasize a disciplinary standpoint, while supporting students' abilities to engage in and comprehend mathematical practices and apply those practices to practical problems. Thus, we see this change as complementary for both fields and beneficial to future mathematics educators as they will be better prepared to work in school environments supporting the Common Core standards movement.

As the institution works towards a major program change for mathematics and science teacher preparation, a key concern expressed by education experts was the removal of the literacy in the content area course where all secondary education disciplines are in the same course. These instructional techniques are important for future teachers to develop, yet they often fall short for mathematics teachers (Siebert & Draper, 2008). As Siebert and Draper (2008) present, literacy experts often do not have a clear vision of literacy instruction in a mathematics classroom. They acknowledge that mathematics teachers are often unconvinced of the value in promoting reading and writing into their class instruction. For example, in many instances, very few teachers use traditional reading and writing techniques in their mathematics instruction. A more common approach for instruction centers on vocabulary, examples, and practice problems rather than reading a textbook. In this case, strategies that are often presented in a reading and writing course do not appear to fit well in the spectrum of mathematics classroom instruction. Further, reading and writing in mathematics often do not center on print or text materials as