PROSPECTIVE TEACHERS' CONCEPTIONS OF AND PERFORMACE TEACHING MATHEMATICS TO SOCIO-CULTURALLY DIVERSE STUDENTS

by

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ABSTRACT

The purpose of this study was to determine (1) the progress prospective teachers' can make in their conceptions of teaching mathematics to socio-culturally diverse students and students in urban, high-needs schools; (2) the progress prospective teachers can make in their performance revising a high-level mathematics task to be culturally relevant for one socio-culturally different middle school student; and (3) the relationship between their conceptions and their performance. Participants included four prospective teachers enrolled in a middle school mathematics methods course. Data sources to measure conceptions included pre-post surveys and pre-post interviews. Data sources to measure progress towards revising a high-level mathematics task to be culturally relevant included a variety of course projects that required the participants to shadow a chosen student, conduct a problem-solving interview with them, and then revise a task to be culturally relevant for that student. Data were analyzed qualitatively using analytical frameworks developed by the researcher based on relevant research literature.

The results of this study indicate that while the prospective teachers made some progress in their conceptions regarding good mathematics teaching practices and the importance of getting to know their students, by the end of the semester they also held on to their unproductive conceptions regarding low income students and students from urban, high-needs schools. In addition, all of the prospective teachers were mostly successful in taking what they learned about a particular student and using it to

revise a high-level mathematics task to be relevant for that student. Finally, the participants' productive conceptions may be related to how they described they would use good teaching practices to implement their revised tasks and how successful they were getting to know the students that they shadowed, despite only being tangentially related to the success they had revising tasks to be culturally relevant.

The results of this study have implications for mathematics teacher educators in that it is important for them to provide targeted activities to address prospective teachers' productive and unproductive conceptions. Also, the results suggest that teacher educators should support prospective teachers to develop culturally relevant teaching practices throughout their teacher education programs in order to better prepare them to better teach students who are socio-culturally different from them.

Chapter 1

INTRODUCTION

It is a known fact that the student population in the United States is becoming more and more racially and culturally diverse. Specifically, from 2001 to 2011, the proportion of public school enrollment composed of racial and ethnic minority students went from 40 percent to 48 percent and is projected to increase to 55 percent by 2023 (NCES, 2014). Unfortunately, racial and ethnic minority students, particularly those from low income backgrounds, may not be being provided access to mathematics teaching that provides them with the best opportunities to learn mathematics for conceptual understanding (Gutstein, 2003, 2006; Ladson-Billings, 1997; Strutchens & Silver, 2000; Tate, 1994). Research has also shown that prospective teachers are not adequately prepared to teach racial and ethnic minority students (Ladson-Billings, 2000). The knowledge, culture, and experiences of prospective teachers may be significantly different from racial and ethnic minority students in their future classrooms (Dee & Henkin, 2002), for example. These differences can be problematic for prospective teachers when they enter the classroom given that knowledge of students is an important part of the knowledge base for teaching (Shulman, 1987). In particular, getting to know students personally (e.g., out-of-school experiences) and mathematically (e.g., mathematical thinking) and using that information in instruction can have a positive impact on students' achievement and on their psychological well-being (Philipp & Thanheiser, 2010).

With the increasing diversity of students enrolled in school and the persistent disparity in opportunities to learn mathematics for conceptual understanding, it is important to prepare prospective teachers to teach racial and ethnic minority students, particularly those in urban, high-needs schools. This is because these schools are typically "heavily populated with culturally and racially diverse learners and [have] a heavy concentration of English language learners, a large number of poorer students – particularly students of color, high attrition of teachers, heavy institutional and systematic barriers, and meager resources" (Milner, 2006, p. 346).

Preparing prospective teachers to teach mathematics to students in urban, high-needs schools includes helping them develop good teaching practices for conceptual understanding of mathematical ideas. Hiebert and Grouws (2007) conducted a review of literature and found strong evidence of two features of good mathematics teaching. The first is that teachers and students should attend specifically to concepts. This means that teachers and students should discuss "connections among mathematical facts, procedures, and ideas" (Hiebert & Grouws, 2007, p. 383). The second feature of good mathematics teaching is that students should struggle with important mathematical ideas. This means that students should spend time and effort in order to make sense of mathematics and to figure out something that is not immediately obvious. There is no "best" method of instruction for conceptual understanding (Hiebert & Grouws, 2007), but research has identified some teaching practices that support the learning of mathematical concepts through productive struggle. These practices include facilitating cooperative groups (Cohen, Lotan, Scarloss, & Arellano, 1999; Horn, 2010), using high-level mathematics tasks (Henningsen & Stein, 1997; Lotan, 2003; Silver & Stein, 1996), facilitating discourse in the classroom (Cirillo, 2013), and confronting status issues (Cohen & Lotan, 1995; Horn, 2010). Importantly, these good teaching practices have been shown to positively impact the academic achievement of racial and ethnic minority students in urban, high-needs schools (Boaler & Staples, 2008; Kitchen, DePree, Celedon-Pattichis, & Brinkerhoff, 2007; Silver & Stein, 1996).

Despite the examples of how good mathematics teaching practices for conceptual understanding can be effective, there is evidence that the differences in opportunities to learn between African American and Hispanic students and their White and Asian American peers comes from the fact that racial and ethnic minority students in urban, high-needs schools do not have access to good mathematics teaching (Ladson-Billings, 1997; Strutchens & Silver, 2000). In addition, because the culture of schools typically reflects the culture of the normalized White, middle-class culture (Joseph, 1987; Romberg, 1992), racial and ethnic minority students often have a "cultural mismatch" that they may experience in school (e.g., Bay-Williams & Herrera, 2007). This "cultural mismatch" between students' culture and school can limit their academic achievement and opportunities to learn in a number of ways (Wiest, 2001). For example, if students' communication and linguistic patterns differ from that of the dominant school culture, then the students may not benefit from instruction in the way that it is intended (Anderson, 2007; Au & Jordan, 1981; Bay-Williams & Herrera, 2007; Murrell, 1994).

Particularly salient for this study is research which demonstrates that a cultural mismatch between home and school can happen even when mathematics teachers implement high-level mathematics tasks set in real-world contexts (Boaler, 1993; Gutstein, 2003, 2006; Lubienski, 2000). There are two arguments given for using contexts in mathematics tasks: one concerns the motivation and engagement of students and the other concerns the transfer of learning through demonstrating the link between school mathematics and real-world problems (Boaler, 1993). One issue with using real-world contexts, however, is that students may not relate to the contexts and so may not be motivated or engaged by such contexts (Gutstein, 2003, 2006). Another issue occurs when mathematics tasks do not realistically create a link between school mathematics and real-world problems. This latter issue often occurs with the problems that are found in many mathematics curriculum materials where "students are required to engage partly as though a task were real whilst simultaneously ignoring factors that would be pertinent in the 'real life version' of the task" (Boaler, 1993, p. 14). This can be challenging for many students as their unfamiliarity with the contexts that mathematics tasks are set in or the different ways in which students experience those contexts outside of school can prevent them from accessing the mathematical concepts the task was designed to elicit because the context doesn't draw on the mathematical knowledge the students have from outside of the classroom (e.g., Tate, 1994). Unfortunately, because these tasks are considered to have "neutral" contexts (despite typically reflecting the experiences of the White middle class), students can be labeled from a deficit perspective that implies that they are prevented from engaging in the task in the way it was intended (Tate, 1994). Viewing students from a deficit perspective means thinking that the students themselves, their home lives, and/or their culture is lacking or insufficient in some way that negatively impacts the students' success at school so that someone else has to step in to "fix" the perceived issues (Gutierrez, 2002; Gutstein, Lipman, Hernandez, & de los Reyes, 1997).

Effective teachers must learn about and develop teaching strategies to effectively teach students who have cultural backgrounds and experiences that differ from the school's culture and expectations so that students' backgrounds and experiences can be used as tools and strengths rather than as deficits for their learning. In the case of mathematics tasks, it is essential for teachers to design tasks that are centered on students' experiential knowledge. Many researchers have made an effort to move away from the deficit perspective to develop and study strategies that will assist teachers in taking the diverse cultures found in their classrooms into account when teaching and in tasks (see, Brown-Jeffy & Cooper, 2011). One area that has developed in the research literature and which is specific to mathematics education is culturally relevant mathematics pedagogy.

Culturally relevant mathematics pedagogy is a pedagogy of good mathematics teaching that takes students' cultures and backgrounds into account during mathematics instruction. Specifically, culturally relevant mathematics pedagogy consists of three components: (1) students must experience academic success in mathematics where instruction is centered on teaching mathematics for conceptual understanding; (2) developing and maintaining students' cultural competence through centering instruction on students' culture and experiences; and (3) developing students' critical consciousness with and about mathematics (Ladson-Billings, 1995a; Rubel & Chu, 2011). This pedagogy has been shown to be effective with racial and ethnic minority students (Ensign, 2003; Enyedy & Mukhopadhyay, 2007; Tate, 1995).

Culturally relevant mathematics teachers hold high expectations for all of their students; get to know their students' interests, home lives, communities, and cultures over time through building relationships with the students, their families, and communities (Ladson-Billings, 1997, 2009); and "empower students to critique society and seek changes based on their reflective analysis" (Tate, 1995, p. 169). Culturally relevant mathematics teachers draw explicitly on students' use of mathematics in their cultures and/or home and community lives in high-level mathematics tasks (Herron & Barta, 2009; Rubel & Chu, 2011) which I call culturally relevant mathematics tasks (as defined at the end of the chapter). It is important to note that while drawing on their students' out-of-school mathematics experiences through culturally relevant mathematics tasks can be an important practice for culturally relevant teachers, it does not encompass their entire practice. By using the term "culturally relevant mathematics task" to label such tasks, I do not intend to imply that this encompasses everything that a culturally relevant teacher is, rather that this is one small part of the practice of culturally relevant teachers.

There is very little published research on culturally relevant mathematics tasks in terms of their existence and creation, but what is known is promising in terms of their effectiveness when used with students (Ensign, 2003; Herron & Barta, 2009; Leonard & Guha, 2002). There is some evidence that the use of culturally relevant mathematics tasks can help improve students' mathematics achievement (Ensign, 2003), can motivate and engage students in terms of maintaining and developing their cultural competence (Leonard & Guha, 2002), and can develop students' critical consciousness (Gutstein, 2003, 2006).

It is challenging for teachers, though, to write their own culturally relevant mathematics tasks (Rubel & Chu, 2011). In the TEACH MATH project, for example, some prospective teachers were successful when asked to write lesson plans that integrated a focus on both students' use of mathematics in their homes or communities and also students' mathematical thinking (Aguirre et al., 2013). However, the relatively few prospective teachers that were able to successfully write lessons suggests the difficulty of this practice. These results suggest that narrowing the focus to mathematics tasks rather than entire lesson plans as well as providing different supports such as revising existing high-level mathematics tasks may be a beneficial step towards learning to write lesson plans. More research is needed to determine how best to support prospective teachers (in a myriad of ways) in learning how to revise existing high-level mathematics tasks to be culturally relevant.

Prospective teachers, like all teachers, bring certain conceptions about students and the teaching and learning of mathematics with them to their teacher education programs and can carry these beliefs throughout their programs and throughout their teaching careers. This may impact their choice to use and potentially implement culturally relevant mathematics tasks. Some conceptions that teachers have about students may stem from stereotypes and deficit views of students (e.g., Terrill & Mark, 2000), some are idealistic (Bell, 2002; Bonilla-Silva, 2002; Martin, 2007; Rousseau & Tate, 2003), and some are productive for prospective teachers to have (Boaler, 2006a; Ladson-Billings, 1997, 2009). In addition, the conceptions that prospective teachers have about students impact the opportunities they provide their students to learn (Milner, 2005). For instance, deficit and stereotypical conceptions about students' mathematics ability could lead to teachers believing that these students can't engage in high-level mathematics tasks.

Research around prospective teachers and culturally relevant mathematics tasks would benefit, then, from a simultaneous examination of prospective teachers' conceptions about mathematics teaching and learning and about racial and ethnic minority students. Conceptions across these two categories include thinking that all students can learn and be successful (e.g., Ladson-Billings, 1997, 2009), that culture plays a role in mathematics teaching and learning (e.g., Ladson-Billings, 1995), and having a growth mind-set about students' intelligence (e.g., Dweck, 2010). It is important for teacher educators to know and understand prospective teachers' conceptions so that they can design their programs to either effectively confront and address beliefs based on stereotypes and idealisms or elicit and build upon productive conceptions. It is particularly important for prospective teachers to develop the conceptions that will support the use of culturally relevant mathematics teaching practices.

Purpose and Research Questions

The purpose of this study was to examine the progress that prospective teachers can make in their conceptions about mathematics teaching and learning and about students who are socio-culturally different from them (along lines of race, gender, socioeconomic status, culture, etc.), their performance, and the relationship between the two. Specifically, this study is guided by the following research questions:

1. What progress do prospective teachers make over a one semester middle school mathematics methods course in

    i. developing productive conceptions of the teaching and learning of mathematics and of socio-culturally diverse students and students in urban, high-needs schools?

    ii. their performance revising a high-level mathematics task to be more culturally relevant for one student who is socio-culturally different from them?

2. How are prospective teachers' conceptions of the teaching and learning of mathematics and of socio-culturally diverse students and students in urban, high-needs schools related to

    i. their performance reporting on what they say that they learned about one student's culture, interests, competencies, home and community lives, and the mathematical practices they participate in related to these categories?

    ii. their performance reporting on how they would use what they learned about their student in their mathematics instruction in general?

    iii. their performance revising a high-level mathematics task to be more culturally relevant for one student who is socio-culturally different from them?

Significance of the Study

Several aspects of this study will contribute to the body of research on mathematics education, prospective teachers' conceptions, and culturally relevant pedagogy, and will inform the work of mathematics teacher educators. The results provide evidence of how a one semester middle school mathematics methods course designed with specific readings, activities, and assignments can impact prospective teachers' conceptions regarding students who are socio-culturally different from them as well as the mathematics teaching and learning related to these students. In addition, the results provide evidence for how a middle school mathematics methods course designed in this way can impact prospective teachers' learning to revise a high-level mathematics task to be more culturally relevant for one student.

Very few studies have examined what culturally relevant mathematics tasks are and even fewer have developed a framework for supporting teachers to learn how to revise high-level mathematics tasks to be more culturally relevant for students. In addition, no published studies have specifically examined how *mathematics* teacher educators can support prospective middle school mathematics teachers' learning to revise high-level mathematics tasks to be more culturally relevant for students. This study examined these issues to define culturally relevant mathematics tasks and developed a framework intended to support prospective teachers in learning to do so.

From a practitioner's standpoint, the results of this study inform the teaching practices of both mathematics teacher educators and K-12 teachers. The theoretical framework and course projects developed can be implemented by mathematics teacher educators in teacher education coursework as a model of a particular culturally relevant teaching practice. In addition, the framework for revising a high-level mathematics task to be more culturally relevant is one that K-12 teachers can use as part of their instructional planning as one way to incorporate students' cultures and home and community lives into instruction in a way that motivates and engages students as well as providing students access to important mathematical ideas and concepts.

Finally, this study provides some evidence of a relationship between teachers' conceptions and their practice in the context of teaching mathematics to students who are socio-culturally different from them and/or in urban, high-needs schools. Specifically, this study provides some evidence of a connection between prospective teachers' conceptions about appropriate teaching practices for all students and their performance getting to know their students, revising a high-level mathematics task to be more culturally relevant, and on how they would implement such tasks in the classroom with students. This study contributes to the field of mathematics education by providing evidence for how mathematics teacher educators can better prepare prospective teachers to use culturally relevant teaching practices as well as identify how prospective teachers' conceptions can support or hinder their use of such practices.

Definitions

As can be seen from the introduction and from the research questions that guide this study, there are several terms that need to be defined or further clarified. First, culture refers to a person's or group's worldviews, values, perspectives, geography, beliefs, rules of interaction, personality and family patterns, and "ways of organizing, interpreting, conceptualizing, and giving meaning to their physical and social worlds" (Ascher, 1994, p. 2). In addition, culture includes a group's artifacts, race, traditions, and ethnicity.

Socio-culturally diverse students refer to students who differ from each other along both social and cultural dimensions. This includes differences along lines of race, gender, socioeconomic status, culture, etc. For this study, the focus was on differences in race, culture, gender, and socioeconomic status in the sense that the participants had to choose a student who was different from them along one or more of these dimensions. In particular, as the participants in this study all self-identified as White from middle-class backgrounds, students who are socio-culturally different from them refer to racial and ethnic minority students and/or students from low income families.

