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Multicultural Children's Literature as a Context for Teaching Mathematics for Cultural Relevance in Urban Schools

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Abstract This article reports on a teacher-research study that used multicultural texts as a context for teaching mathematics for cultural relevance during an elementary mathematics methods course. The results of the study reveal that 28 % (5 out of 18) of the teacher candidates (TCs) chose books that were culturally contextual or culturally amenable. However, 89 % (16 out of 18) of the TCs chose texts that were mathematically robust or mathematically peripheral. Four focal TCs were selected to examine how they used the texts with children to teach mathematics concepts. Math lessons fostered academic success, cultural competence, and critical consciousness. Overall, the results of the study are mixed. We conclude that some TCs' choice of texts may reflect indifference, passive resistance, low self-efficacy, school culture, and mixed messages from the teacher–researcher. Additional studies that include follow-up interviews and classroom observations are needed to determine the factors that influence TCs' selections of multicultural texts and their implementation of culturally relevant pedagogy with students.

Keywords Cultural relevance · Mathematics education · Multicultural literature · Urban education

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Introduction

There is a cadre of mathematics educators who believe that teaching and learning mathematics should be connected to the culture and lived experiences of children (Bartell 2012; Gutstein 2006; Leonard et al. 2010; Matthews 2009; Nasir 2005; Tate 2008; Young 2014). These scholars explore and examine concrete ways of connecting mathematics to students' lives, particularly in urban contexts (Gutstein 2006, 2012; Tate 2005; 2008). However, using culture as a context for learning mathematics in everyday classrooms is difficult for novice teachers. Multicultural children's literature, however, can be used to make connections between mathematics and students' cultural, historical, social, and political experiences (Mendoza and Reese 2001). The purpose of this paper is to report on the results of a teacher-research study by a professor who taught an elementary mathematics methods course at a predominantly white university. Multicultural books were used as a context for learning to teach mathematics for cultural relevance in the mathematics methods course.

This study examines the pedagogy of one teacher–researcher, who is also an author on this paper, and work samples produced by 18 teacher candidates (TCs) enrolled in an 8-week (two credit) elementary mathematics course at an urban university. Having taught mathematics methods for more than 12 years in urban settings and urban students in public schools for 10 years, the teacher–researcher, who is also a faculty of color, believed that equipping TCs with concrete strategies to engage diverse learners in mathematics leads to deeper mathematical understanding and greater academic achievement for underserved K-6 students (Leonard 2008, 2009). Furthermore, she believed that the use of multicultural texts is a low-risk endeavor and could easily be used to anchor mathematics to students' culture and everyday lives.

Educators can rely on multicultural books as vehicles to teach children about mathematics within a cultural context (Chappell and Thompson 2000). Mathematics, for instance, emerges via colorful illustrations in *The Great Migration: An American Story* (Lawrence and Myers 1995). In this text, young children get the opportunity to grasp quantity in terms of population shifts. *First Day in Grapes* (Perez 2002) describes the experiences of a Latino boy who comes from a family of migrant workers and how he uses his knowledge of mathematics to earn respect from his peers. *One Grain of Rice* (Demi 1997) describes the story of a peasant girl who tricks a raja (e.g., monarch or ruler) into giving her all of the rice in the royal storehouse. This book helps children comprehend the concept of exponents and also impresses upon them the importance of sharing essential resources such as food. Multicultural books, likewise, embody the potential to provide teachers with a plethora of story problems based on cultural themes.

Throughout her years as a mathematics educator, the teacher–researcher found that some TCs at predominantly white institutions were resistant to using culture in the mathematics classroom (Leonard 2008; Leonard and Dantley 2005). Comments like "math is math" and "I do not see how culture has anything to do with math or how I teach it" were commonplace. Nevertheless, the teacher–researcher believed she could transform TCs' initial impressions by encouraging them to examine their

own positioning within society as well as their mathematics identity and identity as teacher candidates (Dutro et al. 2008; Price and Valli 1998; Rodriguez and Kitchen 2005; Sleeter 2008). Thus, within a white institutional space, race and gender intersected as one faculty of color engaged predominantly white TCs in activities that she believed would prepare them to teach in urban classrooms. Following a brief synopsis of the theoretical framework and the literature review, a detailed description of the study participants, methods, and results are described in detail.

Theoretical Framework

This teacher-research study is guided by the theory of culturally relevant pedagogy (CRP), which was popularized by Gloria Ladson Billings (1995). Ladson-Billings (1995) developed a grounded theory of CRP based on the following propositions: "(1) concrete experiences as a criterion of meaning, (2) use of dialogue in assessing knowledge claims, (3) the ethic of caring, and (4) the ethic of personal accountability" (Collins, as cited in Ladson-Billings 1995, p. 471). She further elaborated upon these propositions to develop three tenets, which are the hallmark of CRP: 1) academic success; 2) cultural competence; 3) and critical consciousness. These tenets and propositions are interwoven, and provide the guiding framework to engage teacher candidates in innovative activities with diverse learners.

Academic success may be supported by helping students to develop a mathematics identity and by focusing on authentic problem solving and problem posing in the mathematics classroom. Nasir (2005) defined identity as "amalgamation of self-concept, self-understanding, and evaluating oneself in relation to others" (p. 217). Mathematics identity has been described as developing an identity as a mathematics learner (Anderson 2007). In mathematics, how students view their own learning, how they understand that knowledge as well as knowledge gaps, and how they position themselves as learners in relation to others is pivotal to building a positive mathematics identity (Varelas et al. 2013). Teachers can help students to develop a mathematics identity by providing opportunities to develop and use critical thinking and problem-solving skills, which attend to Ladson-Billings' criteria of academic success. In such learning environments, problem solving may be addressed through a culturally *specific* lens (Leonard 2008). Cultural specificity acknowledges language, behavior, history, and tradition in children's communities while using their distinct ethnic or racial backgrounds as the focal point of instruction (Irvine 2002).

