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How Preservice Teachers Use Children's Literature to Teach Mathematical Concepts: Focus on Mathematical Knowledge for Teaching

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Abstract

This descriptive study examines the elements of mathematical knowledge for teaching (MKT) that elementary teacher candidates exhibit as they plan, teach, and reflect on a mathematics lesson that integrates children's literature. Data for this study were gathered from observations and written work of preservice elementary teacher candidates enrolled in a methods of teaching mathematics course. The data were analyzed using three criteria: that of knowledge of content and students, knowledge of content and teaching, and knowledge of content and curriculum. The findings suggest a need for further development of teacher candidates' ability to identify and locate mathematical concepts in children's literature, as well as the need for supporting teacher candidates' critical analysis of curricular materials and mathematical representations in children's literature.

Keywords: Mathematical knowledge for teaching, Children's literature, Preservice teachers, Elementary mathematics.

Introduction

The purpose of this descriptive study was to examine how teacher candidates design and enact mathematics lessons integrating children's literature. Data for this study were gathered from observations and written work of preservice teacher candidates as they developed and taught a mathematics lesson that integrated children's literature. The analysis in this study focuses on the ways in which teacher candidates approach the use of children's literature, how they plan mathematical tasks that incorporate children's literature, and the mathematical content of the tasks they design. The intent is to describe how the teacher candidates interact with the text, mathematical content, and pedagogical knowledge as they design tasks for use with students in their student teaching practicum semester. Teacher candidates were asked to develop and teach their own mathematics lesson that incorporated children's literature as a regular assignment in their methods of teaching mathematics course. Lesson plans and reflections written by teacher candidates as well as observations of enacted lessons were used in developing case studies for three groups of students. The data were analyzed using three criteria from the Mathematical

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Knowledge for Teaching (MKT) framework described by Ball, Thames, and Phelps (2008), that of knowledge of content and students (KCS), knowledge of content and teaching (KCT), and knowledge of content and curriculum (KCC).

Existing research examines the ways in which teacher candidates and novice teachers view and use mathematics curriculum as well as how the integration of children's literature in mathematics teaching and learning affects teachers' pedagogy, student engagement, and mathematical discourse. Published studies have not yet examined how teacher candidates use children's literature in mathematics teaching and learning with a specific focus on mathematical knowledge for teaching (MKT) (Ball et al., 2008). This study contributes to the body of professional knowledge on mathematical knowledge for teaching and teachers' use of curriculum materials as it examines how teachers use supplementary curriculum materials such as children's literature. Many elementary mathematics curricula include lists of children's literature for use in various lessons, however few provide adequate support for preservice teacher candidates or those teachers with weak mathematical knowledge for teaching to be able to effectively use such resources (Hill & Charalambous, 2012). This study examined how candidates decided which resources to use and how they enacted mathematics lessons with those resources.

In this report I use the term candidates to denote preservice elementary teachers. Students refers to the participants or learners in a lesson (either children or the other candidates during enacted lessons), and teachers indicates the person or people leading the lesson. Children's literature is defined in this study as illustrated books whose primary audience are children and which can be read aloud in 20 minutes or less. Finally, methods course refers to a methods of teaching mathematics course for Elementary Education majors.

Background

Candidates and Curriculum

Candidates have a complicated relationship with mathematics curricula. A focus on the analysis of curriculum may mistakenly lead candidates to believe that good teaching is synonymous with avoiding the use of the assigned textbook to guide instruction in the classroom (Nicol & Crespo, 2006). In contrast, candidates may have little choice in the matter and without experience in the critical evaluation of curriculum they may rely on faulty materials (Nicol & Crespo, 2006). Research on the use of curriculum focuses on the context in which teachers use textbooks, how curricula are used to promote instructional change and innovation, and how teachers learn to use various curricula (Frykholm, 2004; Remillard & Bryans, 2004; Stein, Remillard, & Smith, 2007; Van Zoest & Bohl, 2002). Additional research is needed to examine how teachers and candidates come to understand the role of supplemental curriculum materials and how to use, adapt, and engage with those materials to best meet the needs of their students (Nicol & Crespo, 2006). This study addresses the gap in the research by exploring this question: What elements of KCS, KCT, and KCC do candidates demonstrate as the plan, teach, and reflect on a mathematics lesson that integrates children's literature?