An urban school is a school that is located in a large city that is densely populated. An urban, high-needs school refers to a school that is typically "heavily populated with culturally and racially diverse learners and has a heavy concentration of English language learners, a large number of poorer students – particularly students of color, high attrition of teachers, heavy institutional and systematic barriers, and meager resources" (Milner, 2006, p. 346). It is important to note that an urban, high-needs school may be socio-culturally diverse along lines of race, culture, socio-economic status, etc. but it might not be. For example, an urban, high-needs school might have predominantly low-income African American students, which may be more homogenous rather than not. In the pre- and post-interview scenarios that the participants responded to in this study, schools were described as urban or suburban and then demographic information was provided regarding the students in the school (proportion of students by race, free and reduced-price lunch, gender, etc.). The urban, high-needs schools were described in these scenarios as having socio-culturally diverse students along lines of race, gender, and socioeconomic status (see Appendix E).

In terms of the definitions surrounding mathematics tasks for this study, a high-level mathematics task refers to a "groupworthy" task that requires a high level of cognitive demand, is open-ended, requires multiple solution strategies and representations, requires explanations (Stein, Grover, & Henningsen, 1996; Stein & Lane, 1996), and is presented in a real-world context. Further, groupworthy mathematics tasks require group input and multiple student competencies (Horn, 2010; Lotan, 2003). Culturally relevant mathematics tasks are high-level mathematics tasks that are in a relevant context that is related to students' (or one student's) culture and/or home and community lives. A culturally relevant mathematics task also makes realistic connections to students' mathematical experiences related to their culture and/or home and community lives.

Finally, conceptions is a broader term that means "a general notion or mental structure encompassing beliefs, meanings, concepts, propositions, rules, mental images, and preferences" (Philipp, 2006, p. 259). For this study, the focus was on teachers' conceptions of mathematics teaching and learning and conceptions about students more generally. Conceptions of mathematics teaching and learning encompass what a teacher views as important goals, his or her role in the classroom, the students' role in the classroom, appropriate teaching strategies and activities, and acceptable outcomes of instruction (Thompson, 1992). These conceptions were considered specifically in the context of the mathematics teaching and learning of racial and ethnic minority students in urban, high-needs schools. Therefore, I also specifically included conceptions about students separately because the participants' conceptions about students in general as well as math learners might impact (or be related to) their conceptions of math teaching and learning for these students. I view teachers' conceptions about students (deficit/stereotypical and/or not) to encompass conceptions regarding students' race, culture, community, home lives, gender, and socioeconomic status, their academic (specifically mathematics) ability and achievement, and their behavior in and out of school. In regards to conceptions, I consider both productive and unproductive conceptions. Productive conceptions are conceptions that can be beneficial in influencing teachers' use of culturally relevant mathematics teaching practices that provide students opportunities to learn mathematics for conceptual understanding. Unproductive conceptions are deficit, stereotypical, and other misconceptions that can negatively influence teachers' instructional decisions. Specifically, these conceptions are those that may keep teachers from using good and culturally relevant mathematics teaching practices with all of their students.

Chapter 2

REVIEW OF LITERATURE

In this chapter, I first review research about good mathematics teaching for conceptual understanding. This research suggests that good mathematics teaching for conceptual understanding is beneficial for all students' mathematics learning and achievement, particularly for racial and ethnic minority students. This research supports the argument for the use of these practices with racial and ethnic minority students. However, these practices may not be enough on their own to provide racial and ethnic minority students with the best opportunities to learn as they do not always take into account the thinking, culture, and experiences of racial and ethnic minority students. Hence, I then discuss the need for teacher education programs to provide opportunities for prospective teachers to learn how to teach racial and ethnic minority students and/or students from low income backgrounds specifically. Within this argument, I demonstrate how culturally relevant mathematics pedagogy is a pedagogy of good mathematics teaching that is appropriate and effective for doing so. I also specifically address the research related to culturally relevant mathematics tasks and their use in the classroom as this is the focus of this study. This research raises more questions that should be addressed with more research on how to define culturally relevant mathematics tasks and how to support teachers in writing such tasks.

Finally, a discussion of research regarding teachers' affect and conceptions about the teaching and learning of racial and ethnic minority students is presented to argue for the use of conceptions in this particular study. Relatedly, I discuss the research literature surrounding prospective teachers' conceptions about students and how their conceptions are related to and can influence their performance implementing good and culturally relevant teaching practices.

Good Teaching of Mathematics

An important component of the teaching of mathematics is teacher's use of what can be called "good teaching practices" for developing students' conceptual understanding of mathematics. While in the field of education, there is no set definition of what constitutes good mathematics teaching, researchers have evidence to suggest what good teaching for conceptual understanding of mathematics is and what it looks like. Hiebert and Grouws (2007), for example, conducted a review of literature and found strong evidence of two features of good mathematics teaching for conceptual understanding. The first is that teachers and students should attend specifically to concepts. This means that teachers and students should discuss "connections among mathematical facts, procedures, and ideas" (Hiebert & Grouws, 2007, p. 383). The second feature of good mathematics teaching is that students should struggle with important mathematical ideas. This means that students should spend time and effort in order to make sense of mathematics and to figure out something that is not immediately obvious.

There is no "best" method of instruction for conceptual understanding (Hiebert & Grouws, 2007), but research has identified some teaching practices that support the learning of mathematical concepts through productive struggle. These practices include facilitating cooperative groups (Cohen et al., 1999; Horn, 2010), using high-level mathematics tasks (Henningsen & Stein, 1997; Lotan, 2003; Silver & Stein, 1996), facilitating discourse in the classroom (Cirillo, 2013), and confronting status issues (Cohen & Lotan, 1995; Horn, 2010). These good teaching practices are not exhaustive, but are practices that were emphasized during the middle school mathematics methods course for this study as practices teachers should implement with all students, particularly racial and ethnic minority students. The next sections will briefly discuss what these practices are and then will specifically highlight research documenting their effectiveness with all students, particularly racial and ethnic minority students.

Cooperative Learning

One instructional practice considered effective with respect to developing students' conceptual understanding of mathematics is the use of cooperative groups. Despite having the potential to be a good teaching practice for conceptual understanding of mathematics, many classrooms have not had success in implementing cooperative groups because of the task they select for students to work on and/or the groups do not function well due to some students doing most of the work and some students being excluded or choosing not to participate (Boaler, 2006a; Horn, 2010).

A particular instructional approach called complex instruction focuses on how to successfully incorporate collaborative work among heterogeneous groups of students (Cohen, 1994). Teachers who implement complex instruction emphasize particular features of collaborative groups that allow them to be more successful. First, teachers set classroom norms for how students should participate in groups, including having the right to ask any member of the group for help, give reasons for ideas, and everyone gets a turn (Horn, 2010). The use of small group norms is to ensure both that students can function within a group and that all students participate. More importantly, making sure that small groups function efficiently with all students participating can ensure that all students are deepening their understanding of the content being explored (Cohen, Lotan, Abram, Scarloss, & Schultz, 2002; Horn, 2010).

High-Level Mathematics Tasks

The use of high-level mathematics tasks is a good teaching practice that facilitates students' developing a conceptual understanding of mathematics. As noted previously, a high-level mathematics task refers to a "groupworthy" task that requires a high level of cognitive demand, is open-ended, requires multiple solution strategies and representations, requires explanations (Stein et al., 1996; Stein & Lane, 1996), and which may be presented in a real-world context. Further, such tasks require group input and multiple student competencies (Horn, 2010; Lotan, 2003). These tasks need to be designed so that they require input from multiple students working collaboratively so that students can see all of the potential solution strategies that they would not have seen if working on the task alone (Horn, 2010). This implies that the task should allow for multiple representations and solution strategies so students with different competencies are able to contribute to the group discussion.

An essential component of high-level mathematics tasks is the cognitive demand of the task. The cognitive demand of a task refers to the kind of thinking processes that are required of the students to engage with the task (Stein et al., 1996). Stein and colleagues (Smith & Stein, 1998; Stein et al., 1996; Stein & Lane, 1996) define four different levels of cognitive demand: memorization, procedures without connections, procedures with connections, and doing mathematics. The low level cognitive demands are memorization and procedures with connections. Memorization demands are those that ask students to recall facts, rules, definitions, or formulas and do not require a procedure or algorithm to solve. Procedures without connections demands require the use of algorithms or procedures with no connections to the concepts or meaning underlying the procedures. The high level cognitive demands are procedures with connections and doing mathematics. Procedures with connections demands utilize procedures or algorithms but in such a way as to make connections between the procedure and the concept or meaning underlying the procedure. Finally, doing mathematics requires students to explore mathematical concepts and ideas but without implying that any explicit procedure or algorithm needs to be used to solve it. Therefore, a high cognitive demand task might also inherently have the other features of high-level mathematics tasks such as requiring multiple solution strategies or explanations of student thinking.

The QUASAR project (Silver & Stein, 1996; Stein & Lane, 1996) and Railside High School (Boaler & Staples, 2008; Boaler, 2006b) are examples that illustrate the effectiveness of using high-level mathematics tasks on student learning and achievement. Railside High School is an urban school with "an ethnically, linguistically, and economically diverse student body" (Boaler & Staples, 2008, p. 608). Railside High School placed a strong emphasis on creating groupworthy problems that illustrated important mathematical concepts, allowed for multiple solution paths and representations, and drew on the competencies of students in the groups (Boaler & Staples, 2008). The QUASAR project was a reform project aimed at implementing and studying enhanced mathematics instructional programs for economically disadvantaged students in urban middle schools (Silver & Stein, 1996). Both studies illustrated that students improved their achievement at least partly through the use of high-level mathematics tasks. For example, Stein and Lane (1996) report that the greatest gains students made on an assessment that required high levels of mathematical thinking and reasoning were related to the use of high-level mathematics tasks in the classroom. In particular, the student gains were the greatest when the tasks were set up and implemented so that students were encouraged to explain their thinking, use multiple representations, and come up with multiple solution strategies.

The tasks themselves, while important, cannot be the only consideration when teaching. Specifically, how a high-level mathematics task is implemented is important when implementing good mathematics teaching, particularly complex instruction. When implementing high-level mathematics tasks in collaborative groups, students need to have opportunities to explain their thinking. Thus, student discourse is an important good teaching practice that will be discussed in the next section.

Classroom Discourse

In a research brief for the National Council of Teachers of Mathematics (NCTM), Cirillo (2013) highlights the benefits of discussion in the mathematics classroom. The type of discussion that is referred to is not the traditional sequence of teacher initiation, student response, teacher evaluation (IRE) that occurs in many mathematics classrooms, but discussion that allows students to make sense of the mathematics and develop conceptual understanding.

One benefit of classroom discussions is that they can increase student learning and understanding (Boaler & Staples, 2008; Chapin & O'Connor, 2007; Hiebert & Wearne, 1993). In addition, classroom discussions can support teachers to understand and assess student thinking (Cirillo, 2013), "support[ing] teachers in understanding what students already know and in determining what they still need to learn" (Cirillo, 2013, p. 3). Also, teacher questioning can provide teachers with knowledge of students' mathematical understandings (Herbel-Eisenmann & Breyfogle, 2005; Martino & Maher, 1999). The types of questions referred to here are not those typically found in IRE discussion patterns, but focusing questions that "requires the teacher to listen to students' responses and guide them based on what the students are thinking rather than how the teacher would solve the problem" (Herbel-Eisenmann & Breyfogle, 2005, p. 486). Therefore, this kind of discourse in the classroom is a good practice for teaching conceptual understanding of mathematics that is effective in many different ways with students.

Status Treatments

Complex instruction also emphasizes valuing a variety of student competencies in the classroom and providing opportunities for all students to be successful in mathematics. Teachers using complex instruction focus on remedying status issues in the classroom through the use of status treatments. Status issues refer to which students' contributions are being favored over others during collaborative work and during whole class discussions. All classrooms have status issues. One way to confront status issues and create equal-status interactions is to rework "students' assumptions about whose contributions are worthwhile" (Horn, 2010, p. 24). This can be facilitated by the teacher through multiple ability treatments and assigning competence to low status students (Cohen & Lotan, 1995). In a multiple ability treatment, the teachers and the students discuss the different abilities and competencies required to solve mathematics tasks which "produces a mixed set of expectations for competence for each student rather than uniformly high or low expectations" (Cohen & Lotan, 1995, p. 102). The teacher, as a high status individual, can also assign competence to low status students by positively and consistently evaluating students work to the point that the students start to believe that their ability is consistent with the teacher's evaluation (Cohen & Lotan, 1995).

Collaborative learning structured in this way can be beneficial for students' learning. Research has shown its effectiveness in subjects outside of mathematics, such as social studies (Cohen et al., 2002, 1999) as well as within mathematics (Boaler, 2006a). In mathematics, the case of Railside High School discussed above is an example of a school where mathematics teachers successfully implemented complex instruction (Boaler & Staples, 2008). The case of Railside High School illustrates that complex instruction incorporates the other good teaching practices discussed above (discourse and the use of high-level mathematics tasks) with collaborative learning in order to create a learning environment where students can learn mathematics with conceptual understanding.

Conclusion

These good mathematics teaching practices for conceptual understanding are beneficial for all students and therefore, were strongly emphasized in the middle school mathematics methods course for this study as teaching practices to be implemented with all students. Figure 1 illustrates how these practices are a part of good mathematics teaching. This figure will be referred to in later sections to show how a particular pedagogical stance (culturally relevant mathematics pedagogy) that is a focus for this study and prospective teachers' conceptions are related to good mathematics teaching. In the next section, I examine the particular effectiveness of these good mathematics teaching practices with racial and ethnic minority students as this is a main reason for emphasizing these teaching practices for this study.

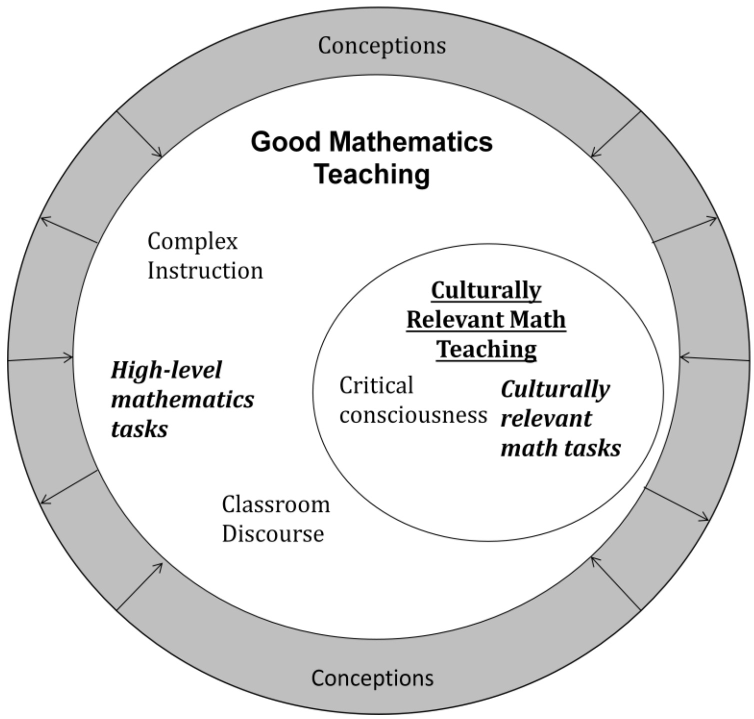


Figure 1 Relationships between Good Teaching, Culturally Relevant Pedagogy, and Prospective Teachers' Conceptions

Effectiveness with Racial and Ethnic Minority Students

It is important to point out that these good teaching practices have been shown to be effective with racial and ethnic minority students in urban, high-needs schools in terms of their academic achievement (Boaler & Staples, 2008; Kitchen et al., 2007; Silver & Stein, 1996). The two cases highlighted above (QUASAR project and Railside High School) are prime examples of how these good teaching practices can be effective with racial and ethnic minority students in urban, high-needs schools in terms of their achievement in mathematics.

In addition to improving student achievement overall at Railside High School, the achievement gaps between students of different ethnic groups were reduced in all cases and eliminated in most cases, the students took more advanced math classes, and students had few behavioral problems (Boaler, 2006a). In interviews, the students also said that "they learned to respect students from other cultures and circumstances" through the use of complex instruction (Boaler & Staples, 2008, p. 610). Similar results were found with QUASAR project students in that the substantial gap in performance scores for African American and White students present at the beginning of the study were narrowed for two of the four cohorts over three years and the performance gap between English language learners and English speaking students were narrowed or eliminated over three years (Silver & Stein, 1996).

Lack of Opportunity for Racial and Ethnic Minority Students

Hiebert and Grouws (2007) accurately noted that "students learn what they have the best opportunity to learn" (p. 383). Despite the above examples, there is research that has shown that in general, racial and ethnic minority students (particularly African American and Hispanic students) are not achieving in mathematics at the levels of their White and Asian American peers (e.g., Lubienski, 2002). While some researchers argue the necessity of examining the achievement gap in order to determine which groups of students or content areas are in need of further study and interventions (e.g., Lubienski, 2008), many other researchers argue that this "gap gazing" can have negative ramifications for the education of racial and ethnic minority students (e.g., Gutierrez, 2008; Ladson-Billings, 2006; Rodriguez, 2001).