Second, *cultural competence* is "the ability to function effectively in one's culture of origin" (Ladson-Billings 2000, p. 219). CRP empowers students to take charge of their own learning by using circumstances that arise in their neighborhood as forms of official knowledge (Ladson-Billings 1995). For example, students used their knowledge about area and space to make recommendations to city council members about land use by proposing a neighborhood redevelopment project (Ladson-Billings 1994). Culturally relevant mathematics tasks, if done appropriately, provide the opportunity for students to develop a strong mathematics identity by using cultural forms of knowledge. Students are more likely to remember

mathematics concepts when the concepts are anchored to the culture of the community the students are most familiar with (Brenner 1998). Ultimately, the experiences students have will influence them to "learn and participate or to resist and disengage" (Martin 2007, p. 16).

Third, *critical consciousness* promotes the questioning of existing ideas, viewing the world through a critical lens, and developing heightened consciousness. This tenet connects to issues of social justice, empowering students to learn and understand institutional structures and dynamics and how to use the democratic process to facilitate change (Gutstein 2012; Staples 2005). Drawing upon this tenet, there are norms, values, and conventional actions shared by a community of learners that shape their attitudes and opinions. These attitudes and opinions can be utilized in the classroom to increase academic engagement and success.

Paris (2012) purports culturally relevant pedagogy does not go far enough and suggests the term culturally *sustaining* pedagogy be used as a means to "foster…linguistic, literate, and cultural pluralism as part of the democratic project of schooling" (p. 95). In other words, Paris believes culturally relevant pedagogy should be more aligned with critical pedagogy. Pluralism and equality will never be realized as long as power and privilege are synonymous with a dominant culture. Rather, indigenous cultures must be valued and placed alongside dominant culture. Yet, affirming one culture does not have to result in negating another culture. Neither should such affirmations be abandoned because of concerns that cultural pedagogues are *essentializing* (i.e., promoting one size fits all) instruction. That is, if each of the components Ladson-Billings proposed is addressed, culturally relevant pedagogy intersects with critical pedagogy when teachers and teacher educators try to develop critical consciousness among their students.

Review of the Literature

Two bodies of literature support this study: culturally based pedagogy and use of multicultural literature in the mathematics classroom. Culturally based pedagogy emerged in the 1990s (Brenner 1998; Ladson-Billings 1994) to improve academic achievement among underserved students by addressing cultural dissonance. Cultural dissonance can be thought of as differences between the culture of the school and the home (Brenner 1998). While some contend that culture has no place in schools (Leonard 2008), the classroom itself is a microcosm of culture (Aikenhead 1997).

Cultural Relevance in the Mathematics Classroom

Several studies reveal that teaching for cultural relevance is complex and challenging work (Lemons-Smith 2013; Leonard et al. 2009, 2010; Young 2010). Decision-making related to how and what to teach in the mathematics classroom requires that teachers reflect upon their own biases and assumptions (Gutstein 2012; Walker 2006) and upon the students they teach (Tate 2005). Malloy and Jones (1998) found that middle school students were successful in solving non-routine

word problems that were culturally relevant. However, students needed more time to solve complex multi-step problems. Tate (2005) found that a mathematics lesson that used the example of pumpkin pie may not be as interesting for some students as it is for others. Issues related to the students' communities, livelihood, or pop culture are worthwhile contexts to explore (Gutstein 2012; Hill 2006; Ladson-Billings 1995; Tate 2008). Lessons that do not take students' values and experiences into account are not culturally relevant, even though they may be culturally relevant to the teacher or another group of students in a different community (Leonard et al. 2009). Students bring unique assets and cultural knowledge to school that can be used as authentic contexts for learning (Leonard 2008). Ultimately, topics under consideration of study to engage students in CRP should come from the students themselves, who must be seen as active participants in their own learning (Frankenstein 2012; Gutstein 2012).

Children's Literature in the Mathematics Classroom

Research has shown multicultural literature's influence on reading development and reading engagement (Pentimonti et al. 2011). For instance, some studies address the incorporation of multicultural literature into reading and language arts classrooms, indicating that at times some children become more engaged when they read books about people from their own cultural backgrounds (Sipe and Daley 2005; Smith 1995). Also, prior knowledge about lived and cultural experiences has been shown to aid in improving reading comprehension and interpretation (Bell and Clark 1998; Lee 1993; Rickford 1999). Parallels between these two content areas suggest there are sound, research driven reasons for the coupling of mathematics and multicultural children's literature. In particular, multicultural literature lends itself well to personalizing story problems in order to teach for cultural relevance.

For example, to generate interest in place value and number sense among fourth and fifth graders, Mack (2011) used multicultural books to explore different types of place-value systems (i.e., Roman, Mayan, and Babylonian) and additive number systems (i.e., Egyptian and Roman). Students read texts like *Senefer: A Young Genius of Old Egypt* (Lumpkin and Nickens 1991) and *Number Stories of Long Ago* (Smith 2001). Mack contended "the books helped students learn more about the culture that developed a particular number system and encouraged them to think about important mathematical ideas" (Mack 2011, p. 104).

Koellner et al. (2009) integrated literature in middle school mathematics classrooms to support students' acquisition of complex mathematical ideas. The authors used advanced search methods and literature databases to find young adult literature that met national standards for teaching middle school mathematics. The authors then read the texts, identified the mathematics content they addressed, and ranked the books by complexity. *Hannah, Divided* (Griffin 2004) is an example of complexity level one—mathematically related. In this situation, mathematics is included in the storyline, but problems are not a part of the plot. *The Toothpaste Millionaire* (Merrill 1972) is an example of complexity level two—mathematically peripheral. In this case, mathematics concepts are included but implicit, skimming the surface without going into depth. *The Number Devil* (Enzensberger 1998) is an

example of complexity level three—mathematically robust. In this circumstance, the mathematics is explicit (i.e., central to the book) and embedded throughout the novel, providing opportunities for students to engage in number sense, algebra, geometry, and problem solving. Integration of literacy and mathematics provides "context and engaging scenarios for students to grasp difficult mathematics concepts" (Koellner et al. 2009, p. 38).

