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K-2 Mathematicians & Writers: Professional Learning Communities for Developing Conceptual Understanding

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Abstract

National Council of Teachers of Mathematics (NCTM) has long supported the use of children's literature, writing, and manipulatives to improve conceptual understanding of mathematics (2000). In a professional learning community for K-2 teachers, professional development was designed and implemented on ways to incorporate literacy and manipulatives into a mathematics lesson. The teachers were charged with collaboratively planning lessons that included multiple components: the standard(s), a mathematics activity, manipulatives, a writing task, and children's literature. As the data were analyzed, it became apparent that while most of the lessons were well connected, this did not happen for all of the lessons. In addition, we observed that there were cases of teacher misconceptions. We feel these misconceptions contributed to the lack of connectedness in some of the lessons.

Keywords: professional development, mathematics and literacy, children's literature, writing, integrated lesson, K-2 teachers

Mathematics reform efforts emphasize the importance of conceptual understanding, procedural fluency, problem solving, and subject specific discourse (Boaler, 2015). National Council of Teachers of Mathematics (NCTM) has long supported the use of children's literature, writing, and manipulatives to improve conceptual understanding of mathematics (2000). Yet, many mathematics teachers report that it is challenging to integrate mathematics and literacy, often viewing these as mutually exclusive content areas. This notion fragments the curriculum and isolates the resources that literacy yields for thinking and communicating in math.

This paper examines a yearlong professional development initiative designed to provide K-2 teachers in a rural school district with content development and resources for an integrated approach to mathematics instruction involving conceptual understanding through the use of children's literature, manipulatives, and writing. Teachers requested this professional development since their school district had low-achievement scores in both Mathematics and English Language Arts (ELA) on K-2 assessments and it had been a long time since they received support in mathematics instruction. Teachers participated in a professional learning community and assumed roles of teacher leaders in developing collaborative learning experiences with grade level colleagues and attending workshops throughout the academic year. This professional learning community approach represents a unique innovation that utilized a teachers teaching teachers model to improve sustainability, embedded professional learning within grade levels, alignment across the district K-2 grades in mathematics, and vertical alignment across K-2 mathematics within four elementary schools. We assert that as children begin school, using resources across the curriculum will support development as mathematicians, readers and writers, and conceptual, metacognitive learners.

As part of a larger study of the professional learning community, we were interested in investigating increases in student learning outcomes and the insights and challenges of adopting an integrated and collaborative approach to mathematics instruction. As we began to analyze the data, the focus on insights and challenges began to reveal more specific research questions. The following research questions inform this study; both of these research questions evolved from the analysis of the data.

1. When teachers create lessons integrating literacy and math, how connected are the various components?
2. What misconceptions were revealed in the enactment of the integrated lessons?

Literature Review

Conceptual understanding refers to "an integrated and functional grasp of mathematical ideas" (Kilpatrick, Swafford, & Findell, 2001, p.118). When students have a conceptual understanding, they know more than isolated bits of information. Rather, they are able to make various connections and represent mathematical ideas in a variety of ways.

Connections

Kilpatrick et al. (2001) claim that, "the degree of students' conceptual understanding is related to the richness and extent of the connections they have made" (p.119). Van de Walle (2016) describes understanding as "a measure of the quality and quantity of connections that a new idea has with existing ideas. The greater the number of connections to a network of ideas, the better the understanding" (p. 21). Making connections should be an essential part of any mathematics lesson for all levels. NCTM (2000) highlights three different types of connections: connections among mathematical ideas, connections to students' existing mathematical ideas, and connections to contexts other than mathematics such as other disciplines and their daily lives. Components of mathematics lessons that have been identified as particularly helpful in fostering students' connections include using children's literature to provide a context, integrating writing to communicate mathematical ideas, and using multiple representations. In the next few paragraphs, we describe how each of these components supports students building connections and how teachers can integrate each into their mathematics lessons.