These include focusing on the gap without offering solutions or noting what contributed to them, supporting deficit conceptions of these students, and narrowing the definitions of learning and equity to those produced by standardized tests (Gutierrez, 2008). However, for this review the focus will not be on the achievement gap, but on the opportunity gap in which some students (mostly racial and ethnic minority and/or low income students) are not being provided access to mathematics teaching that provides them with the best opportunities to learn mathematics for conceptual understanding.

There is evidence that this disparity comes from the fact that racial and ethnic minority students as well as low income students are not given access to good teaching and so lack opportunities to learn mathematics for conceptual understanding (Ladson-Billings, 1997; Strutchens & Silver, 2000). Instead, these students typically experience what are considered more traditional, direct instruction teaching practices such as teachers giving students information, “drill and kill” problem sets, and the learning of isolated facts. These practices are in contrast to the practices discussed above and are typically not seen as beneficial for any students when used by teachers as their primary instructional strategies (Boaler & Greeno, 2000).

Haberman (1991) argued that it is likely that low income students in urban, high-needs schools are more likely to lack these opportunities as these more traditional practices are often found there. However, Lubienski (2002) pointed out that while it can be argued that socioeconomic status can explain some of the achievement differences between African American and Hispanic students and White and Asian American students, there is evidence that these differences exist regardless of socioeconomic status. For example, disparities in the NAEP assessment data illustrate that low income White students outperformed high income African American students (Lubienski, 2002). Some teaching practices that may have contributed to this are the use of computers for basic skills practice, limited access to calculators, and the use of multiple choice assessments with African American students more often than with White students (Lubienski, 2002; Strutchens & Silver, 2000). As a result of these traditional teaching practices being used with racial and ethnic minority students and/or low income students, these students are not being given the same opportunities to develop a conceptual understanding of mathematics (Flores, 2007).

Providing Opportunities to Learn: A Case for Expanding Good Teaching

Because of this lack of opportunity to learn, it is important to investigate how teachers can provide racial and ethnic minority students from low income backgrounds the best possible opportunities to learn mathematics for conceptual understanding. Providing access to good mathematics teaching practices is a logical first step. However, good teaching practices, as outlined previously, do not always take into account the thinking, culture, and experiences of racial and ethnic minority students, thus likely maintaining gaps in students' opportunities to learn. Specifically focusing on providing racial and ethnic minority students with opportunities to learn is important for teachers to do because "culture refers to the deep structures of knowing, understanding, acting, and being in the world" and cannot be suspended to learn a particular subject matter, including mathematics (Ladson-Billings, 1997, p. 700). However, the school mathematics curriculum, assessment, and pedagogy in the United States largely align with the culture of the White middle class (Joseph, 1987; Romberg, 1992). Therefore, researchers have investigated the "cultural mismatch" between students' home lives and cultures and the school culture and how to develop a closer fit between the two (e.g., Au & Jordan, 1981; Mohatt & Erickson, 1981).

Cultural Mismatch and Impact on Student Achievement

This "cultural mismatch" between students' culture and the school culture can limit students' academic achievement and opportunities to learn in a number of ways (Wiest, 2001). For example, if students' communication and linguistic patterns differ from that of the dominant school culture, then the students may not benefit from instruction in the way that it is intended (Anderson, 2007; Au & Jordan, 1981; Bay-Williams & Herrera, 2007; Murrell, 1994). One group of students that this is especially salient for is English language learners (ELLs) because they may not have the vocabulary to participate in whole class discussions or interpret high-level mathematics tasks (e.g., Bay-Williams & Herrera, 2007).

Communication and language barriers can also occur with any students whose communication patterns at home do not match what is expected of them at school. For example, in Murrell's (1994) study of how African American male middle school students reacted to the discourse patterns used in their classroom, the students did not see this discourse as a way to increase focus on the understanding of mathematics concepts and ideas. They viewed the discourse patterns as "a new regimen to be mastered to meet their teachers' requirements" (Murrell, 1994, p. 563-4) and as a way to mask their lack of understanding by engaging in "superficial aspects of math talk" (Murrell, 1994, p. 563). This mismatch between the students' views and what the teacher intended resulted in the students not benefitting from class discussions. Therefore, the use of good mathematics teaching practices is not necessarily enough to provide all students adequate opportunities to learn.

Cultural Mismatch in Mathematics Tasks

In addition, there is research that suggests that cultural mismatch between home and school can happen with high-level mathematics tasks set in real-world contexts. There are two arguments given for using contexts in mathematics tasks: one concerns the motivation and engagement of students and the other concerns the transfer of learning through demonstrating the link between school mathematics and real-world problems (Boaler, 1993). The first issue with using real-world contexts is that students may not relate to the contexts and so may not be motivated or engaged by such contexts. Gutstein (2003, 2006) conducted a study with his own Mexican/Mexican American middle school students in a low income, working class neighborhood using the Mathematics in Context curriculum that uses real-life settings for all of its problem contexts. Gutstein (2003, 2006) found that his students felt that the mainly fictitious stories were not relevant to their lives. For example, one student said "No, we can't relate to them. We don't have family and friends in Africa, we don't go in hot air balloons, we don't go canoeing, we don't go downtown and count cars, they give cheap stories" (Gutstein, 2006, p. 105).

Another issue is related to the purpose of demonstrating a link between school mathematics and real-world problems (Boaler, 1993). The issue occurs with the types of problems that are found in many mathematics curriculum materials where "students are required to engage partly as though a task were real whilst simultaneously ignoring factors that would be pertinent in the 'real life version' of the task" (Boaler, 1993, p. 14). Therefore, students are expected to learn how to engage with these tasks by focusing on what is presented in the task and not questioning the task's distance from reality (Boaler, 1993). However, not all students are as receptive to learning how to do this which can ultimately make students miss the intended mathematical ideas in the task (Lubienski, 2000; Tate, 1994). The cultural mismatch in mathematics tasks will be discussed later in more detail.

Because of this cultural mismatch, it has become necessary for teachers to learn about and develop teaching strategies to provide opportunities to learn for students who have cultural backgrounds and experiences that differ from the school's culture and expectations. Many researchers and teacher educators have made an effort to develop strategies that will assist teachers in taking the diverse cultures found in their classrooms into account when teaching and in tasks (Brown-Jeffy & Cooper, 2011). One area that has developed in the research literature is culturally relevant pedagogy. This pedagogy is a pedagogy of good teaching, but goes beyond what is traditionally considered good teaching by making connections between students' cultures and the school in order to provide students opportunities to learn (Ladson-Billings, 1995a). Before discussing culturally relevant pedagogy, it is important to first discuss what is meant by student culture in the literature and how it will be defined for this study.

Definition of Culture

A student's culture plays an important role in education because it impacts student cognition and ultimately their mathematics achievement (Ladson-Billings, 1997). Many researchers (e.g., Ascher, 1994; Gay, 2002; Herron & Barta, 2009; Leonard, 2008; Moule, 2012; Wiest, 2001) have defined culture and while they have done so in different ways, there are a lot of similarities among these definitions. First, I will consider some of the ways culture has been defined by other researchers in order to situate the definition I have chosen for this study in the existing literature. Then, I will provide the definition that will be used for this study again to remind the reader as I have already presented it in the introduction.

Many people view culture as the things that are visible or tangible about a person or group such as their race, ethnicity, artifacts, traditions, and food. While these things are part of a person's culture, the invisible parts of a person's culture are important for education (and beyond) because these things "are more important for teachers to know than others because they have direct implications for teaching and learning" (Gay, 2002, p. 107). Many researchers agree that the invisible part of culture refers to a person's values, beliefs, views of the world, and communication patterns (e.g., Ascher, 1994; Gay, 2002; Ladson-Billings, 1997; Leonard, 2008; Moule, 2012). For instance, Gay (2002) wrote that culture encompasses "ethnic groups' cultural values, traditions, communication, learning styles, contributions, and relational patterns" (Gay, 2002, p. 107). Similarly, Ascher (1994) states that in any culture, "the people share a language; a place; traditions; and ways of organizing, interpreting, conceptualizing, and giving meaning to their physical and social worlds" (Ascher, 1994, p. 2). Ladson-Billings (1997) refers to culture similarly, writing that "culture refers to the deep structures of knowing, understanding, acting, and being in the world" (p. 700).

It is important for teachers to learn about and draw upon the invisible parts of students' cultures in their teaching "rather than [having] a restricted view that is solely focused on a group's artifacts or a person's ethnicity" (Herron & Barta, 2009, p. 26-7). This is because a person's culture impacts how they experience the world around them and the same situation may be experienced and interpreted differently depending on the person's culture (Moule, 2012). In addition, culture "informs all human thought and activity and cannot be suspended as human beings interact with particular subject matters or domains of learning" (Ladson-Billings, 1997, p. 700) which includes learning mathematics. Therefore, teachers need to become aware of both students' visible and invisible cultures as they are both part of who a person is.

The definition of culture used for this study considers both visible and invisible culture. For this study, culture refers to a person's or group's world views, values, perspectives, geography, beliefs, rules of interaction, personality and family patterns, and "ways of organizing, interpreting, conceptualizing, and giving meaning to their physical and social worlds" (Ascher, 1994, p. 2). In addition, culture includes a group's artifacts, race, language, traditions, and ethnicity. I now turn to a discussion of culturally relevant pedagogy and how it can be a means to provide all students with opportunities to learn.

Culturally Relevant Pedagogy

Culturally relevant pedagogy is a pedagogy defined and advocated by Ladson-Billings (1995a, 1995b, 2009) that maintains that it is essential for teachers to not only use good teaching practices and incorporate students' cultures into the classroom to promote achievement for all students, but to help students "accept and affirm their cultural identity while developing critical perspectives that challenge inequities that schools (and other institutions) perpetuate" (Ladson-Billings, 1995b, p. 469). Ladson-Billings (2009) and others (Boutte & Hill, 2006; Gutstein et al., 1997; Tate, 1995) have found that culturally relevant pedagogy can be an effective means of teaching racially and culturally diverse students.

Defining Culturally Relevant Pedagogy

Ladson-Billings (1995a) defines culturally relevant pedagogy as:

> a pedagogy of opposition…specifically committed to collective, not merely individual, empowerment. Culturally relevant pedagogy rests on three criteria or propositions: (a) students must experience academic success; (b) students must develop and/or maintain cultural competence; and (c) students must develop a critical consciousness through which they challenge the status quo of the current social order (p. 160).

All three of these components are essential to culturally relevant pedagogy. Ladson-Billings describes the three components as the three legs of a stool: "if you pull one out, then you don't have what I'm calling culturally relevant pedagogy" (Willis, Lewis, & Ladson-Billings, 1998). Thus, culturally relevant pedagogy is based on building upon the thinking, culture, and experiences of students (particularly African American students in the case of Ladson-Billings) to promote academic achievement. Also, culturally relevant teachers hold high expectations for all of their students; get to know their students' interests, home lives, communities, and cultures over time through building relationships with the students, their families, and communities (Ladson-Billings, 1997, 2009); and "empower students to critique society and seek changes based on their reflective analysis" (Tate, 1995, p. 169). In the next sections, I will discuss these three components in more depth to highlight successful cases of culturally relevant teaching.

Academic Success

First, Ladson-Billings (1995b) argues that students must succeed academically. Ladson-Billings (1995b) emphasized that "students must achieve. No theory of pedagogy can escape this reality" (p. 475). Culturally relevant pedagogy, which is an appropriate pedagogy with any group of students, is partially geared towards raising the achievement on standardized test scores for racial and ethnic minority students who traditionally do not perform as well as their White and Asian American peers (e.g., Lubienski, 2002). Academic success also includes developing students' other academic and political skills that they will need to be able to participate in a democratic society. The teachers in Ladson-Billings' (1995a) study of successful teachers of African American students not only improved their students' achievement on standardized tests, but also found that they demonstrated the ability to "read, write, speak, compute, pose and solve problems at sophisticated levels" (p. 475).

Culturally relevant teaching is good teaching in that the instructional practices that are considered good teaching practices for all students are used by teachers identified as culturally relevant by Ladson-Billings (2009). The use of these practices helps to ensure that all students are successful academically. For example, the teachers in Ladson-Billings' (2009) study went beyond simply giving students opportunities to work in groups as happens in many classrooms to using a similar approach to complex instruction as examined in a previous section. Ladson-Billings (2009) describes how culturally relevant teaching promotes collaboration that leads students to "believe they cannot be successful without getting help from others or without being helpful to others" (p. 76). In addition, this kind of cooperative learning can be compatible with the students' home culture. For example, another teacher in Ladson-Billings' (2009) study noted that there was not a lot of competition between her students' and their siblings at home, so in the classroom the students would do a lot of sharing and helping everyone else be successful. Therefore, this practice, while important for all students to be successful, can be especially effective with some students because it may reflect the way many students interact at home and with others that share their culture. The absence of collaborative learning could be more harmful to the success of students belonging to these groups than students who belong to White middle class culture, all-too-often taken as the "norm" for classroom collaboration (or competition).

One of the culturally relevant teachers in Ladson-Billings' (2009) study, Ms. Rossi, also used good mathematics teaching practices as discussed in previous sections to improve her students' academic achievement. Ms. Rossi often asked "How do you know?" to get her students to explain their thinking and students were encouraged to pose as well as solve problems using multiple solution strategies (Ladson-Billings, 1997). In addition, Ms. Rossi used instructional scaffolding to move students from what they knew to what they didn't know. Finally, Ms. Rossi not only had an in-depth knowledge of the mathematics content, but also of her students which helped them to succeed. The importance of getting to know students to use that information in instruction will be discussed in the next section.

Cultural Competence

The second component of culturally relevant pedagogy states that students must maintain their cultural competence (Ladson-Billings, 1995b). The use of students' culture and experiences in instruction can help students develop and maintain an understanding that their culture is an important part of who they are and can be a part of their school experience (e.g., Boutte & Hill, 2006). Part of developing and maintaining cultural competence in students that is important for this study includes teachers helping students be successful academically by using the students' culture "as a vehicle for learning" (Ladson-Billings, 1995b, p. 161). In order to do this, teachers need to make an effort to get to know their students' cultures, interests, and home and community lives. Ms. Rossi (Ladson-Billings, 1997), as described in the previous section, made an effort to gain in-depth knowledge of her students which, along with the other practices she used, helped her students achieve at high levels in mathematics. Making connections to students' cultures in instruction expands upon what is traditionally considered good teaching in that it is a way to provide students with opportunities to learn challenging content (e.g., Rubel & Chu, 2011). For example, one of the culturally relevant teachers in Ladson-Billings' (2009) study allowed her second grade students to bring in appropriate lyrics to rap music (which was part of the African American youth culture and of interest to her students) to help them become more fluent and comfortable with standard forms of English. The class worked line by line through the song and "translated" the lyrics into Standard English. In this way, the students were able to make connections between what they are familiar with and Standard English and ultimately became better at both forms of language.

Despite the success that teachers can have in improving student achievement through drawing on their culture, it is important that this is done from the standpoint that students' cultures are tools and strengths rather than as deficits that need to be overcome. For example, Au and Jordan (1981) were a part of the research and development project in Honolulu called the Kamehameha Early Education Program that worked to find better ways to teach native Hawaiian children to read (Au & Jordan, 1981). The Kamehameha Early Education Program researchers hypothesized that the way the students learned at home or among their peers was different from how they were expected to learn at school which led to the native Hawaiian students' low reading abilities. By incorporating similarities to a major speech event in Hawaiian culture, *talk story* and *storytelling*, into the teachers' reading instruction, the students were able to apply "the cognitive and linguistic abilities which they have been shown to have in other situations" in school (p. 146). By doing this, the teachers were able to help students perform above what was expected on standardized reading tests.

Despite the success of the Kamehameha Early Education Program and others like it (e.g., Mohatt & Erickson, 1981), the language and culture of racial and ethnic minority students was viewed as something to be overcome so that the students could be acculturated into the dominant culture. In other words, the language and culture of the students was seen as a potential deficit. In contrast, supporters of culturally relevant pedagogy as defined by Ladson-Billings (1995a, 1995b, 2009) would argue that students' language and culture should be viewed as a resource and treated as such in the classroom. Therefore, it is important for prospective teachers to learn to incorporate their students' cultures into the curriculum while promoting cultural competence instead of using it as a means to acculturate their students into the normalized White middle-class school culture. One way I propose to do this in mathematics classes (revising a high-level mathematics task to be more culturally relevant) will be discussed later.

Critical Consciousness

Considering again Ladson-Billings' three-legged stool metaphor (Willis et al., 1998), it is not enough for students to simply be successful academically and culturally competent. The third leg of the stool for culturally relevant pedagogy to be complete is developing students' critical consciousness. The primary purpose of culturally relevant pedagogy is to "empower students to critique society" and to seek larger societal change (Tate, 1995, p. 169). Students need to develop a broader sociopolitical consciousness so that they can critique the institutions, social norms, and values that “produce and maintain social inequities” (Ladson-Billings, 1995b, p. 162). Therefore, culturally relevant pedagogy seeks to empower more than just individual students, but whole communities of students so that they can strive to combat social inequities.