Multicultural texts can also be analyzed for cultural elements. Chappell and Thompson (2000) categorized multimedia as "*culturally contextual* (culturally specific to one race or ethnic group), *culturally amenable* (not specific to a particular culture or race although the characters may be of a specific race or ethnic background) or *culturally influenced* (neither culturally contextual, nor culturally amenable)" (p. 135–136). An example of a culturally contextual text is *The Black Snowman* (Mendez 1989). This story is about how one young African American boy's attitude changed by learning about the African Diaspora. Briefly, the African Diaspora is the multitude of regions, cultures, and communities shaped by the emigration of Africans from the continent of Africa. Money problems can be created around the recycling project presented in *The Black Snowman.* An example of a culturally amenable text is *The Three Little Javelinas* (Lowell 1992), which is the Spanish version of the three little pigs. The story itself can take place in any culture, but the javelinas represent the southwest cousins of pigs. The text provides a context to develop problems around architecture and construction. An example of a culturally influenced text, is *The Grouchy Lady Bug* (Carle 1996). The text is not specific to any culture or race and neither are the characters, which include a host of animals. However, the text does deal with values and learning to share. In this study, teacher candidates were exposed to instruction that used multicultural children's literature (and other media) as a basis to engage individual and small groups of children in meaningful mathematics activities.

The Teacher-Research Study

The research design for this study is teacher research, which provides an opportunity to use micro-ethnography to study specific phenomenon in educational spaces in order to observe and analyze teacher practice and student learning. Microethnography is part of the ethnographic tradition, allowing researchers to apply a zoom-lens approach to data collection and analysis (Erickson 1985). In the study reported here, the TCs' reflection papers and teacher work samples (TWS) provided evidence for the teacher–researcher to learn about her own practice and to encourage TCs to use multicultural literature as a context for teaching mathematics for cultural relevance. The study took place during an eight-week long mathematics methods course in the spring semester of 2012. The methods course was the third course in a series of courses required for licensure in the early childhood and elementary program at an urban university.

Participants

The participants in this study included 18 teacher candidates enrolled at a predominantly white pubic institution in the Western U.S.: three males and 15

females. Two of the females identified themselves as Latinas, the remaining TCs were White. Ten of the TCs were graduate students and eight were undergraduate students. The graduate program was changed to begin admitting undergraduates in 2004. However, the number of undergraduates was not high enough to warrant scheduling separate courses. For the most part, the undergraduate and graduate participants took all of their courses (including a series of three mathematics education courses and practicum) together using a cohort model. Thus, the participants knew each other and worked together well on joint projects. TCs completed roughly 800 contact hours with children in the field prior to teacher licensure. Most of their practicum, intern, and student teaching experiences took place in one or more of 26 professional development schools (PDSs). Four of these PDSs resided in the urban school district where the institution was located. The remaining PDSs where located in suburban districts; however, some of the suburban districts consisted of Title I schools (i.e., 50 % or more of the students received free or reduced lunch).

Research Questions

The research questions were informed by previous research and are as follows:

1. What choices did teacher candidates' make regarding the selection of multicultural literature to conduct mathematics activities with individual and small groups of students?
2. How did teacher candidates' use the multicultural children's literature to teach mathematics concepts?
3. What did the teacher–researcher learn about her practice and how to facilitate culturally relevant pedagogy in predominantly white institutional spaces?

Methods

The data reported here were obtained after the university granted IRB approval for use of human subjects. The procedures, readings, and activities were piloted and field-tested in prior studies (Leonard and Evans 2012; Newton et al. 2012; Leonard et al. 2009). Two of the these studies focused on helping in-service teachers to engage in practices such as teaching mathematics for cultural relevance (Leonard et al. 2009) or for social justice (Leonard and Evans 2012). Lessons learned from the study on cultural relevance revealed the importance of knowing the culture of the students and what was relevant to them. In other words, teachers cannot assume that subgroups of a particular race or ethnicity share the same values and behaviors (Leonard et al. 2009). It is important for teachers to use member checks to ensure what teachers believe is relevant to the students *actually is.* Thus, it is important that teachers become students of students in order to learn what is appropriate in terms of context (Nieto 2002). This study aimed to support TCs as they learned about CRP, in some cases for the first time, and to document the strategies that could be used to implement it.

To answer the first research question, the teacher–researcher analyzed the type of literature selected by the TCs using a priori coding based on the theoretical constructs established by Chappell and Thompson (2000). The codes include culturally contextual, culturally amenable, and culturally influenced texts. A priori coding was also used to analyze the multicultural texts for mathematical complexity (Koellner 2009). The mathematical codes include mathematically robust, mathematically peripheral, and mathematically related texts.

To answer the second research question, we examined the mathematical and culturally relevant practices of four focal TCs as they used the multicultural texts with children in various educational settings. These four TCs comprised a sample of convenience, as they were the only students who gave permission for reflection papers to be analyzed beyond descriptive purposes. The TCs selected one or more children to implement a project assignment known as the math bag. The math bags were literally bags that the TCs filled with materials to teach three math activities centered on a single theme. The bags included a children's book, manipulatives, and any other needed materials. The math bag was to be implemented at least once in an approved educational setting such as a PDS or an after-school program. The TCs were required to jot down field-notes on the child's interactions and report out on the activity as part of a course grade. The teacher–researcher did not observe these lessons because of distance, timing, school regulations, and IRB limitations. However, the TCs presented letters to their cooperating teachers explaining how their work was related to the teacher education program and the course requirements.