Research supports the use of children's literature to provide a context or storyline to launch mathematical ideas in a lesson and develop connections (Thiessan, 2006, Whitin & Wilde, 1992). "Children must find mathematical experiences interesting if they are to achieve their mathematical potential, and using literature as a springboard is one way to capture their interest" (Welchman-Tischler, 2000, p. 1). Murphy (1999) observed that picture books not only engaged children, but helped them make mathematical connections and visualize concepts. Clarke (2002) found a number of positive results in using picture books with mathematics, including improved explanations and reasoning, greater persistence with challenging concepts, and increased success.

In addition to the research that supports children's literature, NCTM (2000) also recommends the integration of writing in mathematics. Mathematics instruction should enable students to "organize and consolidate their mathematical thinking" through written communication (NCTM, 2000, p.60). Zinsser (1988) suggests that students learn to think their way into mathematics and make it their own through writing. Moreover, language skills have increasing importance in mathematics instruction (Pierce & Fountaine, 2009). NCTM (2000) suggests that students need to "use the language of mathematics to express mathematical ideas precisely" (p.60). Therefore, strategies for robust vocabulary instruction (Beck, McKeown, & Kucan, 2002) are important components of developing mathematical literacy. While a student can have conceptual understanding without explicitly being able to communicate it, written and verbal communication provides a window for the teacher to be able to assess student thinking. Yet, many mathematics teachers find the integration of writing a challenge. For integrating writing in K-2, a number of evidence-based writing strategies are recommended, such as learning logs, think-write-share, shared writing, class books, alphabet books, and drawing and labeling (Wilcox & Monroe, 2011).

Research also suggests that an essential part of making connections among mathematical ideas is being able to connect a variety of representations (NCTM, 2000). The way students understand mathematical ideas is dependent on the ways in which they are able to represent those ideas. One way that students use representations is “to model and interpret physical, social, and mathematical phenomena” (NCTM, 2000, p.67), which includes physical materials referred to as manipulatives. Teachers can “gain valuable insight into students’ ways of interpreting and thinking about mathematics by looking at their representations” (NCTM, 2000, p.68). Students’ representations also give teachers an opportunity to build bridges to more conventional representations.

Mathematical Knowledge for Teaching

Mathematics teachers at all levels need “specialized mathematical knowledge that is different from the knowledge needed by mathematicians, including the mathematical understanding involved in posing questions, interpreting students' answers, providing explanations, and using representations” (Hill & Ball, 2009, p. 68). This specialized knowledge is referred to as Mathematical Knowledge for Teaching (MKT).

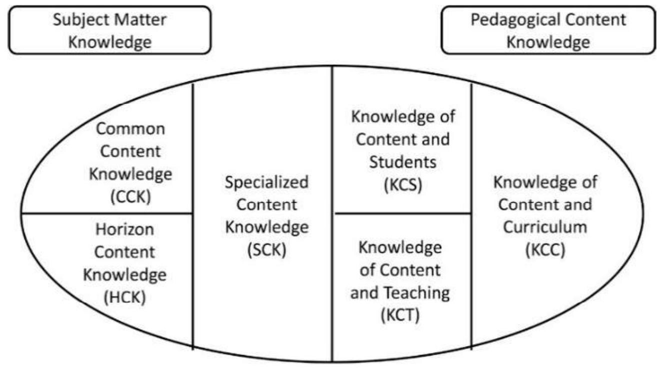

Figure 1. Mathematical Knowledge for Teaching

Ball et. al. (2008) categorized MKT into two major categories, Subject Matter Knowledge and Pedagogical Content Knowledge. Subject Matter Knowledge includes Common Content Knowledge, Specialized Content Knowledge, and Horizon Content Knowledge. Common Content Knowledge (CCK) is described as the mathematical knowledge that we would expect any well-educated adult to know. However, Specialized Content Knowledge (SCK) is knowledge that is not necessarily expected of just any well-educated adult. SCK is knowledge that is only needed for the purposes of teaching, but it does not yet require knowledge of students or knowledge of teaching. Horizon Content Knowledge (HCK) is "an awareness of how mathematical topics are related over the span of mathematics included in the curriculum" (Ball, 2008, p. 403). It also encompasses the anticipation of connections to later mathematical ideas. HCK helps teacher in making decisions about how to talk about a particular mathematics topic, knowing what is on the horizon for their students (Ball, 2008).