MKT and Children's Literature in Mathematics

Candidates must develop two types of knowledge when preparing to teach mathematics, that of content knowledge and pedagogical content knowledge (Shulman, 1986). Ball et al., (2008) further divide the construct of pedagogical content knowledge into three additional categories specific to mathematics teaching: Knowledge of Content and Students (KCS), Knowledge of Content and Teaching (KCT), and Knowledge of Content and Curriculum (KCC) (Figure 1). These three types of teacher knowledge are complimentary

and it is necessary for a candidate to develop all three to be most effective (Ball et. al., 2008).

In KCS, a candidate anticipates areas of struggle for the students, predicts what will motivate and engage students in mathematical activity, and is able to interpret and understand what students communicate about mathematics (Hill & Charalambous, 2012; Ball et al., 2008; Van den Kieboom, 2013). In this study, KCS was used to evaluate how candidates used children's literature to engage students in mathematical activity, as children's literature has been shown to increase students' participation (e.g. Hong, 1996; Jennings et al., 1992; Mink & Fraser, 2005) and expand mathematical discourse (Anderson et al., 2004; Van den Heuvel-Panhuizen & Van den Boogaard, 2008). Case 1 will illustrate these criteria in this report.

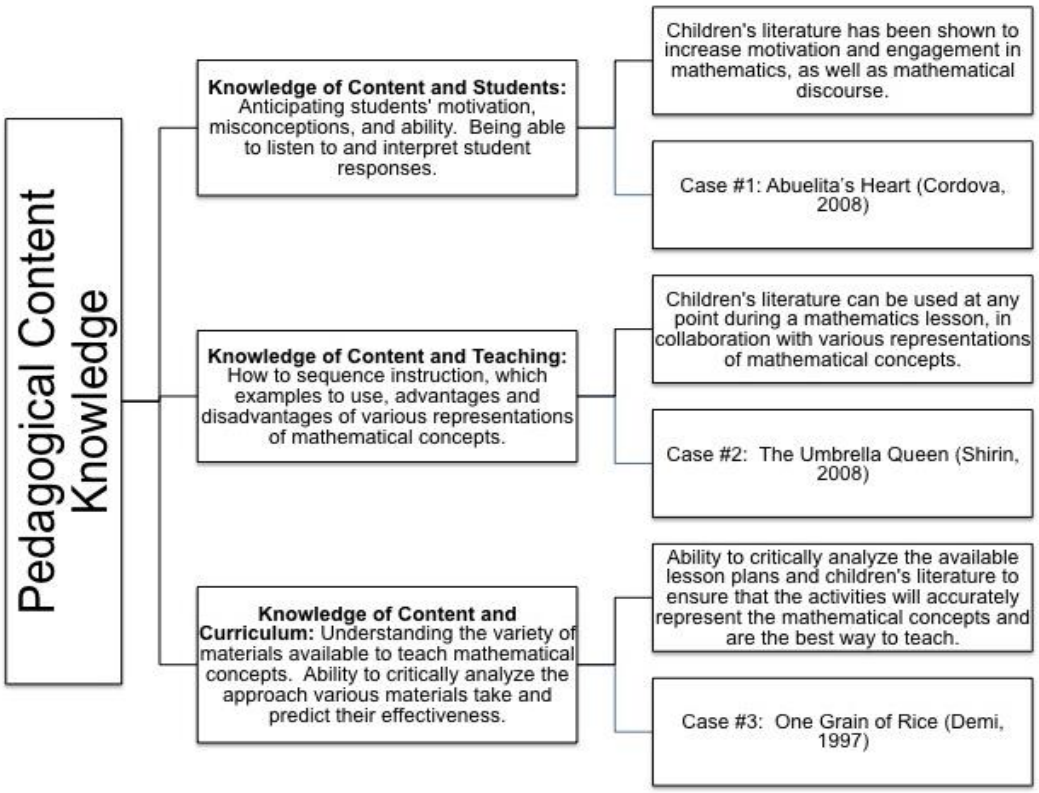

Figure 1. *Relationship among PCK, MKT and Cases Studies in Current Report.*

Candidates must also develop knowledge of planning mathematical instruction. This entails careful selection of examples to use with the students. These examples can serve as an introduction to and as an extension of mathematical concepts. Candidates should consider the advantages and disadvantages of various representations and activities in mathematics. KCT asks candidates to be aware of what "different methods and procedures afford instructionally" (Ball et al., 2008, p. 402). Frequently, studies in mathematics teaching use children's literature to provide a context for mathematical activity, or an experiential space in which students interact with one another as well as text and symbols to produce meaning as a joint accomplishment (Smagorinsky, 2001, p. 141). The teaching and reinforcement of mathematical concepts by teachers is often missing in lessons that use children's literature as context for mathematical activity.

In KCC, a candidate must understand the mathematics he or she is expected to teach and the way that the curriculum approaches those concepts. Specifically, a candidate with well-developed KCC would be able to determine where the curriculum materials are

sufficient and where they are lacking in terms of teaching mathematical concepts. Materials such as children's literature, manipulatives, and technology are often included in a list of supplementary curriculum materials. This is important in this study as often candidates encounter a list of children's literature to use with only minimal explanation of the mathematical content and few suggestions on how to effectively incorporate a book into a mathematics lesson (Halsey, 2005). At times, teachers may think that the use of children's literature is a guarantee that students will learn the mathematical concepts. Though research examining the use of children's literature in mathematics teaching and learning has shown that such integration can result in increased student achievement (Hong, 1996; Jennings et al., 1992; Kisker et al., 2012), candidates must develop a more critical stance towards curriculum materials by reflecting on their own process for designing lessons. Case 3 will be used to illustrate the need for candidates to develop strong KCC in order to critically evaluate the materials they used in teaching their lesson.