To learn how the TCs engaged students with the texts, we used a rubric developed by Lemons-Smith (2013) (see "Appendix") to evaluate the TCs' lesson plans and the math bags they put together using culturally relevant tenets (Ladson-Billings 1995). Secondly, we used content analysis to examine the TCs' reflection papers for themes and patterns (de Sola Pool 1959). Finally, member checks were conducted with the TCs to ensure our observations and conclusions accurately reflected their intentions.

To answer the third research question, we examined the TCs' reflection papers, end of course evaluations, and the teacher–researcher's field-notes that she recorded each week as she taught the elementary mathematics methods course. The field-notes were analyzed to determine what the teacher–researcher learned from her practice and how she adapted the course to maximize the TCs' effectiveness with CRP. The course evaluations provided an additional source of feedback from the TCs, providing information about the effectiveness of the course and how it might be tailored in the future. The reflection papers also provided the teacher–researcher with feedback regarding the use of multicultural texts to teach math concepts.

Procedures

The teacher–researcher had been engaged in practices to facilitate the development of culturally relevant pedagogy for more than 12 years. She often began her methods courses by asking TCs to write a reflection paper on their cultural and prior mathematics experiences in order to address the specific needs of the class. A

mathematics methods text (Hatfield et al. 2008) that addressed aspects of cultural relevance was used to help TCs learn mathematics content and pedagogy. In previous semesters, the teacher–researcher learned that simply using a mathematics methods text was not enough. Thus, new reading material and children's literature were added to the syllabus each semester, based on what was learned in previous semesters and to keep pace with current research and best practices that emerged over the years. TCs read articles from *Teaching Children Mathematics* and *Mathematics Teaching in the Middle School* that promoted teaching mathematics for cultural relevance (e.g., Silverman et al. 2001; White 2001). As a faculty member of color, the teacher–researcher understood the complexities of race and gender as she promoted critical pedagogy and culturally relevant pedagogy as a means to address issues of equity and social justice in her mathematics methods courses. She frequently found the stories she told about the children she had taught in urban and suburban schools along with evidence of their success encouraged TCs to try new ideas.

Moreover, the teacher–researcher modeled how to teach mathematics using multicultural literature, and she used manipulatives to show TCs how to enrich mathematics lessons, engage students at high levels, and improve students' academic achievement (i.e., grades and test scores). She approached mathematics content by introducing each of the NTCM content standards (i.e., number, algebra, geometry, measurement, and data analysis and statistics) over several weeks. The teacher–researcher often presented a mathematics concept with a video clip, word problem, or exploration. In some instances, a multicultural book was not appropriate or was not available for use. Whenever possible, a multicultural book was used to illustrate how the text and related activities could be incorporated with the concept. For example, *Two of Everything* by Lily Toy Hong (1993) is a Chinese folk tale that illustrates the concept of doubling. The protagonists are an old man and woman who learned that a magic pot would double anything that they put into it. A hands-on activity that was used with this text included decorating a Styrofoam cup with a cutout of a pot and having students pretend that if they put a certain number of objects into the cup, it would magically double. In this way, children could learn about functions and understand reciprocal relationships (e.g., If four hairpins are taken out of the magic pot, how many hairpins were put into it? If 8 marbles are put into the magic pot, how many will come out of it?). TCs then demonstrated their ability to teach mathematics concepts by presenting a 15–20 minute lesson to their peers, which was termed microteaching. A rubric was used to judge the quality of the mathematics, peer engagement, and instructional practices.

In addition to microteaching, TCs were also required to develop a teacher work sample (TWS) and to field-test it with students. In this mathematics methods course, the TWS was the math bag (previously described). From the outset, the TCs were told to choose a multicultural book to use with the math bag to teach an individual child or small group of children in a formal or informal learning environment. TCs did not have to purchase the books and were encouraged to borrow one from the school or public library. However, most TCs purchased the book that they chose. Many examples of mathematics texts were presented during the class, and a list of books was provided. Discussions about how to select a book also took place. TCs

presented their books and one activity from the math bag at the end of the course. A rubric was developed and used to judge the quality of lesson plans and activities in the math bag (see "Appendix").

Data Sources

Data sources included artifacts such as the TCs' math bags, which contained the literature they selected, logs, lesson plans, and reflection papers. Other artifacts included the teacher–researcher's field-notes, course evaluations, and rubrics used to rate the texts and the math bag.

Results

Choice of Multicultural Literature

After a priori coding of the books, the data revealed five TCs selected culturally contextual or culturally amenable texts (Chappell and Thompson 2000). *One Grain of Rice* (Demi 1997), *Aunt Harriet's Underground Railroad in the Sky* (Ringgold 1992) and *Sadako* (Coerr 1993) were classified as culturally contextual. The text, *Rows and Piles of Coins* (Mollel 1999), which was used by two different TCs, was classified as a culturally amenable text. The remainder of the TCs chose books that were culturally influenced (e.g., *The Greedy Triangle* (Burns 1995); *Cloudy with a Chance of Meatballs* (Barrett et al. 1978)). Although the teacher–researcher strongly encouraged TCs to select culturally contextual or amenable texts, only 28 % of the TCs did so.

When the same texts were analyzed for mathematical complexity (Koellner et al. 2009) the data told a different story. A priori coding revealed that two TCs selected texts (11 %) that were at level one (mathematically related). One of these texts was also rated culturally contextual: *Aunt Harriet's Underground Railroad in the Sky*. Six TCs (33 %) selected texts that were rated at level two (mathematically peripheral). All of these texts were culturally influenced (e.g., *Inch by Inch*). Ten TCs (56 %) chose texts that were rated at level three (mathematically robust). These texts included one that was culturally contextual and one that was culturally amenable, *One Grain of Rice* and *Rows and Piles of Coins*, respectively. Thus, a text could be culturally contextual but not mathematically robust and vice versa.