Pedagogical Content Knowledge includes Knowledge of Content and Students, Content and Teaching, and Content and the Curriculum. Shulman (1986) defined pedagogical content knowledge as comprising:

> The most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations—in a word, the most useful

> ways of representing and formulating the subject that make it comprehensible to others. . . . Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons. (p. 9)

Knowledge of Content and Students (KCS) is the type of knowledge that teachers need to anticipate how students are likely to think about mathematical topics and the misconceptions they might have. Knowledge of Content and Teaching (KCT) is required to be able to create effective instruction. Teachers need to know how to optimally sequence particular content, examples, and tasks. Teachers need to have a knowledge of a variety of representations and which are most effective for their age group. They also need to know how to connect those various representations. Having KCT allows teachers to distinguish between conceptual and procedural knowledge. Knowledge of Content and Curriculum (KCC) is needed in order for teachers to deeply understand the standards that are appropriate for their particular grade level as well as what those standards mean. They also need to be aware of the standards that their students have covered and those that are forthcoming. Teachers need to know what resources are available, where to find them, and how to choose resources that are most useful for their teaching (Ball et al., 2008).

Methods

This investigation was designed as a mixed methods case study (Creswell, 2015). It occurred in a rural school district in Southeastern United States within four elementary schools, focusing on primary grades kindergarten, first, and second.

Participants and Setting

Twenty-four teachers were recruited across four elementary schools; this included 2 teachers at each grade level (K, 1, 2) from each school. Participation was voluntary, and teachers completed an application process. Applications were reviewed by administrators and program faculty members. While 24 teachers were the focal group of teacher leader/collaborators, all 69 teachers in K-2 participated in collaborative lessons.

As part of the professional learning community, the 24 teacher leaders attended an intensive 8-day Summer Institute. Six workshops were also provided throughout the academic year– three in the fall and three in the spring. The workshops were open to all 69 K-2 teachers and focused on mathematical content development for the teachers. The Summer Institute lessons and workshops always included manipulatives, literature, and a writing connection. Teachers were given manipulatives, resources, and opportunities to brainstorm lesson cycle ideas across schools.

Three university faculty members designed, implemented, and facilitated this professional development. Therefore, researchers in this study were participatory and assumed dual roles of facilitators of professional development and participant researchers.

Data Sources

Data collection commenced at the beginning of the professional development program. Artifacts and evidence were gathered across incidents of professional development and later collaborative lessons in classrooms. The following are the primary data sources for this study.

Collaborative Lesson Artifacts. All 69 K-2 teachers participated in grade level collaborative lessons in the four elementary schools. These collaborations occurred mostly within each school and grade level and were led by the two corresponding teacher leaders.

Collaborative lesson cycles included a jointly constructed lesson plan, lesson implementation, and grade level reflections. All artifacts were uploaded by grade level and school to a shared Schoology Group website. Four collaborative lesson cycles occurred – two in the fall and two in the spring. Overall, we analyzed 48 collaborative lessons.

Classroom Observations. For each collaborative lesson cycle, lead teachers observed either at their grade level or another grade level colleague's lesson and submitted a completed observation protocol. In addition, the three university faculty members observed a lesson at each grade level (K-2) at the four elementary schools for each of the four collaborative lesson cycles. Field notes were taken at each lesson, and the faculty observers completed an observation protocol that was returned with comments to teachers.

Interviews. The three university faculty members interviewed a sample of 10 lead teachers after all 4 lesson cycles were completed. Interview questions focused on collaborative planning, the enacted lessons, student learning outcomes, and their overall experience as part of the professional learning community.

