



Research to Practice Article***Characteristics of Second Graders' Mathematical Writing: Companion Paper***

Based on the published SSM Journal Research Manuscript:
Characteristics of Second Graders' Mathematical Writing

Madelyn W. Colonnese
University of Connecticut

Jeremy A. Cohen
University of Connecticut

Tutita M. Casa
University of Connecticut

Overview

The National Council of Teachers of Mathematics [NCTM] (2000) emphasizes that writing is an “essential part of mathematics and mathematics education” (p. 60). Current research on writing in mathematics has primarily focused on middle-, secondary-, and college- level students (Seo, 2009). Little is known, however, about how students should be writing in mathematics at the elementary grades. This study adds to a growing literature base on writing in mathematics at the elementary level. Characteristics of second-graders mathematical writing between an intervention and control group were compared. The sample included all 384 Grade 2 students who participated in the original Project M² study, which addressed the efficacy of two 6-week Grade 2 geometry and measurement replacement units (Gavin, Casa, Adelson, & Firmender, 2013). These units were designed to position students in a mathematician’s role, emphasizing written communication. Throughout the units’ implementation, students participated in verbal and written discourse in an attempt to support reasoning and use mathematical vocabulary. In total, 1,536 written responses were included in the data set. Students who participated in the study attended one of 10 schools in either suburban or urban districts in Connecticut, Kentucky, South

Carolina, or Texas. Each school contained both control and intervention group teachers. Students were assigned to the control or intervention group dependent upon their teacher.

Research Topic/Question

NCTM (1991, 2000, 2014) has long maintained that written communication should be included in mathematics instruction as a medium for students to explain their thinking. Both the Common Core State Standards for English Language Arts (CCSS-ELA, 2010b) and the Standards for Mathematical Practices of the Common Core State Standards for Mathematics (CCSS-M, 2010a) infer that students should be writing in mathematics. This paper defined mathematical writing as any representation (NCTM, 2000) that students record on paper (including prose, symbols, and other visuals) resulting from prompts that press to include ones’ mathematical reasoning. Engaging students in reasoning-based writing encourages analysis and synthesis of information, thereby deepening conceptual understanding (Rothstein, Rothstein, & Lauber, 2003). Due to a paucity of research on reasoning-based writing in mathematics at the elementary level however, there lacks clear expectations as to how teachers and curriculum authors should effectively pair the disciplines of writing and mathematics. Thus, this study identified

features of reason-based mathematical writing and further analyzed how students in the control and intervention groups used these features. Connections were drawn to identify some of the instructional components of Project M² that may have supported this type of writing.

Discussion of Findings

Students' mathematical writing was analyzed across five variables from three different categories: reasoning, use of mathematical vocabulary, and general writing. The five variables included students' use of linking words, reasons, formal or informal mathematics vocabulary, students' attempt at mathematical writing, and students' use of complete sentences. Observing these variables provided a way to understand how second-grade students composed mathematically written responses.

Results favored the intervention group in categories specific to reasoning. Possible explanations provided for this difference were attributed to specific aspects of the communication components in Project M² such as, Think Deeply questions, rich and worthwhile tasks, a nurturing environment, and the talk frame (specific speaker and writer roles). Throughout the units, students were encouraged to use talk moves, as adapted from Chapin, O'Connor, and Anderson (2009). The talk moves, including add on, agree/disagree and why, partner talk, repeat and check, and think time foster mathematical discourse and focus on reasoning. The talk moves supported the implementation of the talk frame, a central component to classroom discussions (Casa, 2013). All student ideas were written on the talk frame, a graphic organizer designed to support classroom discourse, while the discussion occurred. This provided a visual of the development of the conversation and the reasoning shared to arrive at various mathematical conclusions. Due to the visual representation of the discussion, the talk frame supported the transition from whole class discussion to individual student writing (Williams & Casa, 2011).

Students in the intervention group also tended to include more formal mathematical vocabulary than their counterparts. Possible reasons offered for this

difference were the way in which intervention teachers were encouraged to introduce and model the use of formal mathematical vocabulary when it was needed to communicate a mathematical idea. Further, intervention classrooms contained a word wall of formal mathematics vocabulary which was referred to in written and oral discourse.

Though the results reflect the effect of Project M²'s communication components implemented in their entirety, the authors believed that certain aspects of the components had more of an influence on reason-based mathematical writing. It was proposed that the Think Deeply questions had had the greatest impact, followed by verbal discourse and the talk frame, which served to help students make connections between the spoken and written word. Lastly, establishing a nurturing environment helped support student writing more generally.

Implications for Practice

When implementing mathematical writing, a nurturing environment is an essential component (NCTM, 1991). Creating a space where students feel comfortable, not only sharing their ideas but also critiquing the reasoning of others, helps foster an environment where reasoning is central to learning. Consider asking questions such as, "Student A thinks x. Student B thinks z. Who do you agree with and why?" This prompts students to engage with a mathematical idea, defend their reasoning, and critique the reasoning of others.

The talk moves (Chapin, O'Connor, & Anderson, 2009) and talk frame (Casa, 2013) can aid in fostering mathematically rich discussions and reason-based writing. Teaching students the purpose of talk moves, and further modeling and prompting their use can support students in adopting the talk moves as a way to share their reasoning with others. This may encourage the use of linking words, (e.g., *because*, *so*) which connect ideas in a sentence. The talk frame can help support students in translating their discussions into mathematical writing because it provides a visual representation of the whole class discussion.

Other Research

For further research in this area, "Capturing

Thinking on the Talk Frame” (Casa, 2013) describes how this model can be used with elementary students to promote reasoning. It further supports students in discussions that encourage reasoning and lead towards correct mathematical understanding. “Moving Students to ‘the Why?’” (Cioe, King, Ostien, Pansa, & Staples, 2015) shares collective learning about teaching with justification. This article additionally illustrates how to help students justify their reasoning by addressing what it means, what makes it sound, and how to develop initial ideas. Together, both of these articles advance the literature of cultivating a culture that supports students in developing a foundation for reasoning-based mathematical writing.

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