Analysis of TCs' Use of Multicultural Texts to Teach Mathematics

Table 1 shows the mathematics topic each of the four focal TCs used to engage students with multicultural texts. It also informs the reader about the a priori codes used to rate the texts they chose in terms of mathematics complexity and cultural relevance.

The TCs who gave permission for their reflection papers to be examined represent a cross-section in terms of the types of multicultural texts selected. Texts ranged from culturally influenced to culturally contextual and from mathematically

Table 1 Analysis of math topics and multicultural texts ($n = 4$)

Teacher candidate*	Math topic	Grade level	Title of text	Levels of text complexity
Stella	Measurement	Fifth grade	*One grain of rice* (Demi 1997)	Culturally contextual/ mathematically robust
Cydnei	Money	First grade	Rows and Piles of Coins (Mollel 1999)	Culturally amenable/ mathematically robust
Molly	Number	Third grade	*Aunt Harriet's underground railroad in the sky* (Ringgold 1992)	Culturally contextual/ mathematically related
Krystal	Measurement	Third grade	*Inch by inch* (Lionni 1988)	Culturally influenced/ mathematically peripheral

* All names are pseudonyms

related to mathematically robust. Furthermore, Table 1 reveals that texts could be culturally contextual and mathematically robust (*One Grain of Rice*) as well as culturally contextual and mathematically weak (*Aunt Harriet's Underground Railroad in the Sky*). What is most important is how the TCs used the texts with students.

Table 2 illustrates the interactions that occurred between the TCs and the children they worked with on the math bag.

The data are aligned with Ladson-Billings' (1995) three tenets of culturally relevant teaching (i.e., academic success, cultural competence, and critical consciousness). A rubric developed by Lemons-Smith (2013) was adapted to rate teacher candidates' instruction across these categories as substantial, cursory or superficial. Excerpts extracted from the TCs' journal logs are shown in bold print, and excerpts obtained from their reflection papers are italicized. In addition to describing the mathematics activities, Cydnei and Krystal also described the process they used to make the most of the books they selected:

> After reading the book, it was clear that there would be a plethora of mathematical concepts to teach; some of these included grouping, sets, multiplication, addition, subtraction, division, and money. (Cydnei)
> First, I did some research. I wanted to delve into how students begin to think about the idea of measurement, and I came across the idea of measuring with non-standard units. (Krystal)

Furthermore, Cydnei, Molly, and Krystal assessed their students' knowledge to ensure they completed the tasks successfully:

> Previous assessment determined that this student had a solid understanding of number, is fluent in base-ten concepts, and uses a variety of mental strategies to compute addition with fluency up to three-digit numbers. (Cydnei)
> Once she had her 100 s chart, she did a really good job going by 10 s and 1 s…. Interestingly enough she came up with the right answers even though she was off by 1…on a few….. (Molly)

Table 2 Analysis of teaching with multicultural texts

Text/teacher candidate	*One grain of rice* (Stella)	*Rows and piles of coins* (Cydnei)	*Aunt Harriet's underground railroad in the sky* (Molly)	*Inch by inch* (Krystal)
Student demographics	2 fifth-grade female students	1 first-grade female student	1 third-grade female student	1 third-grade male student
Evidence of teaching for academic success	Cursory	Substantial	Substantial	Substantial
	Students A and B made predictions and calculated amount of rice needed to feed a person for a day using cooking directions for per person rations	Piles of coins and problems were used to develop counting and problem-solving skills by using all four operations	A game was used to help the student count on to calculate the number of slaves Harriet helped to free	The student used predictions and informal tools to learn about measuring
	The girls consistently score high in math. I thought it was interesting that both girls worked the problem in different ways	*After reading the book, it was clear that there would be a plethora of mathematical concepts to teach; some of these include grouping, sets, multiplication, addition, subtraction, division, and money*	*When choosing a student for this math bag, I looked for someone who has struggled with double-digit addition in the past. I chose [Student M] because she…tends to finish last, and she usually has a lot of questions…*	*First, I did some research. I wanted to delve into how students begin to think about the idea of measurement and I can across the idea of measuring with non-standard units*
		Previous assessment determined that this student had a solid understanding of number, is fluent in base-ten concepts, and uses a variety of mental strategies to compute addition with fluency up to three-digit numbers	*I asked her (Student M) to use strategies she'd used in the past to figure out the answers. Once she had her 100 s chart, she did a really good job going by 10 and 1 s…. Interestingly enough she came up with the right answers even though she was of by 1…on a few…..*	*The objects student originally chose to measure showed me he initially wasn't linking object size with [using] smaller units. It took the physical process of measuring for student to…arrive at new understanding*

Table 2 continued

Text/teacher candidate	*One grain of rice* (Stella)	*Rows and piles of coins* (Cydnei)	*Aunt Harriet's underground railroad in the sky* (Molly)	*Inch by inch* (Krystal)
Evidence of teaching for cultural competence	Substantial	Substantial	Superficial	No evidence
	Student A commented she was going to ask her parents for a penny on the first day and double it every day for a month. I thought this was a great connection between the book and their own personal lives	*Student C observed how Saruni counted his money and stated he "probably doesn't have a calculator or a computer with Internet because it doesn't look like they have electricity"*	*I asked her: "What do you already know about the underground Railroad?" She replied.."I know it's some sort of bus thing, like a subway, and it goes underground and people ride on it"*	
Evidence of developing critical consciousness	Substantial	Substantial	Substantial	Cursory
	Examining rice distribution worldwide on freerice.com; played a game to fight hunger in UN World Food Program Calculated how much rice it would take to feed 1 person a meal and for a day	*The equity of this math bag focuses on acknowledging the differences in culture of money and economics, as well as the similarities in the necessity of saving for what we really want (need). The student decided she would buy a vacuum cleaner with her savings to help the family*	*After reading the story…she (Student M) told me…"I bet it would be really scary;" and "I'd be sad if I lost my brother." One of my favorite parts of this lesson was watching her (student M) draw the picture that represented what this story meant to her. She drew a picture of her and her brother: "This is me and my brother; he just found me cause I was lost."*	*I thought this book worked perfectly…. Not only could my student see that things were being measured…but it [book] also introduced [student] to the…hero, an inchworm. I wanted to help this student connect to the book in a larger social justice context. We brainstormed ways the inchworm was a risk-taker and how helped the different birds in his community*