Data Analysis

Quantitative data were analyzed using simple descriptive statistics. Qualitative data from lessons, teacher and student artifacts, observations, and interviews were analyzed according to qualitative coding processes (Corbin & Strauss, 2008; Saldana, 2013). First, a preliminary content analysis of each case involving open coding, sampling, and framing initial categories was conducted. Then, line-by-line analysis was employed using the constant comparison method and initial categories were refined, structured, and defined. Researchers coded separately and then met to develop coherent, defined categories. Triangulation of findings across cases, multiple data sources, and peer debriefing was used to improve the trustworthiness of the findings. Through the process of analyzing the data, we found consistent themes across cases. From these patterns, specific research questions began to emerge from our larger study of the professional learning community. It is these research questions on which this paper is focused. This is consistent with the process of grounded theory, which "begins with basic description, moves to conceptual ordering, and then theorizing" (Patton, 2002, p. 490).

Results

As part of the professional learning community, the teachers were charged with creating lessons that included multiple components: the standard(s), a mathematics activity, manipulatives, a writing task, and children's literature. As the data were analyzed, it became apparent that while most of the lessons were well connected, this did not happen for all of the lessons. In addition, we observed that there were cases of teacher misconceptions. We feel these misconceptions contributed to the lack of connectedness in some of the lessons.

Connectedness of Lesson Components

The possibility for students to experience mathematics as a way to make sense of their world in meaningful ways rests on teachers providing opportunities for connections (NCTM, 2000). While providing connected, worthwhile mathematical experiences does not ensure that students will see and make use of those connections, it is crucial that teachers at least provide these opportunities for students. Using teachers' lesson plans and observations of the enacted lesson, we looked for evidence that teachers created lessons where the various components were connected. Most mathematics lessons in K-2 include a standard, a mathematics activity, and sometimes manipulatives. For the purposes of this professional learning community, we also focused on incorporating literacy, specifically through the use of writing and children's literature, as well as manipulatives, in order to develop students' conceptual understanding.

Making Connections to the Context. Using children's literature often provides an opportunity for naturally connecting mathematics to other content areas. Through analyzing lesson artifacts and classroom observations, we found that teachers began to intentionally integrate other content areas into their lessons, such as science, ELA, and social science. For example, one first grade collaborative lesson was launched by a book called *How Many Seeds are in a Pumpkin?* which focused on counting the seeds in a variety of pumpkins. The activity that followed included length measurement, grouping by tens, and place value. While students predicted that the smallest pumpkins would have the least number of seeds, they discovered that the number of seeds in a pumpkin is dependent upon how many rings are on the pumpkin. The longer the pumpkin is on the vine, the more rings it develops and with each ring comes a new batch of seeds. This explained why the smallest pumpkin in the class had the most seeds, and why there was so much variety in the number of seeds. This connection to life science allowed students to "experience mathematics as a meaningful endeavor" (NCTM, 2000, p. 132) by using grouping and counting strategies to contradict their hypothesis. In another instance, second grade teachers chose a book for their mathematics lesson on money that focused on profit and geography, allowing a connection to social studies. In an effort to connect to the ELA standards, teachers often paused throughout the reading of the book to make explicit connections to parts of speech, such as nouns, verbs, and adjectives. These types of connections to science, social studies, and ELA helped to show students that mathematics has purpose. NCTM (2000) suggests that "it is the responsibility of the teacher to help students see and experience the interrelation of mathematical topics, the relationships between mathematics and other subjects, and the way that mathematics is embedded in the students' world" (p.135).

Making Connections through Writing. As part of their collaborative mathematics lesson, teachers were encouraged to incorporate a writing component. In their lesson reflections, many teachers reported that this was a great opportunity for students to show creativity. For instance, after prompting the students to turn a shape into an everyday object and write about it, one teacher reflected, "I enjoyed seeing students think outside the box."