Method

Setting

The participants in this study were Elementary Education majors, enrolled in the only methods course in mathematics in the Elementary Education program at a regional comprehensive university in the Southeastern United States. The class met for 150 minutes each week for 14 weeks. The purpose of this methods class was to develop candidates' MKT as they experienced inquiry-based mathematics instruction as well as planned and taught their own mathematics lessons. As a regular part of the class, candidates participated in lessons that integrated children's literature. After participating in literature based lessons led by the instructor, candidates were tasked with designing, teaching, and reflecting on a lesson incorporating children's literature around a specific mathematical concept.

Research Sample

The population from which the sample was selected for this study consisted of 21 students enrolled in the methods course. Case studies were developed for three groups, with seven candidates in the sample. Two criteria guided the purposeful selection of participants: 1) the lessons that were planned and taught by each selected group offered clear illustrations of candidates' strengths and weaknesses in MKT, and 2) Groups who selected either a book with overt or hidden mathematical content in order to illustrate the variety of children's literature that is available for use in mathematics teaching were selected. For selection purposes, I use "overt mathematical content" to denote books which are written to illustrate a mathematical concept, such as Amanda Bean's Amazing Dream (Neuschwander, 1998). In Amanda Bean, a young girl loves to count things but struggles to find a way to count them faster. One night, she has a dream and discovers how multiplication can help her quantify various objects more quickly. The story integrates the idea of repeated addition and multiplication. Children's literature with hidden mathematical content are those books in which the mathematics must be drawn out by the teacher, such as Oliver's Fruit Salad (French, 1998). This book tells the story of Oliver who spends time at his grandfather's farm, picking the fresh fruit they grow. After selecting a variety of fruits for Oliver to eat, he tells his mother that he only likes to pick the fruit, not eat it. At that moment, Oliver's grandparents show up and they decide to make fruit salad, something that Oliver will eat. The story in the book does not have much to do with mathematics, but the context can be used to illustrate proportional reasoning (PBS, 1995).

Procedure

Candidates submitted their lesson plans and reflections after teaching their lesson. As they taught their lesson, I took narrative notes, including the time of events, questions the candidates asked and those in the audience had, and other important information. I prepared research memos immediately following each lesson to better capture my impressions and thoughts of the lesson. My experience as a supervisor of student teachers prepared me well for this experience; I have over 200 hours of practice observing and recording narratives of classroom lessons taught by candidates. Copies of the participants' lesson plans, reflections, books, and researcher notes on the candidates' teaching of their lessons were used to gather information related to the ways in which candidates selected appropriate children's literature, identified the mathematical content within, designed appropriate activities, and taught the lessons to their peers.