> The objects the student originally chose to measure showed me he initially wasn't linking object size with [using] smaller units. It took the physical process of measuring for student to…arrive at new understanding. (Krystal)

Thus, Cydnei's, Molly's, and Krystal's lesson plans and work with students were rated substantial in terms of promoting academic success. Not only did these TCs understand the importance of teaching age-appropriate concepts that would lead to deeper mathematical knowledge, they assessed student learning as well. While Stella used a book that was culturally contextual and mathematically robust, there was no evidence that she went beyond simply doing the rice activity. It appears that she passively observed instead of encouraging deeper understanding among the two girls with whom she worked. Thus, her rating on this category was cursory. The absence of details regarding the learning goals and mathematical tasks students performed after reading a book about doubling a grain of rice for 30 days revealed she did not attempt to move fifth-grade students beyond making predictions to generalizing and expressing the power of two to the *nth* term (Beigie 2011). There was also no evidence of assessment.

In terms of developing cultural competence, Stella's, Cydnei's, and Molly's students were able to relate the text to their personal lives in terms of asking parents for a penny a day to watch it double (Stella's student); understanding the privilege of having technology (Cydnei's student); and linking the Underground Railroad to a bus or subway, although this was a misconception that was not corrected (Molly's student). Thus, Stella's and Cydnei's lessons and work in this category were rated substantial. Molly's work was rated superficial in this category because she did not help the student understand the true meaning of the Underground Railroad as an endeavor that involved transporting slaves from Southern plantations to free states in the North along a clandestine route by foot. Finally, no evidence of cultural competence was found in Krystal's logs or reflection paper.

When we examined the TCs' ability to make links to critical consciousness (i.e., social justice), the data showed all four TCs were able to connect the text to larger issues of social justice. Stella, Cydnei, and Molly made references that were rated as substantial. Stella used the Internet to provide students with a context that helped develop their awareness of world hunger. Cydnei helped her student to recognize privilege and how families in some places in the world have to struggle to purchase items needed for survival rather than pleasure. Molly's student was able to understand how some families were separated during the antebellum period. This student personalized the situation by imagining what it would be like for her brother to be lost: "*One of my favorite parts of this lesson was watching her (student M) draw the picture that represented what this story meant to her. She drew a picture of her and her brother: "This is me and my brother; he just found me 'cause I was lost."* However, Krystal's connection to social justice was cursory: "*I wanted to help this student connect to the book in a larger social justice context. We brainstormed ways the inchworm was a risk-taker and how (he) helped the different birds in his community."* Examples of the type of risk-taking behavior would have increased Krystal's rating in this category.

In summary, the evidence shows that Cydnei was able to use multicultural texts to teach mathematics for cultural relevance in substantive ways. Stella, Molly, and Krystal demonstrated that they could incorporate two of the three tenets of CRP, which was also a positive outcome. The reflections of these TCs on the math bag activity support these results.

Teacher Candidates' Reflections on the Math Bag Activity

While the teacher–researcher did not prompt the TCs to specifically address the math bag in their reflections, three of the four focal TCs did so. These excerpts were analyzed to triangulate the data with the lessons plans and ratings the TCs received on the math bags to better understand how they implemented CRP and math concepts. While Molly wrote a reflection, none of her comments focused exclusively on the math bag assignment. The excerpts of the remaining TCs in the sample cohort are presented and analyzed below:

> Overall, I think this activity was fun and challenging for the girls to participate in. It stretched them to evaluate their predictions in comparison to actual results. The only difficulty I had with implementing the math bag was that it took away from their whole-class learning and had nothing to do with the current concepts they were learning. I do see how it can be used as a whole-group or math center activity. It (math bag) certainly challenged me to think about math in a completely different way. (Stella)

Stella saw the math bag as fun but disconnected from the mathematics instruction her cooperating teacher was implementing in the classroom. The purpose of the task was to field-test implementation of CRP while supplementing the mathematics curriculum that was being taught. Knowing how to use bases and exponents and how to find the *nth* term are related to NCTM content standards of number (e.g., operations) and algebra. Although the class may not have been studying that specific concept, in terms of problem solving, the text exposed students to a useful strategy. Furthermore, the protagonist in the story was a female who outwitted a raja. Using this text with fifth-grade girls could help to build positive mathematics identity.

On the contrary, a deeper understanding of the math bag emerged from Cyndei who explained:

> The equity of this math bag focuses on acknowledging the differences in culture of money and economics, as well as the similarities in the necessity of saving for what we really want (need). This math bag makes use of the picture book, *My Rows and Piles of Coins*. in a way that helps to "shape our political, cultural, and moral identities, and inspire us to work toward making our democracy come to life" (Wolk and Labbo 2004, p. 27). (Cydnei)

Likewise, Krystal was very receptive to the math bag:

> The math bag activity was an eye-opener for me. I had never thought to introduce or investigate mathematical concepts using children's literature. But why not? Literature is a concrete way to make connections across other

> content areas and bring in cultural responsibility and social justice. I'm looking forward to exploring this concept more in my own classroom. (Krystal)

Krystal's reflection illustrated the importance of integrating reading and mathematics, which is supported by the literature (Frantz and Pope 2005; Mack 2011). She seemed to understand that literature could be used to connect mathematics across the content and to promote culturally relevant teaching. Moreover, she visualized how to use the concept in her own classroom, which implies that the methods course encouraged her to use literature in everyday mathematics classrooms.