For example, in Ladson-Billings’ (2001) study of prospective teachers, the students in one of the prospective teachers’ classes decided to boycott a pizza chain that provided pizza once a month to the district’s elementary schools. The students found that this pizza chain was owned by a company “with ties to a repressive regime in Asia” (Ladson-Billings, 2001, p. 111). The prospective teacher helped her students write letters to the superintendent and school board members to change pizza chains. Thus, the prospective teacher helped her students develop their writing and speaking skills while tackling a social justice issue that was important to them. Allowing students to examine and critique social justice issues can empower students to work for social change in the future.

Summary

Culturally relevant pedagogy is a pedagogy of good teaching that expands upon what is traditionally considered to be good teaching to draw upon student culture in instruction to provide students with opportunities to learn. It also encourages students to be aware and critical of social inequities and analyze them in order to empower students to combat these inequities. The above sections articulated ideas about culturally relevant pedagogy in order to situate this study within the broader ideas of culturally relevant pedagogy before focusing on culturally relevant mathematics pedagogy which is central to this study.

Before I discuss culturally relevant mathematics pedagogy, in the next section, I specifically discuss the difficulties and successes teachers have in learning to implement culturally relevant pedagogy. It is important to note the challenges teacher educators face when helping teachers learn about and implement culturally relevant pedagogy so that other teacher educators can improve upon this instruction for teachers. For this study, these difficulties and successes were used to design and focus this study to maximize the learning of the prospective teachers who participated.

Teachers' Learning to Implement Culturally Relevant Pedagogy

Despite the effectiveness of culturally relevant pedagogy, it can be difficult for pre- and in-service teachers to understand and implement (e.g., Gosselin & Meixner, 2013; Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Ladson-Billings, 2001; Matthews, 2003; Wortham & Contreras, 2002; Young, 2010). An example of this difficulty is a case study of one teacher's implementation of culturally relevant pedagogy conducted by Wortham and Contreras (2002). The teacher was successful in her attempt to bring her Latino/a students' home culture into her classroom in order to meet the cultural competence goal, but fell short in meeting the academic success goal. The community this teacher created in her classroom helped develop and maintain all students' cultural competence in that the students developed "pride in being Latino" (Wortham & Contreras, 2002, p. 142). The teacher also had an impact on some aspects of academic performance in that students skipped school less often, were not as disruptive during class, and attempted assignments they otherwise might not have.

However, in terms of mainstream academic success (e.g., standardized tests), the teacher did not have as much of an impact: the female students, many of whom who were already doing well, continued to do well whereas the male students, most of whom were not doing well, continued to not do well. Wortham and Contreras (2002) speculated that the male students' home values of being working-class men who support their families did not match the expectations of the school to "'better' themselves and move beyond their culture" (p. 142). This study suggests that it is difficult to balance and be successful in implementing the components of culturally relevant pedagogy, even when only focusing on two components.

One difficulty found in the research literature is that it is particularly challenging for teachers to implement the critical consciousness component (Bartell, 2011; Young, 2010). For instance, Young (2010) conducted a study with teachers and administrators at one urban school in which they worked collaboratively to define, implement, and assess culturally relevant pedagogy. The teachers in this study had a particularly difficult time understanding and implementing the critical consciousness component. In fact, the teachers emphasized the academic achievement and cultural competence components to the exclusion of critical consciousness because they struggled with incorporating social justice issues in their lessons, either because they were uncomfortable doing so or they felt that they had too much material to cover to spend time doing so (Young, 2010). Also, Wortham and Contreras (2002) found that the teacher did not address the critical consciousness component despite there being an opportunity to: the teacher met opposition from the rest of the school faculty based on her unconventional teaching practices. This teacher attempted to foster a community of learners by giving her students more freedom in the classroom which appeared to other teachers as being disorganized and loud (Wortham & Contreras, 2002).

Despite the difficulties that teachers have in learning how to teach in a culturally relevant way, there is some research to suggest that prospective teachers can develop some of the beliefs and practices of a culturally relevant teacher during their teacher education programs (e.g., Downey & Cobbs, 2007; Ladson-Billings, 2001). One example is Ladson-Billings' (2001) study of eight prospective teachers in a master's program striving to understand and implement aspects of culturally relevant pedagogy with the students they worked with in their field placements. One way that many of these prospective teachers excelled was in their understanding of their own and others' cultures and maintaining cultural competence. These prospective teachers became more aware of how culture "influences and shapes the way they understand and act in the world" and were thus able to understand the importance of getting to know about their students' backgrounds and to help their students develop cultural competence (Ladson-Billings, 2001, p. 83). This translated into the way they interacted with students. For example, one prospective teacher was struggling with an African American boy who was struggling to read and write. This student was "a self-proclaimed 'tough-guy' and very skilled at avoiding work" (Ladson-Billings, 2001, p. 87). The prospective teacher understood that this student needed to maintain his dignity and his sense of self as well as be successful academically. Therefore, instead of shouting at him or intimidating him, she spoke gently with him but was persistent in her requests for him to complete his work.

These prospective teachers were also able to question the labels that were placed on their students, get to know them as individuals, and look for ways to help them be successful. For example, one prospective teacher had a student who was diagnosed as having severe emotional disabilities and often became frustrated with his school work. The special educator in the classroom often got into confrontation with this student and it often ended badly. The student teacher tried a different approach with the student by talking with him when he became frustrated. When she spoke with him she tried to reinforce that he was capable of doing the work given to him. While she was not always successful, she seemed to continually try to figure out what else she could do that would allow the student to be successful. This aspect of getting to know students as individuals to look for ways to help them be successful was a particularly important practice emphasized with the participants for this study as they were required to do so.

Summary

To review, there is some evidence to suggest that understanding and implementing culturally relevant pedagogy, particularly the critical consciousness component, can be challenging. This suggests that pre- and in-service teachers need continual support to develop the knowledge and skills needed to implement culturally relevant pedagogy in their classrooms (Young, 2010). Considered another way, there is evidence to suggest that prospective teachers can learn about and implement pieces of culturally relevant pedagogy, particularly the academic achievement and cultural competence components. Given the short duration of this study (one semester) and because it was prospective teachers' introduction to culturally relevant pedagogy, the focus was more on the academic achievement and cultural competence components of culturally relevant pedagogy. This was to ensure that prospective teachers were exposed to the ideas of culturally relevant pedagogy and more likely would have the time to develop the conceptions and practices that support culturally relevant pedagogy.

In the next sections, I will focus the examination of the research literature on culturally relevant *mathematics* pedagogy which is central for this study. First, I will examine why culturally relevant pedagogy has been specifically defined in the context of mathematics to justify the choice to focus on this specific content for this study.

Culturally Relevant Mathematics Pedagogy

Several researchers have narrowed the concept of culturally relevant pedagogy to address the cultural influences specifically on mathematics teaching and learning (e.g., Gutstein et al., 1997; Rubel & Chu, 2011; Tate, 1995). As several researchers have pointed out, mathematics is not a culture- or race-neutral subject (e.g., Leonard, Brooks, Barnes-Johnson, & Berry III, 2010). In fact, students' mathematics knowledge is inherently tied to their cultural practices (Nasir, Hand, & Taylor, 2008). In particular, Nasir et al. (2008) outline a number of studies in their review of literature that provide evidence that students perform better on tasks that are more closely linked to their everyday cultural practices. For example, middle and high school basketball players were asked to solve average and percentage problems in the context of basketball and in the format of a typical school worksheet. The basketball players used invented strategies to correctly respond to the basketball problems whereas they tried to use (and misremembered) standard algorithms on the school-based problems (Nasir et al., 2008).

Unfortunately, mathematics pedagogy, curriculum, and assessment "are often closely aligned with an idealized cultural experience of the White middle class" (Ladson-Billings, 1997, p. 700). In particular, mathematical tasks are often placed in a "real-world" context that White, middle-class students are familiar with, but racial and ethnic minority students may not be (McDuffie, Wohlhuter, & Breyfogle, 2011; Tate, 1994). Gutstein's (2003, 2006) example of using the Mathematics in Context curriculum with his Mexican and Mexican American students as discussed in an earlier section illustrates this issue as the students did not find they were able to relate to the contexts in the curriculum.

On the other hand, students may recognize a context but experience that context differently in such a way that leads them to tackle problems in ways that the teacher may not expect (Lubienski, 2000; Tate, 1994). For example, when answering a standardized test question about deciding whether it would be a better deal to purchase a daily or weekly bus pass, the experiences of many of the African American students (working multiple jobs, working on weekends, etc.) differed from what was assumed by the test writers (working one job five days a week) such that the students “incorrectly” chose to purchase a weekly pass despite the fact that their reasoning was mathematically appropriate and logical in the context of their experiences needing a bus pass for more than five days a week (Tate, 1994).

A similar concern is that some students may not have the knowledge deemed solely important for how much consideration they need to give to the “real-world” factors present in mathematics tasks (Boaler, 1993). Unfortunately, this knowledge seems to be inequitably distributed (Boaler, 2002). For instance, in her study of middle school mathematics reform curriculum as discussed in a previous section, Lubienski (2000) found that the lower socioeconomic status students had difficulties ignoring the unnecessary real-world details related to mathematics problems that they needed to in order to solve the problem. In one example that Lubienski (2000) provides, students were asked to find the volume of three containers for popcorn at a movie theater. One of the students had no trouble finding the volume of each of the containers, but then reasoned using “common sense” that because the prices went up by size, the choice should be determined by how much popcorn she wanted. While this is a reasonable answer given the context, using this approach made her miss the intended experience of working with volumes and then comparing unit prices.

Therefore, students whose cultures clash with the "normalized" White middle class culture may not be as successful as their White middle class peers, not because they are not capable or knowledgeable, but because the knowledge they bring has not been recognized. I discussed a couple of examples of this "cultural mismatch" in earlier sections, namely, the study of native Hawaiian children whose home culture was not represented in the school culture prior to the Kamehameha Early Education Program (Au & Jordan, 1981) and Murrell's (1994) study of how the mathematics discourse patterns emphasized by the teacher clashed with the African American male students' thoughts on the purpose of such discourse. As a result, a number of mathematics education researchers have attempted to address the fact that mathematics and culture are inherently linked by employing culturally relevant pedagogy in the context of mathematics teaching.

In the next section, I examine what culturally relevant mathematics pedagogy is as it is presented in the literature in order to situate mathematics specifically within culturally relevant pedagogy. Then I define culturally relevant mathematics pedagogy for this study to be clear about what is meant by culturally relevant mathematics pedagogy in the rest of the dissertation.

Defining Culturally Relevant Mathematics Pedagogy

Mathematics education researchers have used the three components of Ladson-Billings' definition of culturally relevant pedagogy as a basis for their definitions of culturally relevant *mathematics* pedagogy (e.g., Averill et al., 2009; Bonner & Adams, 2011; Gutstein et al., 1997; Rubel & Chu, 2011). However, each has conceptualized it slightly differently. I draw upon the following definitions of culturally relevant mathematics pedagogy for the definition for this study. In their study of five teachers in a public school in a low-income Mexican American community, Gutstein et al. (1997) proposed a three part model of culturally relevant mathematics pedagogy that aligns with the three criteria Ladson-Billings' proposed but makes specific connections to teaching mathematics for conceptual understanding. Gutstein et al.'s (1997) revised definition of culturally relevant pedagogy took into consideration both the NCTM *Standards* and culturally relevant pedagogy. From the NCTM *Standards,* Gutstein and colleagues draw on the idea of critical mathematical thinking, which includes students creating mathematical arguments, applying reasoning processes, and making and exploring conjectures. They claimed that the potential relationship between the NCTM *Standards* and culturally relevant pedagogy "involves thinking critically about knowledge and the world and building on children's informal knowledge and experience" (Gutstein et al., 1997, p. 718). In other words, their definition highlights the connection between mathematics and culture (Nasir et al., 2008) because they are building on students' knowledge and experiences to help them think critically about mathematics and knowledge more generally. This conceptualization of culturally relevant mathematics pedagogy includes the following three components: (1) developing critical mathematics thinking and critical thinking about knowledge in general; (2) building on students' informal mathematical knowledge and on students' cultural and experiential knowledge; and (3) orientations to students' culture and experience.

The first component means that teachers not only have to promote critical mathematical thinking (e.g., making conjectures, developing arguments, investigating ideas, etc.), but they also must help students think critically about knowledge and society in general through teaching mathematics. This component aligns with the academic achievement component of culturally relevant pedagogy because it emphasizes teaching mathematics for understanding and ensuring that all students experience success while learning to think critically about mathematics. This component also aligns with the critical consciousness component of culturally relevant pedagogy because it implies that students should develop the skills to be critical of knowledge more broadly and to constantly question the standard curriculum to explore multiple perspectives. One teacher in Gutstein et al.'s (1997) study balanced both of these ideas by helping her students not only explain, justify, and communicate their answers, but by helping them to become leaders and have the ability to question the status quo and stand up for what they believe in. Her students constantly asked why they had to do things a certain way and they challenged each other to explain more or give alternate answers.

The second component, building on students' informal mathematical knowledge and on students' cultural and experiential knowledge, aligns with the cultural competence component of culturally relevant pedagogy because Gutstein et al. (1997) urged teachers to be aware of their students' mathematical knowledge as well as their cultural backgrounds and experiences and to use this knowledge in their instruction while at the same time validating their students' culture and knowledge. For example, another teacher in Gutstein et al.'s (1997) study used his students' informal knowledge a number of times to help students understand the concepts of scale and measurement. First, the teacher facilitated a discussion about scale in their native language (Spanish). Then the teacher helped the students understand the inexactness of measurement by giving an example about getting measured with and without shoes at the doctor's office. This teacher validated his students' culture and language by emphasizing that they are advantages, not hindrances on their learning, which is an important part of culturally relevant pedagogy.

Gutstein et al. (1997) proposed the third component (orientations to students' culture and experience) to call attention to two orientations teachers can have towards their students: a deficit orientation and an empowerment orientation. The authors point out that a teacher can know about and use students' cultures in their instruction and still have a deficit view of their students. For instance, teachers can fail to challenge students academically and/or they can assume that the students' families do not support them enough and so someone else has to step in. Therefore, it is important for teachers to have an empowerment orientation which "helps create the conditions for students to develop personal and social agency" (p. 727). This is a particularly important idea for this study because, as discussed in the sections about teachers' conceptions, holding deficit views of students can lead to lowering expectations and direct instruction practices. Thus, it is important to help prospective teachers focus on student strengths, rather than deficits.

This third component of Gutstein et al.'s (1997) model aligns with all three of Ladson-Billings' (2009) components of culturally relevant pedagogy because teachers who empower their students help them to succeed academically, develop cultural competence, and develop the tools to question and critique larger social inequities. Overall, Gutstein et al.'s (1997) model of culturally relevant mathematics pedagogy incorporates Ladson-Billings' (2009) model of culturally relevant pedagogy, but also incorporates ideas about good mathematics teaching.

Another definition of culturally relevant mathematics pedagogy was developed by Rubel and Chu (2011). This definition serves as the basis for the definition for this dissertation study. Rubel and Chu (2011) present a three component model of culturally relevant mathematics pedagogy that is very similar to Ladson-Billings' (2009) conception of culturally relevant pedagogy. However, they specifically expanded upon Ladson-Billings' conception in the context of mathematics in order to support their effort to increase students' opportunities to learn mathematics by expanding upon what it means to teach mathematics for understanding (Rubel & Chu, 2011). Their components are: (1) teaching mathematics for understanding; (2) "centering instruction on students' experiences;" and (3) "developing students' critical consciousness about and with mathematics" (p. 41). With the first component, Rubel and Chu (2011) advocate that teaching mathematics for understanding is necessary for improving students' mathematics achievement. This component aligns with the academic achievement component of culturally relevant pedagogy in that they are advocating for the use of practices aligned with teaching mathematics for understanding that, combined with the other two components, will provide students with more opportunities to learn and achieve in mathematics.

The second component suggests that teachers should utilize students' culture to develop meaningful and relevant contexts in mathematics instruction. It should be noted that this practice differs from simply incorporating "real-world" contexts into mathematics problems which may not be appropriate for all students (e.g., Lubienski, 2000). The context, if not chosen carefully, can be artificial and not connected to nor used to illustrate a mathematical concept (Boaler, 2002; Rubel & Chu, 2011). For example, one of the teachers in Rubel and Chu's (2011) study listed a set of jersey numbers for the members of a basketball team and a second set of jersey numbers of players who could not play in the game to model a set and its complement. However, the basketball context "illuminates neither the concept of set nor its notation" (Rubel & Chu, 2011, p. 49). Thus, while the context of basketball could potentially motivate and engage students, it was not utilized in a way to help students understand the concept of set notation. This issue will be discussed in more depth in the section on culturally relevant mathematics tasks.