While teachers saw value in the writing task for showing creativity, we saw the writing task as a way of making connections explicit, giving teachers a glimpse into how students are making those connections, as well as giving students an opportunity to "use the language of mathematics to express mathematical ideas precisely" (NCTM, 2000, p. 60). Figure 2 shows an example of a kindergarten student's work on a writing task, which was inspired by the book *The Day it Rained Hearts*. After reading the book, the teacher prompted the students to write a story problem and create a model that involved combining two sets of hearts. This student wrote, "It was raning harts on Thursday. There where five red harts and one purple hart. So in all my sum is six."

Figure 2. Raining Hearts Student Work

Notice the student's correct use of the word sum in describing the result of combining two sets of hearts. By engaging in a more open-ended writing task rather than a fill in the blank task, students were able to use their own opinions in order to organize and express their conceptual understanding. Students made connections between the model, the story, and the number sentence in the form of written communication.

In another collaborative lesson, the writing activity was to write a letter to a character in the book in order to help him mathematically solve a problem. Through letter writing, this was an opportunity to connect to ELA as well as "understand how mathematical ideas interconnect and build on one another to produce a coherent whole" (NCTM, 2000, p. 64). This writing task gave the students the opportunity to use precise mathematical language and was an embedded, authentic assessment of student learning. The lesson covered the standard "Measure the length of an object twice, using length units of different lengths for the two measurements; Describe how the two measurements relate to the size of the unit chosen" (CCSS, 2010, p. 21) and used the book *How Big Is a Foot?*. In this book, an apprentice tries to build a bed for the queen by measuring with his own feet rather than the king's feet. When the bed turns out to be too small, the apprentice is thrown in jail. The teacher paused at this point in the book and tasked the students with helping the apprentice get out of jail by writing a letter to him describing why his bed was too small and what he could do differently. In the mathematics activity that followed, the students traced and cut out their own foot to measure things around the room; then they compared their measures with their peers' measures and discussed why they were different. It is clear that the writing component was connected to all other components of the lesson and that this provided an opportunity for teachers to assess the conceptual understanding of the students. With a well-connected writing component, students were accessing and incorporating their funds of knowledge and everyday living experiences in understanding new mathematical concepts. For many teachers, the use of writing in mathematics was a novel idea. On the final survey, one teacher responded, "I learned how to incorporate writing and literacy into math. It has become a regular part of our mathematics lessons."

Overall Connectedness. In the process of analyzing the lesson artifacts and classroom observations, we noticed that while most teachers included all of the components of the integrated lesson, there were cases where there was a lack of connection between the content standard, the story, the manipulatives, the mathematics activities, and the writing task. In order to quantify each lesson's connectedness, we developed a scheme in which we gave each component of the lesson one point if it was connected to another component of the lesson. Thus, each lesson was scored from 0-5, where 0 indicates no connection among the lesson components, and 5 indicates that all components were connected. Figure 3 shows a connectedness score of 5.

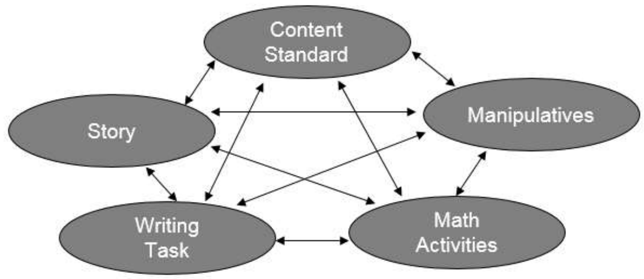

Figure 3. Connectedness of Lesson Components

It is important to note that a connectedness score of 4 would indicate that 4 components were all connected to each other, as in Figure 4.

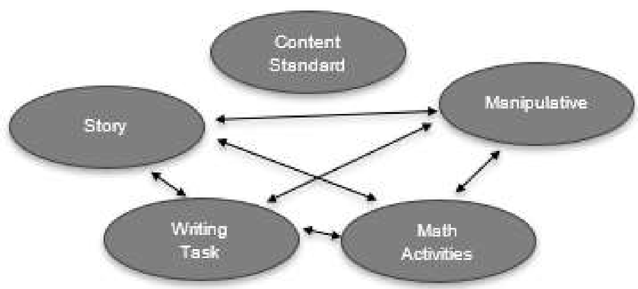

Figure 4. Connectedness Score of 4

In contrast, if 2 components were connected to each other while 2 other components were connected to each other, as in Figure 5, the connectedness score would be 2.