The Teacher–Researcher's Reflections

Examination of the teacher–researcher's field-notes revealed some discomfort with how to approach the course and how much time was needed to ensure the TCs learned how to teach important early childhood and elementary mathematics concepts like fractions, decimals, and percent while holding true to her conviction about the importance of teaching mathematics for cultural relevance. Although the institution addressed issues of culture and social justice in the mission statement, the teacher–researcher's course evaluations were mixed when students reflected on social justice aspects of the course. Some of the TCs thought there was too much focus on social justice: "Too much social justice….; I felt like this was a social justice course, not a math course; I felt the instructor was not open to alternative points of view or questions." A couple of TCs, however, felt the social justice focus was appropriate: "[The instructor] had great presentations, skills, and entertaining stories; Good activities and social justice activities." Furthermore, field-notes revealed that critical pedagogy (Giroux 1983) resonated with a few students who emerged as leaders in the class. These TCs' microteaching episodes reflected elements of CRP. Moreover, their leadership during the presentation of articles revealed they were open to new ideas about teaching mathematics.

Analysis of the course evaluations revealed 13 TCs wrote constructive comments: 12 comments were positive and 8 were negative (see Table 3).

The positive comments reveal that seven TCs believed the lessons, unit or activities were effective; six TCs thought the articles and readings were effective; and two TCs mentioned the math bags as a positive aspect of the course. Specific comments relative to the most effective aspects of the course were: "Learning how to incorporate literature with math; Linking social justice to math lessons." Analysis of the ineffective aspects of the course reveal that one TC thought the math bag was out of context; although one wrote there were not enough examples of social justice activities, and one disliked the thematic unit. Despite spending 5 weeks on content, two TCs remarked that they did not learn how to teach mathematics in the course: "Not learning any particular ways to teach concepts and only 'learning' the concepts for ourselves; We learned very little about math methods or methods to teach math." On the contrary, one TC thought there should be less of a math focus: "Too much math; I already know math." These comments reveal TCs' beliefs about

Table 3 Course evaluation comments

TC ID#	The most effective aspects of this course were	The least effective aspects of this course were
1	Learning how to incorporate literature with math	Not learning any particular ways to teach concepts—only "learning" concepts for ourselves. I felt like this was a social justice course, not a math course; I felt the instructor was not open to alternative points of view or questions
2	Creation of lessons and the ability to present to the class	
3	[The instructor] had great presentation skills and entertaining stories. The readings were good, too	
4	Good activities and social justice activities	Not very many primary social justice activity examples. More of these
5	The article presentations	The thematic unit
6	The articles and demonstrations	
7	Group activities and discussions	Lesson about the stock market
8		We learned very little about math methods—or methods to teach math.
9	Linking social justice to math lessons	Too much social justice….
		Too much math; I already know math.
10	The projects, math bag, and thematic unit	The length of the class
11	Articles and ideas for lessons	
12	Math bags, thematic unit	
13	Articles and class discussions	Out of context "math bags"

the nature of mathematics. For some, mathematics is computation and non-contextualized problem solving. These TCs did not recognize critical pedagogy as a method of teaching mathematics. However, other TCs had a broader understanding of teaching mathematics that included multiculturalism, cultural relevance, and social justice. Analyses of the course evaluations support prior findings that the results of the study were mixed.

Upon reflection, the teacher–researcher was pleased that most TCs were receptive to learning how to teach mathematics for cultural relevance. However, she also realized that she needed to continue to remind TCs about the importance of infusing culture in mathematics classrooms in order to help them understand it as an authentic method for teaching mathematics content. She also came to the realization that she was ultimately responsible for approving the multicultural books the TCs chose to include in the math bags. She did not require a justification to explain why a particular book had been chosen or how the book was related to cultural relevance or mathematics content. Rather, she shared her collection of multicultural mathematics books and discussed how they may be used to teach math concepts. It was important to the teacher–researcher not to dictate what books TCs should chose but to exercise flexibility so that the TCs had some investment in the process.

Furthermore, the TCs may have had a favorite childhood book they wanted to share. Thus, TCs simply reported which books they planned to use. However, requiring the TCs to reflect on the compatibility of the book they selected may have reduced the number of culturally influenced and mathematically related texts that were selected.

Discussion

The results of this study reveal three findings. First, 89 % of the TCs in the teacher–researcher's elementary mathematics methods course selected mathematically peripheral (33 %) or mathematically robust (56 %) texts (Koellner et al. 2009). However, only 28 % of the TCs chose multicultural texts that were culturally contextual or culturally amenable (Chappell and Thompson 2000). The results of this study reveal choosing a text that was culturally contextual and mathematically robust was challenging for these teacher candidates. Multicultural texts that are culturally contextual and mathematically robust are in short supply and may not be readily available in school or public libraries. Recall two TCs purchased the same book. On the contrary, culturally influenced texts are more readily available. Prior analyses of genre suggest that children's literature consists primarily of stories about animals and fictional characters rather than biographies of real people (Pentimonti et al. 2011). Krystal's selection of *Inch by Inch* (Lionni 1988) is an example of this. The cultural connection she was able to make was limited by the text. Given that her text was culturally influenced rather than culturally contextual, the text presented additional limitations in terms of providing mathematical examples that could be used to develop cultural competence.

The second finding reveals four focal TCs were able to integrate multicultural texts with mathematics tasks and use them to facilitate learning in early childhood and elementary classrooms with pairs or individual students. One TC was able to demonstrate all three tenets of culturally relevant teaching in a substantive way (Ladson-Billings 1995). Recall that Cydnei set herself apart by not only choosing a book that challenged her student and made strong connections to culture and social justice, but she incorporated a quote in her reflection paper that revealed her values and beliefs. Cydnei was a non-traditional student, and perhaps broader life experiences were a factor. On the contrary, Stella's lesson made weak connections to mathematics even though her text was mathematically robust. Stella may have glossed over opportunities to use the mathematics in the text to engage students in more rigorous mathematics concepts. Moreover, her reflection reveals a negative attitude about the math bag itself. Her statement about lack of alignment with the mathematics curriculum at the school where she implemented the bag may explain her lack of reference and reflection on the mathematics learning and assessment of her students. School context is important, and the culture of the school will influence novice teachers' practice.