Data Analysis

The MKT framework, specifically the constructs of KCT, KCS, and KCC were used to code the data in this study. Each case was developed as research memos and the candidates' written artifacts were coded

While developing each case I coded my observations and the candidates' written artifacts around the type of mathematics identified by the candidates, mathematical understandings that occurred during the literature-based activities, and the outcomes of the lessons. Descriptive data illustrate the candidates' ability to identify, teach, and assess mathematical content embedded in children's literature. Ultimately, the interpretation of the data was drawn from a "mix of personal experience, scholarship, and assertions of other researchers" (Stake, 1995, p. 12). Data were triangulated through convergence across multiple sources. Member checks were performed as written feedback on participants' assignments. In the feedback, I summarized what I understood from their writing, the codes I used in analyzing their work, and any other pertinent information. The participants were asked to review my interpretation and add to or modify my conclusions. I also employed peer debriefing. In this method, the data and research processes are reviewed by someone outside of the project, but who is familiar with the research (Creswell & Miller, 2000). The role of the external reviewer is to critically analyze the methods and interpretations during and after data analysis.

Results and Discussion

The purpose of this study was to discern the elements of MKT that teacher candidates exhibited in their literature-based lessons. In this report I will present each of the three cases separately as an illustration of KCS, KCT, or KCC expressed by teacher candidates as they planned, taught, and reflected on their mathematics lesson that integrated children's literature.

Case 1: Abuelita's Heart

David, Katie, and Lisa worked together to design a lesson that had as its goal the development of understanding of fractions as parts of a whole and to convert fractions to decimals. The book they selected, Abuelita's Heart (Cordova, 2008) did not contain overt mathematical content. In Abuelita's Heart (Cordova, 2008), a young girl visits her grandmother (abuelita) at her home in the desert southwest. The two share a meal of pinto bean soup before heading out to the desert for a walk. In Case 1, the group attempted to make a connection between the story in the book (the activity of making a bean soup) to converting fractions and decimals but showed some misconceptions about fractions in their activity tied to the book. Figure 2 shows the lesson sequence as this group enacted it.