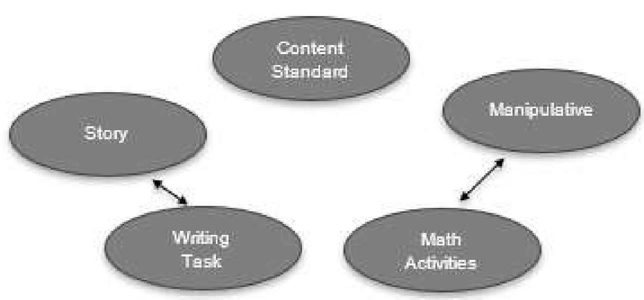

Figure 5. Connectedness Score of 2

The 48 collaborative lessons were given a connectedness score. Table 1 shows the relative frequencies of the connectedness scores.

Table 1

Connectedness Scores

Score	0-0.99	1-1.99	2-2.99	3-3.99	4-4.99	5-5.99
Relative Frequency	0%	0%	6.25%	6.25%	43.75%	43.75%

The mean connectedness score was 4.33 with a standard deviation of 0.78, indicating that there was not a lot of deviation from the mean. The modes were 4 and 5, indicating that most teachers intentionally connected almost all components of the lesson. However, our intention was for teachers to explicitly connect all components of the lesson, such as the *How Big is a Foot?* lesson described in a prior section. Figure 6 shows the connections for this lesson, which was given a connectedness score of 5 because all 5 components are connected.

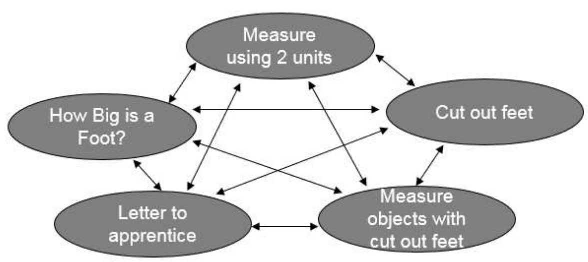

Figure 6. Connectedness of How Big is a Foot? Lesson

Although the average connectedness score was greater than 4, we observed that less than half of the lessons had all components connected, which would be scored a 5. For instance, we determined a score of 2 for one group's first and second collaborative lessons (See Figure 5). In their first lesson, the mathematics activity was connected to the manipulative as a way to model part-part-whole concepts with ten; this is indicated by the bidirectional arrow in Figure 5. The other components had little or nothing to do with this concept. The standards listed in the lesson plan addressed place value and counting by ones to 120. The book chosen, which was *Two Ways to Count to Ten*, focused on skip counting to ten, and the writing prompt was “If you could be an animal, what animal would you be?” This prompt, while loosely connected to the context of the book, included no mathematical content connection; this is indicated by the one directional arrow in Figure 7. This lesson’s connectedness score of 2 was determined by the two fully connected components.