Finally, Rubel and Chu (2011) see developing critical consciousness in two ways: *with* and *about* mathematics. Developing critical consciousness *with* mathematics implies using mathematics to investigate social inequities and developing critical consciousness *about* mathematics implies providing opportunities to be critical about the math they study in terms of who created it and for what purposes. In these ways, Rubel and Chu (2011) have taken Ladson-Billings' three criteria of culturally relevant pedagogy and modified them to fit the findings of their research in the context of mathematics education. Overall, these ways of conceptualizing culturally relevant pedagogy in the context of mathematics teaching and learning utilize what research has shown about good mathematics teaching for conceptual understanding and expanded those ideas to connecting students' backgrounds to the mathematics in order to provide students with opportunities to learn. The definition I provide for this study takes these ideas into account along with some of the ideas from Gutstein et al.'s (1997) definition.

For the purposes of this study, I define culturally relevant mathematics pedagogy by drawing on Ladson-Billings' (2009), Gutstein et al.'s (1997), and Rubel and Chu's (2011) definitions of culturally relevant pedagogy. Specifically, the three components of culturally relevant pedagogy will largely be constructed from Rubel and Chu's (2011) definition. I used this as the basis for my definition as it directly addressed the importance of good mathematics teaching practices while also utilizing students' everyday cultural experiences to provide students with opportunities to learn mathematics for conceptual understanding which, as discussed near the beginning of this review, is essential for the achievement of racial and ethnic minority students. However, I also want to stress the orientations to students' culture and experience component of Gutstein et al.'s (1997) definition to focus my study on moving from deficit views of students to empowerment views in order to utilize students' backgrounds as a tool or strength to provide students opportunities to learn mathematics for conceptual understanding. Therefore, I define culturally relevant mathematics pedagogy for this study as consisting of three components: (1) students must experience academic success in mathematics where instruction is centered on teaching mathematics for conceptual understanding; (2) developing and maintaining students' cultural competence through centering instruction on students' culture and experiences; and (3) developing students' critical consciousness with and about mathematics. As Figure 1 illustrates, culturally relevant mathematics pedagogy is a part of good mathematics teaching because good mathematics teaching should include the good teaching practices discussed earlier in this chapter, but part of being a good teacher is also recognizing the link between culture and mathematics (Nasir et al., 2008) in order to provide students with the best opportunities to learn.

In the next section, I examine the effectiveness of culturally relevant mathematics pedagogy. This will be done to illustrate what culturally relevant mathematics pedagogy looks like in practice and to further support that culturally relevant pedagogy can be effective, specifically in the context of mathematics.

Culturally Relevant Mathematics Pedagogy in Practice

There is some research that shows that culturally relevant mathematics pedagogy can be effective with racial and ethnic minority students in terms of providing them with opportunities to learn mathematics for conceptual understanding (Ensign, 2003; Enyedy & Mukhopadhyay, 2007; Tate, 1995). Specifically, making connections to students' culture and home lives can help to improve students' achievement in mathematics. For example, in Ensign's (2003) study, second, third, and fifth grade students in urban schools were asked to write their own mathematics story problems for the class to solve based on their mathematical experiences outside of school. During one lesson, the teacher asked the students to think about a time when they used money. One student wrote a problem about buying milk for the family. The class had a discussion about how to represent the cost of the milk and had a discussion about how many different ways there were to represent 25 cents. The results of this practice illustrated that not only did students perform better on textbook unit tests, their perception of the mathematics they use outside of class increased (e.g., understanding how they earned money at home and how they made sure they were not cheated when they made purchases), their interest in mathematics increased, and the teachers also learned more about their students in order to teach them more effectively (Ensign, 2003).

In addition, designing lessons around students' cultural, home, and community experiences is a way to not only provide students opportunities to learn mathematics for conceptual understanding, but also to develop their critical consciousness by being able to learn mathematics through analyzing a social justice issue. In addition to completing mathematics word problems related to their home lives, the students in Ensign's (2003) study also discussed the social issues related to the problems they posed, such as comparing the cost of their rent and other necessities to students living in the suburbs. Also, Enyedy and Mukhopadhyay (2007) sought to help high school students learn and understand statistical concepts and how they can be used to analyze a social science issue. The students used a computer program to make maps to analyze a social science issue regarding inequities in education. One map that a group of students created was used to explore the quantitative and statistical relationships between who lives in an area and the qualifications of teachers who teach there. The map was of the percentage of the Hispanic population in Los Angeles in different census tracts that also included information about the certification (or lack of) of teachers that teach in those different census tracts. The students were asked to analyze patterns in the map regarding which census tracts had the least certified teachers and whether that matched the areas with large percentages of Hispanic students. Based on the results of a pre-post test, the students made statistically significant gains in critically analyzing a social justice issue with statistical data analysis methods. In particular, being able to analyze data in the context of a meaningful social justice issue helped the students be better able to make inferences about aggregate data and evaluate claims based on data. In addition, the students were able to support the claims they made about a social justice issue with quantitative and qualitative evidence.

Therefore, culturally relevant pedagogy can be used effectively in mathematics classrooms in a number of ways to provide students with opportunities to learn mathematics. In the next section, I describe another means of incorporating culturally relevant mathematics pedagogy in the classroom; namely through the use of culturally relevant mathematics tasks. I specifically focus here because the use of culturally relevant mathematics tasks can help improve students' mathematics achievement (Ensign, 2003) and can motivate and engage students in terms of maintaining and developing their cultural competence (Leonard & Guha, 2002).

Culturally Relevant Mathematics Tasks

For this study, culturally relevant mathematics tasks are high-level mathematics tasks that are set in a context that is related to students' (or one student's) culture and/or home and community lives. There is very little research on culturally relevant tasks (generally and within the context of mathematics education), but what is known is promising in terms of their effectiveness when used with students. In this section, I will start by discussing the research that does discuss culturally relevant tasks. I will also examine related research about prospective teachers writing mathematics lesson plans that draw on students' mathematical thinking and their home and community funds of knowledge. I do this to argue that focusing on revising high-level mathematics tasks to be more culturally relevant (as opposed to creating and designing an entire lesson plan from scratch) may be an appropriate starting activity for prospective teachers to begin to develop the practices of a culturally relevant mathematics teacher.

Many of the studies that discuss the design and use of culturally relevant mathematics tasks are in the context of elementary school mathematics where students are asked to write their own problems based on their cultures and home and community lives (Ensign, 2003; Leonard & Guha, 2002). These studies illustrate the potential effectiveness of using these kinds of tasks on student learning. By fifth grade, the students in Ensign's (2003) study discussed in the previous section were writing their own problems that would be used during instruction. The second through fifth grade students in Leonard and Guha's (2002) study wrote their own problems based off of pictures they took while walking around the neighborhood surrounding their church. For example, one student had a picture of a woman who was bringing groceries to the church and wrote the following problem: "On Saturday Mrs. Hood brought in 2 bags of groceries. There are more groceries in one bag than in another. There are less than 17 [items] in one bag and more than [13] items in the other. If the total number of grocery items is 30, how many items are in each bag?" This task was deemed culturally relevant because it "embeds the mathematics in a cultural context that matters to [students]" (Leonard & Guha, 2002, p. 115). Both of these studies found that students performed better in mathematics whether it was higher trends in students' scores on unit tests (Ensign, 2003) or that the students were highly motivated by this activity and used mathematics in new ways by noticing the mathematics in the pictures they took (Leonard & Guha, 2002).

There is also some evidence that high school mathematics teachers can effectively write their own culturally relevant mathematics tasks for use with students (Rubel & Chu, 2011). One of the teachers in Rubel and Chu's (2011) study successfully wrote culturally relevant mathematics tasks by contextualizing the "mathematics in geometric features of the local, urban environment" by providing the students with a grid of the neighborhood and having the students develop the distance formula using the Pythagorean Theorem by finding the distance between the school and the nearest subway station. However, it can be difficult for teachers to write culturally relevant mathematics tasks. As discussed previously, many of the teachers in Rubel and Chu's (2011) study wrote tasks at a superficial level. The example about using the jersey numbers of basketball players to teach set notation as described earlier illustrates how difficult it is for teachers to write their own culturally relevant mathematics tasks. Thus, elementary and high school teachers have had some success with using culturally relevant mathematics tasks, but Rubel and Chu's (2011) study suggests that it can be difficult for teachers to do well. Therefore, one could argue that teachers need support to learn how to write culturally relevant mathematics tasks. One place where this learning could begin is during prospective teachers' teacher education programs.

There is some research on how successful prospective teachers can be writing their own culturally relevant mathematics tasks when given support during their teacher education programs to learn to do so. The TEACH MATH (Teachers Empowered to Advance Change in Mathematics) project gives some insight into how prospective teachers engage in writing high-level mathematics tasks that draw on students' cultures and home and community lives and the stages through which prospective teachers go through in learning how to do so (Aguirre et al., 2013; Turner et al., 2012). One of the ways TEACH MATH supported prospective teachers to write their own mathematics tasks is the *Community Mathematics Exploration Module* (CME) in which prospective teachers were required to visit different locations in their students' communities and use what they learned to write a problem solving-based mathematics lesson plan (Aguirre et al., 2013). The authors developed a learning trajectory for how prospective teachers develop practices and understandings for connecting to students' mathematical thinking and their cultural/community funds of knowledge (Aguirre et al., 2012). Children's community/ cultural funds of knowledge refers to the “diverse cultural and linguistic knowledge, skills, and experiences found in children’s homes and communities” (Turner et al., 2011, p. 68). Part of the trajectory consists of three levels of connections: emergent, meaningful, and transitional. Emergent connections refer to connections to students’ home or community knowledge or their mathematical thinking that are more “superficial” in nature, such as changing the names or contexts in word problems. Transitional connections refer to connections made to students’ mathematical thinking and home and community experiences, but one or both were underdeveloped in the prospective teachers’ lesson plans. Meaningful connections refer to making connections to students’ use of mathematics in their homes or communities and their mathematical thinking to design “mathematically rich problem-solving experiences” (Turner et al., 2012, p. 77).

In an analysis of 113 elementary prospective teachers’ 70 CME projects, the majority were labeled as emergent (53%) or transitional (30%) whereas only 17% of the lesson plans were at the meaningful connections level (Aguirre et al., 2013). It is promising that the prospective teachers in this study were able to write mathematics lessons that connected to students’ mathematical thinking and home and community practices at some level. However, the relatively few prospective teachers that were able to write lessons at the meaningful connections level suggest the difficulty of writing their own lesson plans and tasks that make meaningful connections to students’ mathematical thinking and home and community practices. The results of this study suggest that narrowing the focus to mathematics tasks rather than entire lesson plans as well as providing different supports such as revising existing high-level mathematics tasks may be a beneficial step towards learning to write culturally relevant mathematics lesson plans.

This hypothesis has some support from one study that looked at in-service elementary school teachers learning to revise existing textbook mathematics problems to be more culturally relevant for their students. Herron and Barta (2009) investigated the effects of using culturally relevant word problems on second graders' mathematics achievement as compared to students who used textbook word problems. The teachers in the study were supported in revising textbook word problems to be culturally relevant through a problem revision guide. The cultural dimensions on the guide included:

> 1) names of students in the class; 2) local settings (parks, stores, etc.); 3) games, activities, sports, or hobbies of students; 4) food or restaurants particular to the students; 5) names of family members or pets; and 6) special celebrations of the students and their families" (Herron & Barta, 2009, p. 30).

The information contained in these guides was collected by the teachers from surveys given to the students. The teachers were encouraged to change every possible dimension in the word problems to reflect something from the guide. For example, one of the textbook problems stated "Judy has 6 marbles. Billy gave her 6 more marbles. How many marbles does Judy have now?" The revised problem changed the names in the problem to names from students in her class and changed "marbles" to "toy cars" which was something taken from a student's survey. The revised task read: "Mason has 6 toy cars. Braden, his brother, gave him 6 more toy cars. How many toy cars does Mason have now?" The teachers in this study were successful in revising textbook word problems based on this problem revision guide. As this is the only explicit framework found in the research literature related to revising mathematics tasks based on what they know about their students' lives outside of school, it will be compared to the theoretical framework developed for this study in later sections. Specifically, this framework only addresses one part of the framework for this study.

As can be seen from the above discussion, many researchers have some similar ideas for what a culturally relevant task is (e.g., drawing on mathematically meaningful experiences, cultures, interests, etc. of students; engaging and motivating). At the same time, no single definition emerges. In addition, little published research was found that examined how to support prospective teachers in learning how to revise existing high-level mathematics tasks to be culturally relevant, particularly at the middle school level. Such research is important as it can provide information on a specific practice that prospective teachers may be able to develop during their teacher education program that is part of teaching mathematics in culturally relevant ways. It can also provide evidence of the kinds of supports that are appropriate and effective for prospective teachers to learn to be more culturally relevant mathematics teachers at this stage in their teacher education. In the next section, I discuss a theoretical framework for how to revise a task to be more culturally relevant that was used in this study to support the prospective teachers in revising high-level mathematics tasks to be more culturally relevant for their students.

Theoretical Framework for Revising High-Level Mathematics Tasks to be Culturally Relevant

This framework serves both analytical and theoretical purposes. Analytically, this framework provided a means for analyzing the relative success the study participants had when revising a high-level mathematics task for their students. The analytic use for this framework will be discussed in detail in the methods chapter.

Theoretically, this framework serves as a contribution to the literature on culturally relevant mathematics tasks in that there has not been much of a discussion of or a framework for culturally relevant mathematics tasks; particularly what they are and how they can be created. This framework was specifically designed to highlight five components for revising an existing high-level mathematics task to be culturally relevant for students rather than writing tasks from scratch as this may be a more supportive first step for prospective teacher learning. The components to this framework were developed based on the research literature related to good mathematics teaching practices and culturally relevant mathematics pedagogy examined in the previous sections.

Table 1 provides a summary of the theoretical framework. The first column of Table 1 theorizes components that teachers need to consider when revising a high-level mathematics task to be more culturally relevant and the second column provides the ways in which teachers can address each of the components in order from less ideal to more ideal. For example, in terms of the cognitive demand of the task, the first level is that teachers could lower the cognitive demand in their revised task which is not ideal or they could maintain or raise the cognitive demand which is ideal. In the following sections, I expand on each component in detail. Each of the components in Table 1 must be present to be an ideal culturally relevant task. Without one or more of these components, students might not be provided with the best possible opportunity to learn the mathematics. For example, if the cognitive demand of the revised task is made to be at a low level, the context may be engaging and meaningful, but students may not be getting the opportunity to grapple with mathematical concepts, which can negatively impact their learning (Stein & Lane, 1996).

Table 1 Theoretical Framework for Revising a High-Level Mathematics Task to be Culturally Relevant

Components	Levels of Addressing
1. Draw on something meaningful learned about students	1. Draws on students' interests (hobbies, sports, etc.) 2. Draws on students' mathematics (or other subject) knowledge or thinking 3. Draws on students' home and/or community experiences 4. Draws on students broader culture
2. Changes draw on the mathematics in the context	1. Changes were made at a surface level (changed names, places, things, etc. only) 2. Changes draw unrealistically on the mathematics in the context. 3. Changes draw realistically on the mathematics in the context.
3. Revisions draw on mathematical practices of the students	1. Revisions related to interest/home/community/culture but not the mathematical practices the students or people/adults in the home/community/culture do 2. Revisions related to the mathematical practices the people or adults in the home/community/culture engage in, but not the students 3. Revisions related to the mathematical practices the students engage in
4. Maintain or raise cognitive demand of the task	1. Cognitive demand is lowered (to memorization or procedures without connections) 2. Cognitive demand is maintained (at procedures with connections or doing mathematics) 3. Cognitive demand is raised (from procedures with connections to doing mathematics)
5. Address the same mathematics content as the original task	1. Mathematics content addressed is different from the original task 2. Mathematics content addressed is the same as the original task

Also, it should be noted that these components were developed prior to data collection and they guided the work during the middle school mathematics methods course, particularly the course activities where the prospective teachers were taught how to revise a high-level mathematics task to be more culturally relevant for one student. This will be discussed in more detail in the methods chapter. In addition, it is important to note that the original high-level tasks that are being considered here for revision are not necessarily culturally relevant for any given student. In other words, the original tasks are placed in "real-world" contexts that students may or may not be familiar with, may or may not be meaningful for students, and may draw superficially on the context. The tasks under consideration are those generally found in middle school mathematics curricula. All of the tasks given to the prospective teachers in the middle school mathematics methods course in this study to revise were selected based on their high cognitive demand (procedures with connections or doing mathematics) for methodological reasons discussed in the next chapter. However, this does not have to be the case to apply this framework as a teacher could also simultaneously raise the cognitive demand of a low-level mathematics task. I now turn to a detailed presentation of each of the components of the framework in Table 1 as situated in the research literature.