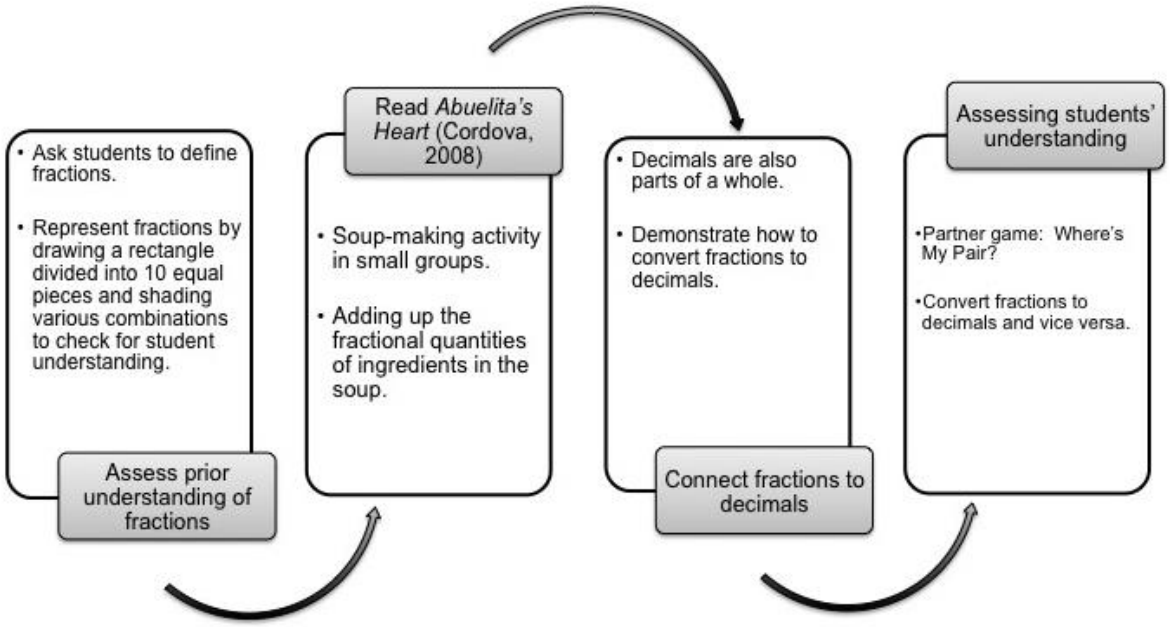

Figure 2. *Lesson Sequence for Case Study 1.*

KCS combines knowledge of students and of mathematics as teachers predict what will motivate students to participate in mathematical activity as well as the paths students might take as they work through examples and tasks (Ball et al., 2008). Teachers must also be able to listen to and interpret students' mathematical communication, identifying areas where students have misconceptions or incomplete understandings of mathematics concepts (Ball et al., 2008). The lesson taught by this first group illustrates the developing KCS that candidates have as they learn to teach.

Motivating students to participate in mathematical activity. David, Katie, and Lisa had two goals in selecting the book for use in their lesson. First, they wanted "to use [a book with] Hispanic culture" and second, they knew that one way to represent and work with fractions was through the concept of sharing. Once they located the book, Abuelita's Heart (Cordova, 2008), they decided to make a connection between the characters' actions of sharing a bowl of soup and the idea of creating or cooking soup in our classroom. They write, "we connected the book with sharing, a task that most children experience every day, but this was not good enough so we decided to relate [the story] to cooking and how it can be used on a daily basis". Students were able to make this connection, however when asked to convert fractions to decimals, they struggled to see the relevancy. In the United States, our recipes typically use fractional quantities; using decimals was unfamiliar and ultimately confusing for the students within the context of cooking.

Interpreting and understanding student responses. After reading the book, Group 1 directed students to make their own soup, similar to the actions of the characters in the book. The teachers provided each group of students with a bowl of beans and a set of additional ingredients (cheese, chicken, rice, and cilantro). Students were to add ingredients to their bowl of beans, keeping track of the fractional quantity they added. Many students struggled with the concept of adding the ingredients because the size of

each addition varied. For example, one group of students started by adding one small spoon of cheese and then later went back and added a larger portion of cheese using the same spoon. These students understood that the fractional quantities they were putting in were not equal, even if the same size spoon was used. As a result, many of the groups made estimations of their quantities such as "that spoonful of chicken should count as two because it was twice as big as the last one we put in." When the teachers asked the students to count only the number of ingredients they added and not the quantity of ingredients, students were further confused. Because each group of students had only four ingredients (some had rice and others had cilantro) and all of the groups put all four ingredients in, they all had fractions of. This seemed to confuse David, Lisa, and Katie as they asked groups to report out their fractions; I overheard David whisper to Lisa that the groups were supposed to have denominators of ten, since he started the lesson with an illustration of fractions by dividing a rectangle into ten equal pieces. Additionally, the teachers and students were confused when they asked the students to add up the fractional ingredients, only to end up with a mixed number when the students could clearly see that there was a single bowl of soup on the table. Instead of pursuing this idea, David chose to move ahead to the next part of the lesson and demonstrate how to convert a fraction into a decimal. This illustrates the teachers' developing KCS as they were unable to interpret or reply to the student responses. This left misconceptions and questions in the minds of the students (e.g., why was the answer a mixed number when we added up our ingredients yet we have only a single bowl of soup? What could we do differently?).