The third finding reveals the complex environment of teaching for cultural relevance in white institutional spaces for faculty of color (Han 2013; Leonard and Dantley 2005; Matias 2012). White privilege operates to challenge the learning context, which may result in teacher candidates receiving mixed messages about

course goals and objectives. The teacher–researcher in this study acquiesced when TCs informed her of their book choices even though the books may have been weak in terms of culture or mathematics content. The teacher–researcher had worked at the institution where this study took place for less than 2 years. Moreover, it was her second semester of teaching at that university, and as one of three mathematics educators, she wanted to build a reputation as an excellent teacher and scholar who was fair and flexible as she had done at her previous institution. Clearly, one goal of the course was to "ensure the valuing and maintenance of our multiethnic and multilingual society" (Paris 2012, p. 93). The use of multicultural literature was a salient feature in this study, and three TCs demonstrated they could augment children's mathematics knowledge with multicultural texts (Koellner et al. 2009; Mack 2011). Yet, navigating the space where teacher educators' beliefs about inclusion of culture in high-status courses like mathematics requires shifting TCs' beliefs about the nature of mathematics. It is critically important to help TCs to realize that mathematics education is not devoid of culture but influenced by it historically and methodically.

Implications

Teacher educators who champion multiculturalism and believe it is important to engage children in culturally relevant practices should be cognizant of several factors. First, teacher educators must understand the institutional space in which they work. Second, they must be reflective about their decision-making and classroom practices while being open to diverse perspectives. Decision-making related to how and what to teach in math classrooms requires mathematics educators reflect upon their assumptions about themselves and who they teach. Third, teacher educators must help teacher candidates understand how their backgrounds and culture influence their behaviors and teaching practices (Dutro et al. 2008; Price and Valli 1998). Fourth, they must help teacher candidates to broaden their view of the nature of mathematics, which is more than rules and algorithms. Changing teacher candidates' beliefs about the nature of mathematics takes longer than 8 weeks. Yet, teacher beliefs are malleable (Newton et al. 2012). Learning to teach from a culturally relevant perspective takes time and involves learning practices that will motivate children by allowing them to see themselves in the curriculum (Sipe and Daley 2005). Finally, teacher educators must understand and assess the risks associated with teaching from a critical or multicultural perspective. At times, course evaluations may be lower than average, which may impact merit decisions. In such cases, it is necessary to have open and honest conversations with department chairs and deans to gain their support.

Conclusions

Linking cultural relevance to mathematics instruction was not as simple as the teacher–researcher in this study believed. Personal identity and perceived risks and

consequences of classroom implementation had an influence on TCs' pedagogical decisions (Dutro et al. 2008; Nasir 2005). While some TCs in this study may have passively resisted selecting multicultural texts to avoid teaching mathematics for cultural relevance, other factors such as indifference, low self-efficacy in mathematics, and school culture may have influenced text selection and ensuing lesson plans. The TCs had the choice of selecting a multicultural text to teach mathematics for cultural relevance. However, the specific contexts in which they worked, the beliefs and attitudes of cooperating teachers, and parental concerns may have influenced their choices. Additional studies that incorporate follow-up interviews, justification of multicultural text selection, and classroom observations to examine how TCs use CRP in mathematics classrooms are warranted. Given limited access to schools and IRB constraints regarding human subjects, collecting these data during a short 8-week course was not feasible.

The teacher–researcher contended that culturally relevant pedagogy is necessary to work with children in urban classrooms. Yet, the results of this study reveal that engaging in culturally relevant pedagogy can be complicated. Race and gender operate in white institutional spaces to influence decisions among teacher educators and teacher candidates. While knowledge is not neutral and teaching is political (Wager and Stinson 2012), decisions made by teacher-educators have some influence on TCs' decisions to engage or disengage in culturally relevant pedagogy. The decision to focus on cultural relevance was a conscious choice by the teacher–researcher that led some TCs to question the goals and objectives of the course. The ability to read and write the world with mathematics (Gutstein 2006) requires the ability to read and write the cultural *norms* of institutional spaces where teacher educators work and make curricular decisions.

Use of culturally relevant pedagogy in mathematics classrooms in the U.S. is sparse and under theorized in mathematics education courses. While there is a learning curve associated with CRP, appropriate examples and greater effort are required of teacher educators to make clear connections to mathematics content. Moving CRP from the fringes and toward dominant mathematics discourse requires taking some risks. However, as T.S. Eliot once said, "Only those who will risk going too far can possibly find out how far it is possible to go."

Appendix

See Table 4.

Table 4 Rubric to measure the use of culturally relevant tenets

CRP level	Definitions	Examples	Connections to theory
Substantive (3)	Inclusion of cultural issue that is current and highly relevant to student, family or community to anchor the lesson	e.g., using musical genres like Hip-hop to help students learn data analysis and statistics	Uses all three tenets of CRP (academic success, cultural competence, and critical consciousness;
Cursory (2)	Inclusion cultural context from the past (not relevant to now) or general to all populations to engage student interest in the lesson	e.g., using slavery as an example or context without reference to how it impacts life today	May use two or more of CRP tenets
Superficial (1)	Use of an historical social event to raise student interest in the lesson	e.g., mentioning Civil Rights movement or Women's Suffrage or holidays like Martin Luther King in specific math problem	May use only one or two tenets of CRP
No evidence (0)	No attempt is made to include elements of culture in the lesson	Focuses only on the math in order to teach minimum standards of proficiency	No links are made to any cultural issue

Adapted from Lemons-Smith (2013)

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