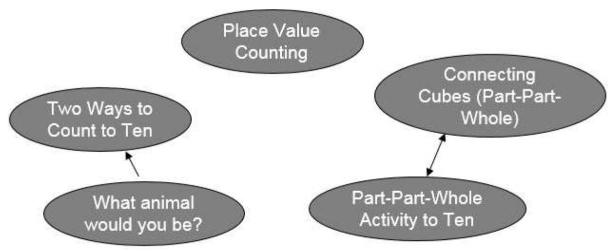

Figure 7. Connectedness Score of Two Ways to Count to Ten Lesson

This lack of connection deprived students of the opportunity to “organize and consolidate their thinking….[and] use the language of mathematics to express mathematical language precisely” (NCTM, 2000, p. 60). These teachers did include a context through the story, but it was not connected to any other components. This was a missed opportunity to develop conceptual understanding by having students “recognize and apply mathematics in contexts outside of mathematics” (NCTM, 2000, p. 64). In their reflection on the lesson, the teachers noted, “Students had a difficult time making a connection between the literature and making a ten.” This indicates that the teacher believed that the book was connected to the mathematics activity and the manipulative. The book chosen was a resource that was given to the teachers during a summer workshop as part of the professional learning community. We wondered if these teacher leaders felt compelled to use the resources provided to them. For these same teacher leaders, we determined a score of 5 for their third and fourth lesson, which was a 150% increase in connectedness. For these lessons, the teachers seemed to start with the content standard and find a book that was intentionally connected. As teachers began to see the value of using literature in mathematics lessons, they began to seek out books beyond those provided, starting their own mathematics literature library. We found this encouraging because it suggests that teachers will continue to incorporate literature in their mathematics lessons.

In many lessons, time played a role in some of the missing components. In 25% of the 48 lesson reflections, teachers reported that there was not enough time to implement the integrated collaborative lesson in their designated mathematics time. Teachers often planned for students to verbally share at the end of the lesson, but time restraints did not always allow for students to communicate their mathematical ideas. NCTM (2000) encourages teachers to "help students learn to talk about mathematics, to explain their answers, and to describe their strategies" (p.128). This fosters a better understanding of their own mathematical thinking. Sharing mathematical thinking also gives students the opportunity to listen to their peers, which helps them to "become aware of alternative perspectives and strategies" (p.128). On their reflection, one group of teachers recognized, "Having students share their work is also essential to their learning."

Misconceptions

As we analyzed the lesson artifacts and classroom observations, we noticed that in a few cases, the teachers seemed to be fostering a misconception. In one lesson focused on teaching students to use the doubles plus one strategy for adding, a teacher asked the question, "How could we determine the sum for 6+7?" When one student answered, "We could use 7+7," the teacher responded by saying, "No because 7 is too…" anticipating the students to say with her, "big." The discussion ended with the students agreeing that they had to use the doubles fact 6+6 to solve 6+7. In order to help students to see mathematics as a way to make sense of their world, it is good to follow the student's line of reasoning even when it is not exactly what the workbook lesson intends. Because this teacher was not able to do that, we believe that she lacked KCS. In this example, 7+7 is definitely a double that could be used to determine the sum 6+7. The teacher, following the child's reasoning, could prompt the student by asking her what she could do to figure out 6+7 if she knew 7+7. The teacher could encourage her to use the connecting cubes to figure out that she could take a cube away from one of the 7's to get back to 6+7. This series of equations shows this line of reasoning: 6+7=(7-1)+7=7+7-1=14-1=13. We believe that this teacher lacked CCK since she did not seem to realize that a doubles minus one strategy could be used to solve this near doubles sum. This deficiency in her MKT may have contributed to the lack of overall connectedness in this lesson, since the score was a 2. Classroom instances such as this require "interaction between specific mathematical understanding and familiarity with students and their mathematical thinking" (Ball et al., 2008, p. 401).

In another lesson, where the standard was listed as "Identify whether the number of objects is greater than, less than, or equal to another group" (CCSS, 2010, p. 10), the activity focused on making equal groups related to multiplicative structures. For example, the students were asked to determine the number of pancakes that each of three friends would get if they had to equally share 12 pancakes. This activity was not connected to any kindergarten standards in the CCSS. It seemed that the teacher may have started with the book, *Pancakes for All*, and planned the lesson around the book rather than beginning with the standard. This group of teachers seemed to lack KCC because they did not correctly interpret the standard for their grade level. We also believe that this indicates a lack of CCK since comparing groups is a basic concept. This directly contributed to their connectedness score of 3.5. When a teacher cannot correctly interpret the standard, it is unlikely that they will be able to create a connected experience for their students.