Case 2: The Umbrella Queen

Case 2 demonstrates multiple elements of KCT in their lesson planning, enactment, and reflection. Candidates develop KCT as they learn to sequence instruction, select appropriate examples to use in order to deepen understanding of mathematical content, and are able to critically evaluate various instructional approaches (Ball et al., 2008). Case 2 was also selected for this study because they chose a children's book that did not contain overt mathematical content and used it to teach alternative algorithms, whereas the other groups in the class tended to use their books to teach traditional algorithms. The Umbrella Queen (Bridges, 2008) tells the story of a girl living in a small village in Thailand. A tradition in Thailand is that of making paper umbrellas and painting them with designs of flowers and butterflies. In the story, the girl begins making umbrellas under the direction of her mother. When it comes time to paint the designs the girl paints her umbrellas with elephants and other animals. The mother scolds the little girl, who then begins making small umbrellas from the scraps of the larger one and painting those with her imagined designs. Each year, the king visits the village to select the best umbrella, crowning its maker the umbrella queen. As he visits this year, he catches sight of the girl's elephant umbrellas and declares her the queen.

In their lesson planning, Group 2 carefully sequenced instruction (Figure 3), beginning by activating students' background knowledge on Thailand and then reading The Umbrella Queen (Bridges, 2008), building students' interest in how Thailand and painting umbrellas connected with methods for solving addition problems. In their reflection, Monica and Celeste noted that they wanted to use the book as "an example to show that there is more than one way to do things, such as the concept of alternative algorithms" and during the lesson explicitly mentioned this connection between the story and alternative algorithms. Monica and Celeste's lesson alternated between whole group, individual, and small group work. Their problems were carefully selected and sequenced to allow the students multiple opportunities to try invented and non-standard algorithms. One interesting element of KCT that I noticed is that they used formal mathematical algorithms prior to using manipulatives, which is a reverse of what typically occurs (using hands-on

manipulatives as a way to construct the algorithm). Neither candidate mentions their rationale behind this instructional decision. It may be that they were following the format of the lesson plan template, which asks candidates to describe their structured practice and application in terms of what the teacher will do, the questions he or she may ask, and what the students will do. The order of these questions makes it seem as though this portion of the lesson (the largest part) should only be teacher directed and after that would be when the students would work with hands-on materials.