Component 1

The first component of this framework is that teachers need to draw on something that they learned about the students that was meaningful for them. This component is essential as it directly addresses the link between students' mathematics knowledge and their cultural practices (Nasir et al., 2008). Also, drawing on meaningful student experiences related to their culture and home and community lives can support students' maintaining and developing their cultural competence (Gutstein et al., 1997; Ladson-Billings, 1995a, 2009) as well as providing a means for students to access important mathematical ideas (Boaler, 1993). In this study, something is considered meaningful for students if it is an activity they engage in or have experience with on a regular basis, express enthusiasm for, or otherwise note its importance in their lives. It should be something that the students show more than a passing interest in or an activity they only engage in sporadically. Table 1 shows that teachers can draw on students' interests (hobbies, sports, etc.); students' mathematics (or other subject) knowledge or thinking; students' home and/or community experiences and practices; or students' cultural knowledge and experiences. It should be noted that the meaningful characteristic teachers draw on should focus on student competencies in different settings (at school or in home/community) rather than perceived deficits. Part of being a culturally relevant teacher is moving away from viewing students from a deficit lens towards an empowerment lens that focuses on student competencies which can support student learning (Gutstein et al., 1997).

For the revised task to be culturally relevant, the task should draw on students' home and community lives and experiences and their cultural experiences. Therefore, using student interests is seen as a beginning step towards revising a high-level task to be culturally relevant, but not necessarily culturally relevant itself. Student interests can be influenced by a person's culture, family, friends, language, community, etc. however that is not necessarily the case. Getting to know student interests can help teachers make mathematics interesting for students by drawing on familiar contexts (like sports or dance) and can also motivate them. However, when considering culturally relevant tasks, teachers must go beyond interest and motivation to make connections to what students know, understand, and experience which is largely connected to students' culture. Therefore, drawing on student interests is at a lower level in the framework than drawing on students' home and community experiences and cultures.

Teachers can (and should) also draw on their knowledge of their students' mathematics (or other subject) knowledge or thinking. As the TEACH MATH project researchers argue, it is important to draw on both students' mathematical thinking and their cultural, home, and community experiences when writing mathematics tasks and lessons (Aguirre et al., 2012, 2013; Turner et al., 2012). This is because there is research that shows that teachers who understand and draw upon students' mathematical thinking (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Fennema et al., 1996) and those that draw upon students' cultural, home, and community experiences (González, Andrade, Civil, & Moll, 2001; Ladson-Billings, 2009) can support student learning. Therefore, teachers need to integrate the two in order to most effectively support their students' learning. Therefore, teachers must draw on both students' mathematical thinking and their home and community experiences and cultures for culturally relevant mathematics tasks as well.

Herron and Barta's (2009) task revision framework as discussed in a previous section mostly falls under this component as it only consists of the different categories of information the teachers were required to learn about their students. It is also important to note that these categories largely fall under the beginning stages of drawing on student interests while only some categories address their family practices (e.g., places they go with their family). The teachers then worked with the researchers to replace every dimension in second grade word problems with something written in the guide (e.g., replace names in the problem with names of students in the class). This aspect will be discussed in relation to component 2.

Component 2

Once a meaningful context is decided upon, the second component of the framework states that the revisions made to the original task must draw on the mathematics present in that context. In other words, the context of the task should connect to the mathematics in a realistic way. This could be done by having the context illustrate or motivate a mathematical concept (Rubel & Chu, 2011). For example, if the revision draws upon students' interest in soccer, then the task should utilize the mathematics present in the game of soccer, such as changes in speed running on the field or the angle at which the ball was shot at the net.

The beginning stages of learning to do this in the framework would be drawing on the context in the problem in a superficial way such as changing names or places and things (Aguirre et al., 2013). For example, if students have an interest in soccer, a task that draws superficially on this context could be asking students to write a story that matches a graph of the speed of a student walking from home to soccer practice. In this task, soccer does not help to illuminate the concepts required for analyzing a graph to write a story. A better revision that draws on the mathematics in soccer would be if the graph represented the speed of a soccer player throughout a game. A student who plays soccer might have an understanding of how a person's speed changes as they run around the field during a soccer game. Herron and Barta's (2009) framework for revising tasks largely falls under this beginning stage in that the teachers were instructed to replace every noun with a different one based on the information they collected about their students. The example given in a previous section illustrates this in that the names of children in the class were replaced with names of students in the class and objects, places, hobbies, holidays, etc. were replaced with others (e.g., marbles replaced with toy cars). Component 2 of the framework in Table 1 requires teachers to go beyond these types of revisions. However, it is important to note that prospective teachers who attain the beginning stage of this component is a good first step because Herron and Barta (2009) found some evidence that even these surface level changes can have a positive impact on student achievement.

Another part of this component relates to the realistic application of the mathematics present in a context. This has to do with how closely the revised task represents reality. Boaler (1993) discusses an investigation that asks students to imagine a city with streets that form a square grid where police can see anyone 100 meters ahead of them; each police man being able to see 400 meters (100 meters in four directions) when standing on a street corner. The students are supposed to determine the minimum number of police needed for different sized grids. The issue with this task is that it asks students to suspend reality and assume that all police men only see in units of 100 meters when that is not the case. As discussed previously, this distance from reality can be problematic for many students (Lubienski, 2000). Therefore, a culturally relevant task should draw realistically on the mathematics present in the context.

Component 3

Not only does a teacher need to consider drawing realistically on the mathematics present in the context, the third component of the framework requires that the revised task should draw on the specific mathematical practices of the students. This component suggests that not only should a culturally relevant task draw realistically on the mathematics present in the context, but should also be mathematics that the student has experience with related to the student's meaningful interest, cultural experience, or home and community experience (component 1). The TEACH MATH project discusses using the "knowledge, skills, and experiences found in students' homes and communities" which includes the mathematical practices that occur within the community as used by adults, employees, or children (Aguirre, Turner, Bartell, Kalinec-Craig, et al., 2012, p. 179). This also includes drawing upon the mathematical experiences that students participate in and experience themselves. The use of such knowledge and experiences in mathematics tasks benefits students' mathematical learning (Foote, 2009).

While the mathematical practices of adults or employees in a context might support making meaningful connections (Aguirre et al., 2013; Turner et al., 2012) and thus be good sources for culturally relevant mathematics tasks, for this study the focus will be on the students' own mathematical practices. As discussed in a previous section, drawing on individual students' experiences can be beneficial for student learning (Ensign, 2003). In order to meet all of the field placement requirements for the middle school mathematics methods course, the prospective teachers in the current study were asked to get to know one student during one week where they were in their field placement school instead of spending time in the students' communities. Thus, the prospective teachers in this study were not asked to determine the mathematical practices of the students' communities or of the adults in their homes and communities. They were asked to get to know only one student in order to maximize the amount of information the prospective teachers could gather in that short amount of time because getting to know an entire classroom of students in one week would not necessarily lead to them learning about students' meaningful knowledge and experiences in order to complete the task revision well.

Component 4

The fourth component of the framework is that when revising a task to be culturally relevant, the cognitive demand of the task should be maintained or raised (if possible). One primary component of culturally relevant pedagogy is that students must experience academic success (Ladson-Billings, 1995a) and for mathematics, this means that students must have opportunities to learn about and make connections between mathematical concepts and struggle with important mathematical ideas (Hiebert & Grouws, 2007). High cognitive demand tasks that require multiple representations, multiple solution strategies, and students to explain their thinking can provide such opportunities and are important for students learning mathematics for conceptual understanding (Silver & Stein, 1996; Stein & Lane, 1996). Therefore, an ideal task revision is one that maintains (remains at procedures with connections or doing mathematics) or raises (going from procedures with connections to doing mathematics) the cognitive demand of the original task.

Component 5

The fifth component of the framework states that the mathematics content addressed in the revised task must be the same as the content addressed in the original task. The reasoning behind this is a more practical one for teachers as opposed to being directly related to the research literature. Ultimately, this component is to ensure that the revised task still provides students opportunities to make progress towards the intended learning goal for the lesson of which this task will be a part. Teachers set daily mathematics learning goals for their students and select tasks and write lesson plans that are designed to meet those learning goals. In addition, many schools and school districts have a common curriculum or pacing guide that mathematics teachers have to follow with specified learning goals that they need to address each day. Therefore, teachers should be cognizant that when they are revising mathematics tasks to be more culturally relevant for their students, they are not changing the mathematics content addressed by the original task to avoid using a revised task that will not allow students to meet the set learning goal.

Summary

There are a number of good teaching practices that can be effective with all students for learning mathematics for conceptual understanding. For racial and ethnic minority students who experience a cultural mismatch between home and school mathematics, culturally relevant mathematics pedagogy is one means of addressing this issue because maintaining and developing students' cultural competence through the use of culturally relevant mathematics tasks in conjunction with good mathematics teaching practices can be an effective means for providing students with opportunities to learn mathematics for understanding. However, research has shown that learning how to implement culturally relevant pedagogy in general and writing culturally relevant mathematics task specifically, pose challenges for prospective teachers. Therefore, this theoretical framework has the potential to provide support to prospective teachers in learning how to revise high-level mathematics tasks to be culturally relevant.

In the following sections, I turn to an examination of the literature on teachers' affect and conceptions. This is because a teachers' affect and conceptions about students can ultimately impact the opportunities they provide students to learn (Milner, 2005). Thus, it is important for teacher education programs not only to prepare prospective teachers to use effective teaching practices, but also to develop the beliefs that support their use. I also provide an argument for looking at the relationship between prospective teachers' conceptions and their performance revising a high-level mathematics task to be culturally relevant for one student (research question 2).

Prospective Teachers' Affect and Conceptions

The affect and conceptions that prospective teachers bring with them to their teacher education programs could impact their learning to use culturally relevant teaching practices and the actual use of these practices in their future teaching. In the following sections, I will first examine some definitions of *affect* and *conceptions* and related terms found in the research literature in order to justify and situate the use of the term *conceptions* for this study. Then I will address teachers' affect and conceptions specifically regarding mathematics teaching and learning and racial and ethnic minority students and the potential impact these various conceptions can have on teaching practice. This is to illustrate different conceptions that prospective teachers could express and to argue why it is important to consider both prospective teachers' instructional performance and conceptions. Finally, I will examine the challenges and successes teacher educators have had on influencing prospective teachers' affect and conceptions. This is to argue for the need for more research on how teacher educators can support prospective teachers in fostering and developing the conceptions that will support the use of effective teaching practices with all students.

Affect and Conceptions

Affect and conceptions play an important role in mathematics education because teachers' affect (in particular, attitudes and beliefs) and conceptions that they have about students shape the opportunities they provide for their students to learn (Milner, 2005). In this section, I will first examine some definitions of affect found in the research literature as well as definitions of constructs related to affect including emotions, attitudes, and beliefs. Then I will define conceptions, specifically about students and mathematics teaching and learning, as this study aimed to look at how prospective teachers' conceptions progressed over one middle school mathematics methods course as well as how their conceptions are related to their progress revising a high-level mathematics task to be more culturally relevant for one student.

In a review of the literature on affect in mathematics education, McLeod (1992) defines the affective domain as "a wide range of beliefs, feelings, and moods that are generally regarded as going beyond the domain of cognition" (p. 576). McLeod (1992) includes emotions, attitudes, and beliefs as part of the affective domain. After reviewing the literature on mathematics teachers' affect and beliefs, Philipp (2006) defines affect as "a disposition or tendency or emotion or feeling attached to an idea or object" (p. 259). Similar to McLeod (1992), Philipp's (2006) definition also includes emotions, attitudes, and beliefs as comprising affect.

Emotions can be defined as "feelings or states of consciousness" that change more rapidly than attitudes and beliefs and are felt with more intensity (Philipp, 2006, p. 259). For example, in terms of student emotions in mathematics, a student could feel frustrated when attempting to solve a difficult mathematics problem, but then feel joy when finding the solution. McLeod (1992) defines attitudes as "affective responses that involve positive or negative feelings of moderate intensity and reasonable stability" (p. 581). In other words, attitudes are ways of feeling and thinking that show one's opinion or disposition towards something (Philipp, 2006). Attitudes are more stable and felt less intensely than emotions but are more easily changed than beliefs. When an emotional response occurs multiple times (such as frustration), that feeling can become more stable which could lead it to becoming an attitude (McLeod, 1992). For example, if a student repeatedly feels frustration when doing geometry proofs, that student may develop a negative attitude towards geometry. Because attitudes are more stable, they can be measured through interviews, questionnaires, etc.

Beliefs are "psychologically held understandings, premises, or propositions about the world that are thought to be true" (Philipp, 2006, p. 259). The truth value is important for beliefs. Beliefs tend to develop gradually and are more stable than attitudes or emotions. Therefore, both beliefs and attitudes can be measured and have been by many researchers. In addition, beliefs can be held with varying degrees of certainty or conviction (Philipp, 2006; Thompson, 1992). Therefore, a person who believes something to be true may be willing to accept that others have different beliefs and even be willing to accept contradictory evidence (Furinghetti & Pehkonen, 2002). Thus, beliefs have the potential to be changed, although it is difficult to do so (McLeod, 1992; Philipp, 2006).

Finally, related to beliefs and other constructs in the affective domain are teachers' conceptions. *Conceptions* is a broader term that means "a general notion or mental structure encompassing beliefs, meanings, concepts, propositions, rules, mental images, and preferences" (Philipp, 2006, p. 259). For this study, the focus will be on teachers' conceptions of mathematics teaching and learning and conceptions about students more generally. Conceptions of mathematics teaching and learning encompass what a teacher views as important goals, his or her role in the classroom, the students' role in the classroom, appropriate teaching strategies and activities, and acceptable outcomes of instruction (Thompson, 1992). These conceptions will be considered specifically in the context of the mathematics teaching and learning of racial and ethnic minority students in urban, high-needs schools. Therefore, I also want to specifically include conceptions about students separately because the participants' conceptions about students in general as well as math learners might impact (or be related to) their conceptions of math teaching and learning for these students. I view teachers' conceptions about students (deficit/stereotypical and/or other conceptions) to encompass conceptions regarding students' race, culture, community, home lives, gender, and socioeconomic status; their academic (specifically mathematics) ability and achievement; and their behavior in and out of school. For this study, I want to specifically consider prospective teachers' conceptions of racial and ethnic minority students and/or low income students and their conceptions of mathematics teaching and learning of these students (e.g., their conceptions of appropriate teaching strategies for racial and ethnic minority students).

Given this definition, it is important to consider how open to change prospective teachers' conceptions are about mathematics teaching and learning as well as their conceptions about students. There is a plethora of research that suggests that teachers develop their conceptions about teaching early in their lives, mainly through their experiences as students in school (e.g., Barlow & Reddish, 2006; Handal, 2003; Lortie, 1975). This is also true of prospective teachers' conceptions about racial and ethnic minority students and/or low income students in that their conceptions are developed early, usually through learning and internalizing conceptions from the media or their parents (Milner, 2005). The fact that prospective teachers' conceptions are developed early and perhaps without being addressed prior to entering their teacher education programs suggests that they may be difficult to change.

There are studies that suggest that it is challenging to change teachers' conceptions regarding mathematics teaching and learning (Philipp, 2006; Thompson, 1992) and about racial and ethnic minority students (Causey, Thomas, & Armento, 2000; Kyles & Olafson, 2008; Milner, 2005), but it is not impossible. In fact, there are numerous studies that suggest that teachers' conceptions can change as a result of changing their teaching practices (e.g., Carpenter et al., 1989), through coursework in multicultural education (e.g., Middleton, 2002), and field experiences with racial and ethnic minority students (e.g., Ukpokodu, 2004).

One factor that can contribute to when and how teachers will change their conceptions is in regards to the level of commitment they hold to their conceptions. Conceptions and beliefs can be held with varying levels of commitment (McLeod, 1992; Philipp, 2006). If a person holds a conception without much conviction, they may accept contradictory evidence to change or accommodate their existing conception (Furinghetti & Pehkonen, 2002). However, if a person holds a conception with a stronger level of commitment, they may only assimilate the new conception without changing the old one or may reject the new conception altogether (Thompson, 1992). Thus, it is possible to change teachers' conceptions, but it may be challenging to do so depending on the level of commitment to that conception. The factors that can contribute to successfully changing teachers' conceptions about the mathematics teaching and learning of racial and ethnic minority students will be discussed in subsequent sections.