Implications and Conclusions

Findings of this research offer insights into the early childhood curriculum and the dreams, possibilities, and necessities of public education. By focusing on an integrative approach, K-2 teachers saw the value in including children's literature and a writing component in an integrated mathematics lesson. Through our data analysis, we saw that the teachers' integration of children's literature in a mathematics lesson gave opportunities for connecting to other disciplines, such as science, social studies, and ELA. This integration also helped students see mathematics as meaningful and useful. Incorporating a writing component in a mathematics lesson allowed teachers to assess students' current connections and to broaden those connections between and among a variety of representations. The writing component also allowed students to develop precise mathematical language, and teachers valued the creativity aspect of using open ended writing prompts.

We saw that most teachers were intentional about connecting all of the components of an integrated lesson, and some progressed in their level of connectedness. However, we would like to see teachers make connections between all components of their lesson, which include the standard(s), a mathematics activity, manipulatives, a writing task, and children's literature. We observed that less than half of the lessons had a connectedness score of 5, which raises concern about how to provide support during professional development opportunities for teachers. In some cases, specifically acknowledged in 25% of the teachers' reflections, the lack of connections could be explained by a perceived lack of time. A possible solution for including all of the critical components of an integrated lesson is to plan for the lesson to span a few days of instruction. Another possible solution is to plan for the lesson to take both mathematics and ELA time since standards from both subject areas are being met.

In other cases, the lack of connections could be explained by a teacher's deficiency in MKT. We especially saw cases where teachers showed evidence of holes in their CCK, KCS, and KCC. This points to an overarching theme that K-2 teachers need continual opportunities to develop MKT in these specific domains. Although we cannot say for sure how teachers understand certain mathematical topics, their lesson plans, activities, and lines of questioning give a glimpse into their understanding. It is probable that these teachers hold the very misconceptions that they were fostering in their students.

> If a teacher's conceptual structures comprise disconnected facts and procedures, their instruction is likely to focus on disconnected facts and procedures. In contrast, if a teacher's conceptual structures comprise a web of mathematical ideas and compatible ways of thinking, it will at least be possible that she attempts to develop these same conceptual structures in her students. We believe that it is mathematical understandings of the latter type that serve as a necessary condition for teachers to teach for students' high-quality understanding (Thompson, Carlson, & Silverman, 2007, pp. 416–417).

When teachers do not have a well-connected understanding of mathematical content, it limits how they are able to respond to their students. They are more likely to shut down thinking that does not match with their own.

In the way mathematics is traditionally taught, students perceive mathematics as a discipline where you have to recall facts whereas other subjects require you to think about it (Boaler, 2015). Boaler states,

> The fact that students are drilled in methods and rules that do not make sense to them is not just a problem for their understanding of mathematics. Such an approach leaves students frustrated, because most of them want to understand what they're learning (Boaler, 2013, p. 37).

When teachers have mathematical knowledge for teaching, they can embrace multiple methods that emerge from their students' thinking. Student-invented strategies necessarily begin with their current ways of understanding, which helps them view mathematics as something that belongs to them. This dispels the myth that only certain people are good at mathematics, which is an idea associated with a fixed mindset.

We noted that particular attention to the ways writing and the use of children's literature can support mathematical learning is essential. However, it is not enough to provide teachers with resources and expect them to know what to do with them. It is also not enough to model the use of these resources, which was done by the university faculty members during the professional learning workshops. We have discovered that we need to be explicit about how our instructional decisions about connecting all components were made. We have found that when teachers start with the children's literature, rather than starting with the standard, the lesson is not as well connected.

Through this experience, K-2 teachers developed integrated lessons connecting literacy and math. In integrated lessons, teachers engaged young learners in conceptual understanding and skill development through the use of stories and real-life experiences, providing relevance and accessing the funds of knowledge that children possess. By highlighting conceptual learning in math, teachers are preparing young children for possibilities of higher level mathematical achievement throughout their educational career and improving their life futures. The focus on language and literacy increases practice and development of early literacy and communication skills and the potential for successful reading achievement by third grade, an initiative of the National Governors Association (2013). For these reasons, the emphasis on early literacy and conceptual understanding in mathematics demonstrates an advocacy for greater equity in education for children regardless of their background and experiences, thus promoting the promise of a public education for all children.

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