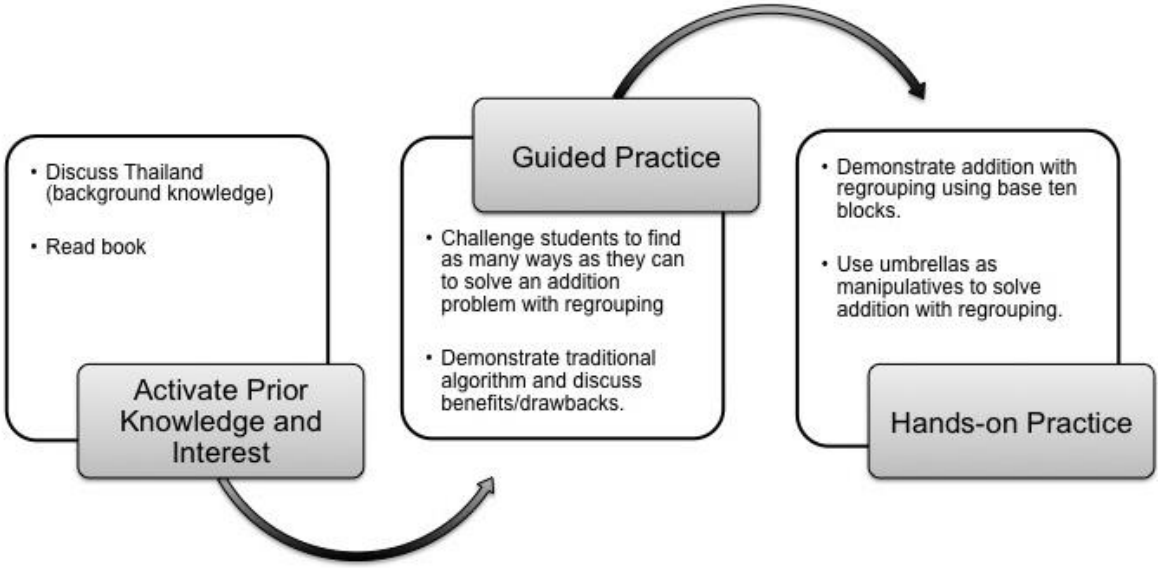

Figure 3. *Lesson Sequence for Case 2.*

Monica and Celeste explicitly mentioned the connection between the story and the alternative algorithms. Group 2 then went on to ask students to model addition problems with regrouping using drink umbrellas to represent tens and macaroni noodles to represent ones. I wrote in my observation notes, "Why umbrellas and noodles instead of base ten blocks?" Base ten blocks would have been a much clearer representation of the concepts of regrouping as they are proportionately sized to one another (e.g., 10 units lined up will be the same length as one rod) and students can physically count the numbers on the blocks (the rods are sectioned into ten). The umbrellas, representing ten, had none of these advantages. In this case, it seems that the candidates were stretching to find a way to incorporate the story further, which may have come at the cost of reduced mathematical understanding in the students. This demonstrates the need for further development in the area of KCC as the representations of the mathematical concept that Monica and Celeste chose to use served to hide the relationship among quantities in base ten.

Case 3: One Grain of Rice

KCC defines a teacher's ability to critically evaluate all of the curricular resources and instructional materials that might be used to teach a particular mathematical concept. In evaluating such resources, a teacher must be able to identify the approaches taken by the materials as well as their effectiveness. Case 3 was selected for this study because of the 10 groups who completed the assignment they were the only one to select a book with

overt mathematical content. The book selected by Group 3, One Grain of Rice (Demi, 1997) fits within the category of overt mathematical content as the story explains exponential growth through doubling a quantity of rice each day for 30 days. One Grain of Rice tells the story of a Rajah who keeps almost all of the villages' rice for himself and does not share any of his supply of rice from the royal storehouses when famine strikes the villages. One day, as some of his rice is being transported from the storehouse to the palace, a small hole develops in one of the bags, spilling rice along the path. A young girl named Rani collects this rice in her skirt, but instead of taking it home to her family, she brings it to the Rajah. He is so impressed by her honesty and loyalty that he offers her a reward. Rani tells the rajah that he can reward her by giving her a single grain of rice that day. "Then, each day for thirty days you will give me double the rice you gave me the day before. Thus, tomorrow you will give me two grains of rice, the next day four grains of rice, and so on for thirty days" (Demi, 1997, p. 13). On the 30th day, Rani receives 536,870,912 grains of rice, leaving the royal storehouses empty.

Alison and Carrie specifically mentioned that they were looking for a book with overt mathematical content to use in this lesson. In their reflection, Carrie and Alison identified the relationship of doubling a quantity daily for 30 days. They also wrote that the book "incorporate(s) multiplication by having the students figure out how much rice [Rani] had at the end of the book". They mentioned that the book was listed in the required textbook in the methods course but because the textbook offered no support in terms of what mathematical concepts the story in One Grain of Rice (Demi, 1997) could illustrate, Alison and Carrie were left to find the mathematics themselves. One Grain of Rice (Demi, 1997) does illustrate a doubling relationship, as the rajah is forced to give Rani double the amount of rice he gave her the previous day for 30 days. What the book does not show is how that calculation was carried out. During the lesson, I observed many students who did not use a multiplication algorithm to double the quantity, choosing instead to add the day's total twice to find the next day's amount. Both approaches are valid, however with Alison and Carrie's identified goal of teaching multiplication of multi-digit numbers, the book fell short of ensuring that students would indeed practice that skill. During the lesson, as students worked on completing a doubling chart, they began to realize that doubling the number of the day instead of the quantity of rice received was incorrect because the amounts were not matching up to what happened in the story. In their reflection on the lesson, Carrie and Alison wrote, "students wanted to double both sets of numbers in the multiplication problem versus just multiplying by two each time. We believe that once students understood and were all on the same page with the doubling chart that they were able to accurately complete the worksheet". To help the students get on the "same page", Alison and Carrie referred back to the book, showing pictures of the rice Rani was receiving on each day and asking students if their answers made sense. Ultimately, a demonstration on the board was necessary for students to grasp how to accurately complete the doubling chart.

Alison and Carrie relied heavily on the mathematical content of the book they selected. Students were able to achieve the learning goal of practicing multiplication through doubling, however it was not as a result of Alison and Carrie's teaching. As the group taught their lesson, they did not use any sample problems that included two as a multiplicand. This disconnect between the mathematical content of the book and the teacher-led activities demonstrates the developing KCC of these candidates in that they relied heavily on the story and less on their own teaching to get the mathematical concept across to students.