It is also important to note that teachers may have conflicting or inconsistent conceptions and beliefs. Conflicting conceptions can lead teachers to have to prioritize certain conceptions over others in their instruction depending on the context that they are in (Chen, 2008; Philipp, 2006; Rousseau, 2004). For example, Rousseau (2004) conducted a case study of one high school whose mathematics teachers wanted to re-design their Pre-Algebra course so that it moved away from traditional instructional practices. Rousseau (2004) found that these teachers held conflicting conceptions about how to improve students' achievement during the course: whether to focus on developing basic skills or providing them with opportunities to problem-solve and explain their thinking. Ultimately, the teachers' prioritized their conception that their students could not cope with the more challenging work which led them to increase their use of more traditional teaching methods and eventually abandon their reform effort altogether. Thus, it is important to consider the multiple conceptions and beliefs that teachers have as they make their instructional choices at least in part through negotiating the similar and conflicting conceptions they have about students and about teaching and learning.

These terms, particularly attitudes, beliefs, and conceptions, are used widely throughout the literature and will be used as the researchers have used them in their studies in the following sections. In the next section, I examine the literature on teachers' affect and conceptions regarding racial and ethnic minority students and the potential impact affect and conceptions have on teachers' practice. This is done to illustrate the different conceptions prospective teachers may have during their teacher education program and how teacher educators need to take prospective teachers' conceptions into account as they have the potential to negatively (or positively) impact their future teaching practices.

Prospective Teachers' Affect and Conceptions and their Impact on Practice

Prospective teachers bring certain conceptions about students and the teaching and learning of mathematics with them to their teacher education programs and can carry these beliefs throughout their programs and throughout their teaching careers. Some conceptions that teachers have about students may stem from stereotypes and deficit view of students (e.g., Terrill & Mark, 2000), some are idealistic (Bell, 2002; Bonilla-Silva, 2002; Martin, 2007; Rousseau & Tate, 2003), and some are productive for prospective teachers to have (Boaler, 2006a; Ladson-Billings, 1997, 2009). All of these conceptions can have an impact on prospective teachers' future teaching effectiveness; whether it is positive or negative (see Figure 1). Thus, it is important for teacher educators to know and understand prospective teachers' affect and conceptions so that they can design their programs to either effectively confront and address beliefs based on stereotypes and idealisms or elicit and build upon productive conceptions.

In this section, I will discuss commonly-held conceptions that prospective teachers may have about the mathematics teaching and learning of racial and ethnic minority students in urban, high-needs schools and their impact on practice. This is done to highlight the conceptions that the participants in this study could potentially express and to illustrate the importance of addressing and/or maintaining these conceptions during teacher education programs by describing the impact these conceptions might have on prospective teachers' current and future performance.

Deficit and Stereotypical Conceptions

Some studies have found that many prospective teachers come to their teacher education programs with stereotypical or deficit beliefs and conceptions based on indirect information gathered from places like the media or their parents (Milner, 2005). Deficit thinking "occurs when teachers focus on what students do not have or know rather than what students have or know" (Milner, 2005, p. 771). For example, prospective teachers (who are typically White from middle class backgrounds (Hollins & Guzman, 2005)) can hold deficit perspectives and stereotypes about racial and ethnic minority students in rural and urban schools. These include feeling that these students would have "higher levels of discipline problems, lower levels of parental support, higher levels of child abuse, fewer gifted and talented students, and lower levels of motivation" (Terrill & Mark, 2000, p. 152). These conceptions may be unproductive for prospective teachers to have in that they could prevent them from developing lessons that provide students with adequate opportunities to learn (Milner, 2005). Specifically, it leads some teachers to employ what Haberman (1991) terms the "pedagogy of poverty," which is characterized by traditional, teacher-driven practices, because, for example, teachers may feel that these practices are means to control their perceived student discipline problems.

There are many deficit and/or stereotypical conceptions held by teachers that can negatively impact the opportunities they provide students to learn. They include misconceptions that racial and ethnic minority students from low income backgrounds do not have supportive home lives (Sztajn, 2003), they have low mathematics ability (Boaler, 2002), and their intelligence is a fixed trait (Dweck, 2010; Mueller & Dweck, 1998). Sztajn's (2003) study of two in-service teachers illustrates how the misconception that students from low income backgrounds do not have supportive home lives can impact the instructional decisions of teachers. Sztajn (2003) observed that both teachers believed that higher-order thinking skills are important. However, the teacher at the school with the high percentage of low income students expressed that her students came from “unstable, chaotic homes…[where] parents are not willing to participate in the children’s education” (Sztajn, 2003, p. 64). Her stereotypical views on her students’ home lives made her teach in a more traditional way, focusing on learning basic facts and memorizing rules, in order to make her students more organized and responsible. Teaching mathematics in this structured way was her means for doing so (Sztajn, 2003).

The other teacher’s stereotypical conception that her higher income students had supportive parents led her to believe she could spend more time on problem-solving and projects that were interesting and challenging for her students (Sztajn, 2003). Therefore, despite each of these teachers having similar conceptions about mathematics teaching and learning, it was their misconceptions about low income students’ home lives that led them to implement very different activities in their classrooms. It is essential for prospective teachers to develop conceptions that students’ home lives are sources of information that they could use to provide students opportunities to learn (Ladson-Billings, 1995a; Rubel & Chu, 2011) rather than as obstacles to their students’ success and potentially leading to direct instructional practices (e.g., Sztajn, 2003).

Another common deficit conception that could lead to teachers not providing racial and ethnic minority students with opportunities to learn is that these students have low mathematics ability. Boaler (2002) noted in her work regarding the practices teachers use with curriculum designed to promote equity, the mathematics teachers at the school who took a more traditional approach to teaching (i.e. direct instruction) said that they offered a structured procedural approach because their students from low income backgrounds "would not have been able to cope with open-ended work" because they did not feel the students had the support at home to cope with such work (p. 255). This may stem from the all-too-accepted idea that some people are "bad" at mathematics (Gutierrez, 2002; Ladson-Billings, 1997) and those that are "good" at mathematics have an innate ability (Allexsaht-Snider & Hart, 2001; Nasir et al., 2008). This leads some teachers to believe that the failure of some of their students will be inevitable (Ladson-Billings, 2009). This misconception is important to confront and address with prospective teachers during their teacher education programs. In this study, it was addressed by helping prospective teachers understand the complex instruction idea of multiple ability treatments in that all students have some knowledge and skills that can contribute to all students' learning (Cohen & Lotan, 1995).

Related to the conception that some students have low mathematics ability is whether a teacher has a fixed mind-set or a growth mind-set about their students. Dweck (2010) defines a fixed mind-set as a belief that "intelligence is a static trait: some students are smart and some are not, and that's that" (p. 26). In their review of six studies, Mueller and Dweck (1998) found that praising students for their intelligence had more negative consequences on students' achievement and motivation than praising students for their effort. Treating intelligence as a fixed trait can lead to students not performing to their potential because they believe that their potential is fixed. In addition, having a fixed mind-set coupled with the idea that some people are "bad" at mathematics (Gutierrez, 2002; Ladson-Billings, 1997) could ultimately lead teachers to ignore the differences in performance of their students along lines of race and socioeconomic status (Rousseau & Tate, 2003). In other words, these teachers could perpetuate the issue that these students are continuing to underperform compared to their White and Asian American peers by not providing opportunities for these students to develop their potential. This deficit conception received specific attention in this study because it was important to prevent the prospective teachers from carrying this deficit conception into their teaching and instead develop and maintain the idea that all students can learn mathematics and they all have important ideas and skills that they can contribute to their learning of mathematics for conceptual understanding. The opposite of fixed mind-sets, growth mind-sets, will be discussed in a later section.

Finally, it is important to note that deficit conceptions about students can be held by teachers who also have more productive conceptions such as needing to get to know their students' culture and experiences (Gutstein et al., 1997). For example, a teacher might want to draw on students' cultures or interests to make mathematics more interesting for the students but also hold a conception that her students cannot handle challenging mathematics. Thus, even though the intent is to interest and motivate the students, they still might not be given the opportunities to struggle with challenging mathematical concepts. Therefore, for this study, it was important to design course activities that confronted and addressed these deficit conceptions while simultaneously fostering and developing more productive ones. It was essential to do so because these conceptions could have impacted prospective teachers' performance revising a high-level mathematics task to be culturally relevant. For example, a prospective teacher who thinks their student is not capable of engaging in high-level mathematics might lower the cognitive demand of the original task when revising it.

Color- and Culture-Blind Conceptions

Many prospective teachers express different misconceptions about how racial and ethnic minority students should be taught aside from the more deficit and stereotypical conceptions described above. One such conception is the notion of color- or culture-blindness where teachers make conscious efforts to not notice race or culture and to treat all students the same when teaching (Gay, 2009; Milner, 2005). Milner's (2005) and Bell's (2002) qualitative studies on White teachers found that notions of color-blindness were prevalent throughout their interviews. These teachers claimed that they do not see race and simply look for the individual. For example, in Milner's (2005) study, one of the prospective teachers stated that she was told by the school and her parents that "everyone was equal and everyone was the same. We should treat everyone the same no matter what [colour] they are and everyone was equal" (Milner, 2005, p. 774).

Color- and culture-blind conceptions may be particularly prevalent in a mathematics classroom given the conception that mathematics is a racially and culturally neutral subject and so race and culture do not matter in mathematics instruction (Ladson-Billings, 1997; Rousseau & Tate, 2003; Sleeter, 1997). For example, in their study on in-service mathematics teachers' beliefs about equity and race, Rousseau & Tate (2003) found that many teachers refused to acknowledge the patterns of achievement along racial lines, the potential role of racism in the underachievement of students of color, and did not want to discuss issues of race in their classrooms because they felt they do not need to be considered in their mathematics instruction.

Having such color- and culture-blind conceptions will likely lead them to ignore race and culture in their instruction. Purposefully ignoring or not seeing a student's race often leads teachers to see "fragmented, incomplete students" (Milner, 2005, p. 770) and to ignore the impact of racism in schools and society (Rousseau & Tate, 2003). However, culture refers to the "deep structures of knowing, understanding, acting, and being in the world" and cannot be suspended to learn a particular subject, including mathematics (Ladson-Billings, 1997). In other words, racially and ethnically diverse individuals may experience the world in different ways than the White majority and ignoring that can prevent teachers from seeing the systemic issues that can be present in schools (Johnson, 2002). Examples of these systemic issues include ignoring the achievement gap (Rousseau & Tate, 2003) or high numbers of African American students being suspended or expelled (Johnson, 2002). Therefore, it is important for teachers to take race and culture into account in their instruction. For this study, course activities, discussions, and assignments related to culturally relevant pedagogy were designed to confront and address color- and culture-blindness to highlight the role that culture and race play in students' school experiences and achievement.

Missionary Conceptions

An idealistic set of conceptions that can impact teachers' practice is what Martin (2007) describes as "missionary." The description of teachers as missionaries implies that these teachers must "save" their students from themselves, their culture, and their communities. This conception manifests itself from viewing mathematics education from an achievement lens (Martin, 2007) by focusing on the achievement gap between African American and Hispanic students and White and Asian American students on national tests like the NAEP (see, Lubienski, 2002). Further, by focusing on the achievement gap, one can view racial and ethnic minority students' cultures as being a deficit that one needs to “save” these students from. In other words, teachers who hold this conception want to help improve the lives of their racial and ethnic minority students (to be more like the teacher’s life) through improving their academic achievement (mainly on standardized tests) so that they can break away from their culture and communities and have greater opportunities later in life.

Although this conception may be held with good intentions, it can cause teachers to devalue students’ cultures and experiences, effectively ignoring and breaking down students’ cultural competence. As discussed in previous sections of this literature review, maintaining and developing students’ cultural competence is an essential component of culturally relevant pedagogy, which has been shown to be effective pedagogy for racial and ethnic minority students in terms of their achievement and their psychological well-being (Ladson-Billings, 2009; Tate, 1995). Therefore, teachers who hold missionary conceptions may not do what is best for their students, despite their good intentions. Instead, teachers can and should view education from an experience lens (Martin, 2007) that takes into account the fact that teaching and learning does not occur in isolation from a students’ cultural experiences and ways of being (Ladson-Billings, 1997; Nasir et al., 2008). These productive conceptions will be discussed in more detail in the next section.

One way that missionary conceptions can be problematic is when it manifests itself in the classroom through direct instruction that emphasizes mastery of basic skills. This can occur because a focus on ensuring that students achieve in the traditional sense (i.e. on standardized tests), “fuels a concern with [students’] mastery of standardized, mainstream (valued) knowledge” which is an orientation that favors gaining control of students over the learning of high-level content (Martin, 2007, p.

14). In essence, holding missionary conceptions ignores the influence that students' culture and community have on their learning. For this study, missionary conceptions were a concern because they may have conflicted with the prospective teachers' conceptions about effective mathematics teaching practices more generally and their conceptions related to culturally relevant pedagogy more specifically which could have impacted their performance revising a high-level mathematics task to be more culturally relevant.

Productive Conceptions

Despite the more deficit, stereotypical, and other misconceptions that many prospective teachers may have, there are some more productive conceptions that prospective teachers may have that can support the use of effective and culturally relevant teaching practices for racial and ethnic minority students in urban, high-needs schools. Researchers have found that some mathematics teachers have a conception that all students can learn and be successful and that this belief is related to their use of effective teaching practices that provide students opportunities to learn mathematics for conceptual understanding (Boaler, 2006a; Gutstein et al., 1997; Kitchen et al., 2007; Ladson-Billings, 1997, 2009). For example, the mathematics teacher, Ms. Rossi, in Ladson-Billing's (1997, 2009) study of effective culturally relevant teachers discussed in previous sections held this conception, which led to her use of a number of practices that were effective at getting her students to perform at high levels of mathematics achievement. This included Ms. Rossi using scaffolding and problem solving activities to allow students to move from what they know (i.e. prior knowledge and experiences) to what they don't know (Ladson-Billings, 1997).

A closely related conception is having a growth mind-set about students' intelligence. Dweck (2010) defines a growth mind-set as a belief "that intelligence can be developed by various means – for example, through effort and instruction" (p. 26). Having a growth mind-set doesn't mean that everyone is the same, but it does mean that intelligence is malleable and that all students have the potential to grow. If a teacher believes that all students have the potential to grow and are capable of success, then they may be more likely to push and challenge students to learn at higher levels. Therefore, it is important for prospective teachers to develop or maintain a growth mind-set and a conception that all students can learn high-level mathematics because this can counteract some deficit conceptions and promote the use of teaching practices that help students develop a conceptual understanding of mathematics content. Importantly for this study, if prospective teachers hold these conceptions, they may be more open to learning about culturally relevant teaching practices and may subsequently perform better revising a high-level mathematics task to be more culturally relevant for one student.

Finally, a conception that is central to the implementation of culturally relevant pedagogy is that culture matters when teaching mathematics to racial and ethnic minority students (Ladson-Billings, 1997, 2009). As discussed previously, culture influences the way people come to know and understand the world and so will have an impact on students' learning of mathematics. In her research on effective teachers of African American students, Ladson-Billings (1994, 1995) has shown that the teachers who believe that culture matters when teaching students in urban, high-needs schools have found effective ways of incorporating culturally relevant curriculum into their instruction of every subject, including mathematics. As argued in previous sections, culturally relevant pedagogy can be an effective means of providing opportunities for students to engage in high-level mathematics content in a meaningful way and so it is important to foster this conception in prospective teachers if they are to be successful in implementing culturally relevant teaching practices.

Overall, it is important for teacher educators to learn about prospective teachers' conceptions in order to confront and address the deficit and stereotypical ones and develop and foster the productive ones as their conceptions can ultimately impact the opportunities they provide their students to learn mathematics for conceptual understanding. Specifically for this study, an intervention was designed in the context of a middle school mathematics methods course in order to foster and develop prospective teachers' more productive conceptions regarding racial and ethnic minority students and mathematics teaching and learning that support the use of culturally relevant practices. I now turn to the literature on how teacher educators have used coursework and field experiences to support the development of prospective teachers' conceptions in order to highlight the success and difficulty in doing so and to provide support for the design of the middle school mathematics methods course for this study.

Changing Conceptions

Given that many prospective teachers' enter their teacher education programs with unproductive conceptions about racial and ethnic minority students and/or low income students, it is important for teacher education programs to determine ways to confront and address these unproductive conceptions and foster and develop prospective teachers' productive conceptions. It may not be surprising that courses in multicultural education and diversity and field experiences in socio-culturally diverse school settings have been incorporated into teacher education programs in order to address prospective teachers' productive and unproductive conceptions (Sleeter, 2001). In the following sections, I discuss relevant research that has examined the impact these courses and field experiences had on prospective teachers' conceptions. Overall, the research shows that courses in multicultural education (Cho & DeCastro-Ambrosetti, 2005; Middleton, 2002), field experiences in socio-culturally diverse school settings (Cook & van Cleaf, 2000; Kyles & Olafson, 2008; Pope & Wilder, 2005; Ukpokodu, 2004), and other teacher education coursework with an included field experience (E. L. Brown, 2004; Causey et al., 2000; Lee, Eckrich, Lackey, & Showalter, 2010; Walker-Dalhouse & Dalhouse, 2006) can have some positive impact on prospective teachers' conceptions. However, there are factors related to the design of the course and prior experiences of the prospective teachers that may have an impact on how much their conceptions change.