Summary of Findings

This report presents three case studies, each illustrating expressions of MKT by preservice teacher candidates as they planned, taught, and reflected on a mathematics lesson that integrated children's literature. Case 1, Abuelita's Heart (Cordova, 2008) shows the risk of relying on a book to teach a concept if your own content knowledge is not developed. Case 2, The Umbrella Queen (Bridges, 2008) illustrated how the use of children's literature can help shift or change students' beliefs about the nature of mathematics by validating students' alternative paths to solution. Case 3, One Grain of Rice (Demi, 1997), was selected for this study to show how using a book with explicit mathematical content is not enough to ensure that an effective lesson with increased student learning will take place.

Limitations of the Study

The goal of qualitative research is a deep understanding of experience, rather than a search for cause and effect among variables (Creswell & Miller, 2000; Merriam, 2009; Saldaña, 2009). A small sample size contributes to the likelihood that such an understanding of the experiences of the participants can be explored. This study had a sample of only three groups. The sample was kept purposefully small in order to be able to present a full description of the experiences of the participants. Such a small sample size affects generalizability. This study took place in a certain setting at a certain time, neither to be replicated again. Instead I have tried to present the reader with enough information about the participants and their experiences that he or she can judge for themselves if the findings of this study ring true.

Other research examining KCS, KCT, and KCC in connection with candidates' use of curricular materials uses formal assessments of the candidates' MKT levels (e.g., Hill & Charalambous, 2012). No such assessment was used in this study, as the focus was not on a correlation between MKT and effective use of curricular materials, but on the elements of KCS, KCT, and KCC that candidates naturally exhibited. A formal assessment of the candidates' KCS, KCT, and KCC may have added another piece of information to support the findings of this study. Also, interviews with the teachers before and after their lessons may have given further insight into the reasons for misalignments between the assigned content, mathematics standards, and activities during the lesson, building on the reflections that the candidates completed.

One additional limitation to this study exists. In qualitative research the researcher operates as the primary instrument, bringing with her all of her biases, beliefs, and values. My experiences as a classroom teacher, mathematics teacher educator, and children's librarian all influenced how I viewed the data and structured the results. My beliefs in the effectiveness of using children's literature in mathematics teaching and learning provide one facet through which I analyzed the data. Richardson & St. Pierre compare qualitative research to a crystal, writing, "What we see depends on our angle of repose-not triangulation but rather crystallization" (2000, p. 963). It is entirely possible that a different researcher may see different conclusions in the data, depending on their personal angle of repose. In this study, I have attempted to present the clearest and most detailed picture possible of what occurred during the study, how I analyzed the data, and the conclusions I drew from the experience.

Summary

The findings of this study may influence the design of a methods of teaching mathematics course. I recommend that mathematics teacher educators focus less on the mechanics of filling out a lesson plan (e.g., here is where you write the standard, now write an essential question) and more on the evaluation of instructional resources. These resources may

include published lesson plans, children's books, manipulatives, or technology. Candidates need support as they learn how and when to use various resources such as published lesson plans, children's literature, manipulatives, or technology. Teacher candidates must be guided as they learn how to critically evaluate the effectiveness of such materials. The teacher educator, course assignments, and class activities can develop these critical thinking skills through modeling. One example of a class activity that could be used to teach these critical analysis skills is the idea of giving candidates two different lessons or activities that teach the same concept and then having them select the one they would use. Candidates would then need to explain how and why they selected one activity over the other in order to justify their selection.

The purpose of this study was to examine the elements of MKT that teacher candidates exhibited as they planned, taught, and reflected on mathematics lessons that integrated children's literature. Using a case study design and qualitative methodology, three groups' experiences were examined. Findings suggest that candidates demonstrated developing levels of MKT as they planned and taught their lessons. Using a book with overt mathematical content was not enough to guarantee that a group was able to teach an effective lesson. Groups that used books with hidden mathematical content also struggled. Ultimately, teacher candidates need further support for developing MKT, specifically knowledge of content and students, knowledge of content and teaching, and knowledge of content and curriculum.

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