Design of Courses and Field Experiences

There is research that shows that the design of the course and/or field experience in terms of the kinds of activities and opportunities there are for prospective teachers to confront, address, and develop their conceptions is important (Causey et al., 2000; Lee et al., 2010; Middleton, 2002; Ukpokodu, 2004). For example, Middleton (2002) found that 79 prospective teachers enrolled an undergraduate-level cultural diversity course had positive changes in their beliefs towards students based on race/ethnicity, gender, social class, sexual orientation, language, and "related practices, policies, and procedures within schools" by the end of the semester (Middleton, 2002, p. 345). However, Middleton (2002) attributed this success to the design of the course. In particular, she presented a thematic framework to describe how instructors of the course facilitated the positive experiences that contributed to the prospective teachers' changes in their beliefs. This framework included 1) helping the prospective teachers become aware of and assess the misconceptions they initially held through course activities; 2) providing a classroom environment where the prospective teachers felt safe "to express their thoughts, concerns, fears, and biases without negative repercussions" (p. 352); and 3) providing opportunities for the prospective teachers to gain the knowledge and skills needed to teach in racially and culturally diverse school settings through hands-on activities, research, and authority figures.

Brown (2004) found similar results in White prospective teachers' conceptions in her study of two different multicultural education courses with an included field experience. Prospective teachers had more positive changes in their conceptions when the multicultural education course activities that were implemented in the first course focused on reducing their resistance to examining ideas of culture and race and provided them with opportunities for self-examination as opposed to course activities implemented in the second course that "students perceive as threatening or hostile to their cultural frame of reference" (p. 336).

In terms of designing field experience assignments for prospective teachers, Ukpokodu (2004) examined the effects of a field experience assignment in which 45 mostly middle-class, White female prospective teachers were required to shadow a K-12 student of their choosing who was culturally different from them and found positive results. The prospective teachers were required to learn about their chosen student's biographical and family information and their school experiences (e.g., favorite teachers, favorite subjects, motivation at school, and relationships with their peers). All of the prospective teachers reported that the experience allowed them "to dispel stereotypes, misconceptions, and preconceived notions they previously held about culturally different students" (Ukpokodu, 2004, p. 22). They all also reported feeling that they were able to gain first-hand knowledge of culturally different students that they previously had no experience with or knowledge of beyond stereotypes. Ukpokodu's (2004) study illustrates how powerful this type of experience can be for prospective teachers and thus, was included as part of the intervention in the middle school mathematics methods course for the current study.

There is also evidence that while a course in diversity may result in prospective teachers positively changing their beliefs, the instructor may have a significant impact on whether this change occurs. Despite the productive changes in the prospective teachers' beliefs, Middleton's (2002) analysis of the differences between the four sections of the course provided interesting results. The results of statistical tests showed that Sections 1, 2, and 3 had similar positive changes in their beliefs whereas Section 4 did not significantly change their beliefs. Middleton (2002) attributed the differences between the first three sections and Section 4 to the instructor of that section as he was unable to attend the meetings held by the other instructors where they coordinated their lessons and class activities.

Finally, there is some evidence to suggest that having a field experience while taking a course in multicultural education can be beneficial for prospective teachers' changing conceptions (Causey et al., 2000). Causey et al. (2000) found in their study of 24 prospective teachers enrolled in a middle school social studies methods course with a field experience in urban schools that they changed some of their attitudes positively. Despite participating in coursework, the prospective teachers reported that their field experience had the greatest impact on their attitudes. The prospective teachers challenged their prior expectations and stereotypes based on their experiences working with diverse students during their field placements, stating that they were "impressed with their knowledge" and were "impressed with the way students looked" because they expected them to "look poor and unkempt" (p. 37).

However, the type of field experience may play a role in the effect it has on prospective teachers as evidenced by Lee et al.'s (2010) study. Their results revealed that the field experience component of the course did not have an impact on the prospective teachers' conceptions. The researchers examined the effects of 10 general education and teacher preparation courses in different subject areas (English, mathematics, biology, psychology, etc.) that had been redesigned to incorporate an urban education focus with an optional field experience in an urban setting on 153 prospective teachers' attitudes, perceptions, and intentions to teach in urban schools. Statistical analyses of the survey data indicated that there were no significant differences in attitudes between prospective teachers who attended the field experience and those that did not. Specifically, the results indicated that these prospective teachers' perceptions about urban schools, regardless of whether or not they participated in the field experience, changed positively by the end of the course. Specifically, they were less likely to endorse stereotypical statements about urban schools. Because this study was conducted on prospective teachers enrolled in a number of different courses, it is unclear whether the field experience was consistent across the courses. Therefore, there is no evidence to say whether the field experience component in any of the courses was designed in a way that would be beneficial for prospective teachers' conceptions.

The results of these studies suggest that simply taking a course and/or field experience related to multicultural education may not be beneficial for changing prospective teachers' conceptions, but it is the design of these experiences that matter. Therefore, for the current study, the middle school mathematics methods course incorporated course readings, activities, and a safe classroom environment (see, Brown, 2004; Middleton, 2002) in order to provide opportunities for prospective teachers to develop productive conceptions. This included providing a shadowing assignment similar to the one Ukpokodu (2004) found success with. It was also important for the researcher to be the instructor of the middle school mathematics methods course (see, Middleton, 2002) so that the course activities would be conducted in the way they were intended in order to maximize the chances of productive changes in the prospective teachers' conceptions. However, there are some factors that are out of the control of teacher educators that could impact changes in prospective teachers' conceptions; namely, their prior experiences working with students who are socio-culturally different from them.

Prospective Teachers' Prior Experiences

There is evidence that coursework and/or field experiences can have mixed results depending on the experiences prospective teachers have with racial and ethnic minority students prior to and during their teacher education programs (Kyles & Olafson, 2008; Lee et al., 2010; Pope & Wilder, 2005). Pope and Wilder's (2005) study of 295 mostly White female prospective teachers' awareness of diversity during their student teaching experience is an example. They found that prospective teachers that had a high value of diversity at the end of the course (as opposed to those with a low value of diversity) expressed having more interaction with diverse students and parents both prior to their student teaching and during their student teaching, discussed issues of diversity with their students during student teaching, and read more articles about issues of diversity during the experience.

Kyles and Olafson (2008) found similar results in their study of the effects of the second of two field experiences prior to student teaching on 15 prospective teachers' beliefs about diversity. During the field experience, the prospective teachers were expected to write reflective response letters and cultural autobiographies to investigate their personal beliefs and past experiences with cultural diversity. They found that the prospective teachers that had at least some multicultural experiences prior to this field experience (e.g., their experiences growing up in a racially and culturally diverse neighborhood) were better able to move past simply articulating their beliefs to starting to reconstruct those beliefs for the support of multicultural education after participating in a field experience in a diverse elementary school consisting of Hispanic, White, African American, Asian, Pacific Islander, and American Indian students.

The results from these two studies suggest that prior experiences may impact prospective teachers' maintenance and development of productive conceptions more than taking a single multicultural education course and/or field experience in a racially and culturally diverse school. This has ramifications for this study as the prospective teachers did not report having many experiences prior to or during their teacher education program with students who are socio-culturally different from, them which could have impacted the progress they made over one semester.

Difficult to Change Conceptions

While there is evidence that coursework and/or field experiences can have some positive impact on prospective teachers' conceptions, as discussed in previous sections, it may be difficult to change them. For example, in Causey et al.'s (2000) study discussed above, many of the prospective teachers, in addition to making productive changes in their conceptions, held onto their color-blind conceptions, saying that "these kids were really no different from any other kids" (p. 37). Similarly, Kyles and Olafson (2008) found that the prospective teachers that did not have multicultural experiences prior to this field experience held on to color- and culture-blind conceptions of fairness in teaching. Therefore, while the course with a field experience had some impact on the prospective teachers' attitudes, the results suggest that it is difficult to change some beliefs over the course of one semester.

Summary

Based on the results of the studies examined in the above sections, there is enough evidence to indicate that these experiences have at least some positive impact on prospective teachers' conceptions of teaching students who are socio-culturally different from them. Therefore, researchers continue to advocate for their inclusion in teacher education programs (see, Causey et al., 2000; Kyles & Olafson, 2008). However, the research also suggests that it is difficult to change prospective teachers' conceptions and that some conceptions may be harder to change than others (e.g., Causey et al., 2000) and so multiple courses in which they have opportunities to confront, address, and develop their conceptions may be required during a teacher education program to have a lasting impact (Cho & DeCastro-Ambrosetti, 2005; Kyles & Olafson, 2008; Pope & Wilder, 2005). There is also little evidence for how a general course in multicultural education impacts prospective teachers' conceptions in the context of teaching particular content, specifically mathematics. Therefore, the aim of the current study was to determine which conceptions and to what extent prospective teachers' conceptions regarding teaching mathematics to students who are socio-culturally different from them could be positively developed in the specific context of teaching middle school mathematics to students who were socio-culturally different from them.

Conclusions across Literature Review

It is important to note that teaching is a system (Stigler & Hiebert, 1999) and so the good and culturally relevant teaching practices described in this literature review may not be effective in isolation, but together in some combination as was prevalent in many of the studies discussed in early sections of this review. Similarly, individual conceptions do not necessarily influence teachers' practice, but the many conceptions that teachers hold may influence the practices they use in their classrooms. For instance, as discussed above, teachers can believe that culture matters in their mathematics instruction and so employ cultural elements in their curriculum, but still hold a deficit view of their students in terms of having low ability (Gutstein et al., 1997). Therefore, they may not sufficiently challenge their students. Thus, it is essential for researchers to consider all of the conceptions that teachers hold as they may be in conflict with each other, which can constrain or support their use of effective teaching practices, particularly culturally relevant ones.

Prospective teachers need to develop the conceptions and practices of culturally relevant mathematics teachers in order to be prepared to provide racial and ethnic minority students and/or low income students with the best opportunities to learn mathematics for conceptual understanding. There has been some research that has characterized culturally relevant mathematics teachers who are effective with racial and ethnic minority students (e.g., Ladson-Billings, 1997; Tate, 1995). However, what is unclear is how these teachers developed the skills that made them effective.

Therefore, a question remains as to whether and how teacher education programs can adequately prepare prospective teachers to teach mathematics in a culturally relevant way. There are a few studies that suggest that teacher education programs may be helpful for prospective teachers to begin to develop the beliefs and practices that characterize culturally relevant teachers (e.g., Ladson-Billings, 2001). However, more research is needed on whether and how teacher education programs can prepare prospective teachers to be effective culturally relevant teachers of *mathematics*. More specifically, research is needed to determine what experiences, discussions, field experiences, and activities mathematics teacher educators can and should implement during coursework to not only help prospective teachers develop the beliefs necessary to teach racial and ethnic minority students, but to develop the skills and practices necessary to be culturally relevant mathematics teachers.

In this study, I address the need for additional research and take an in-depth look at the conceptions and performance of four prospective teachers, documenting the progress that they made towards becoming culturally relevant mathematics teachers over the course of one semester. I discuss the details of this study in the next chapter.

Theoretical Perspectives on Prospective Teacher Learning

Situated, sociocultural perspectives of teacher learning guided this study (J. S. Brown, Collins, & Duguid, 1989; Putnam & Borko, 2000; Vygotsky, 1987). Sociocultural perspectives on teacher learning center around the concept of learning as situated in particular social contexts (Putnam & Borko, 2000). Specifically, prospective teachers develop understandings, conceptions, and practices through interacting in different settings such as methods courses and field placement classrooms. From a situated, sociocultural perspective, learning is socially constructed (J. S. Brown et al., 1989; Vygotsky, 1987). In other words, learning occurs through interacting with others (e.g., mathematics teacher educators, other prospective teachers, etc.) through discourse and participation structures. "Learning is coming to know how to participate in the discourse and practices of a particular community" (Putnam & Borko, 2000, p. 5). For this study, this means providing prospective teachers with opportunities during their methods course to grapple with and discuss their ideas and conceptions around mathematics teaching and learning and socio-culturally diverse students with their peers and then to put some of those ideas into practice during their field placements while interacting with their cooperating teachers and their students.

An important aspect of this perspective is the concept of the zone of proximal development which is "the discrepancy between a child's mental age and the level he reaches in solving problems with assistance" (Vygotsky, 1987, p. 187). In other words, knowing how a prospective teacher performs with assistance (through instruction) is the best indicator of their development rather than just measuring what the prospective teacher is capable of doing on their own. For this study, this means providing the prospective teachers with opportunities to work with their peers and with supports or scaffolding developed by the mathematics teacher educator to support their learning.

Another important aspect of this perspective is that learning experiences should be situated in authentic activities which are the "ordinary practices of a culture" or the activities that are similar to what teachers actually do in the classroom (Brown et al., 1989, p. 34). For prospective teachers, these activities should occur during their (1) teacher education program coursework where they can engage in discussions of teaching situations and practices as presented in readings, videos, etc. and (2) field experiences where they may have the opportunity to engage in some of the practices that an in-service teacher engages in (Putnam & Borko, 2000). What is important for teacher learning is the nature of these courses and field experiences and how they are designed to support the learning that is necessary for developing the conceptions and practices of effective mathematics teachers for all students. Specifically, if prospective teachers are to develop the conceptions and practices of a culturally relevant mathematics teacher of low income urban students, they need experiences that are authentic to such teachers (e.g., a field placement located in a low income and/or urban area). Some of the considerations that need to be made when designing coursework and field experiences in terms of the opportunities prospective teachers need to make progress in their conceptions and their performance were discussed throughout the literature review (e.g., having prospective teachers shadow a student socio-culturally different from them can have a positive impact on their conceptions about students). The design choices that were made for the middle school mathematics methods course are discussed in the next chapter in greater detail.

Chapter 3

RESEARCH DESIGN AND METHODOLOGY

This chapter describes a qualitative study that was designed to investigate (1) the progress that prospective teachers can make in their conceptions of the teaching and learning of mathematics and socio-culturally diverse students and their performance revising a high-level mathematics task to be more culturally relevant for one middle school student and (2) how the prospective teachers' conceptions are related to their performance revising a high-level mathematics task to be more culturally relevant for one middle school student.

For the purposes of this study, a high-level mathematics task refers to a groupworthy task that is at a high level of cognitive demand, is open-ended, requires multiple solution strategies and representations, requires explanations (Stein et al., 1996; Stein & Lane, 1996), and is presented in a real-world context. In addition, culturally relevant mathematics tasks are high-level mathematics tasks that are in a context that is related to students' (or one student's) cultures and/or home and community lives. Culturally relevant mathematics tasks also make realistic connections to students' mathematical experiences related to their cultures, and/or home and community lives.

In this chapter, I present the research questions for this study. Then I provide a rationale for using qualitative research methods to answer the research questions. Next, I discuss the participants, the intervention for the middle school mathematics methods course, the implications of being the instructor of the course as well as the researcher, data collection processes, and data analysis techniques.

Research Questions

The research questions that guided this study are as follows:

1. What progress do prospective teachers make over a one semester middle school mathematics methods course in

    i. developing productive conceptions of the teaching and learning of mathematics and of socio-culturally diverse students and students in urban, high-needs schools?

    ii. their performance revising a high-level mathematics task to be more culturally relevant for one student who is socio-culturally different from them?

2. How are prospective teachers' conceptions of the teaching and learning of mathematics and of socio-culturally diverse students and students in urban, high-needs schools related to

    i. their performance reporting on what they say that they learned about one student's culture, interests, competencies, home and community lives, and the mathematical practices they participate in related to these categories?

    ii. their performance reporting on how they would use what they learned about their student in their mathematics instruction in general?

    iii. their performance revising a high-level mathematics task to be more culturally relevant for one student who is socio-culturally different from them?

It should be noted that in the context of this study, a relationship between conceptions and performance is taken to mean that the two constructs are associated or aligned in some way. In other words, relationships were discerned through looking across the participants' expressed conceptions to determine the extent to which they are consistent or aligned with their performance revising a high-level mathematics task to be culturally relevant and what teaching practices they stated they would implement in their related course projects as described in later sections. I am interested in addressing these questions because it is important to help prospective teachers maintain and develop productive conceptions and confront and address their unproductive ones as these conceptions may impact their use of good and culturally relevant mathematics teaching practices (e.g., Ladson-Billings, 2009; Sztajn, 2003). In addition, given the difficulties teachers have in understanding and implementing culturally relevant teaching practices (e.g., Young, 2010), it is important to determine how coursework can support prospective teachers in learning to understand and implement such practices.

These questions address the need in the research literature for more knowledge on how we can support prospective teachers to maintain and develop productive conceptions, specifically related to the culturally relevant teaching of mathematics to socio-culturally diverse students. In addition, there is a lack of research on how to prepare prospective teachers to be effective culturally relevant teachers of *mathematics*. This study has the potential to address this need in the literature by providing evidence of a how a carefully designed middle school mathematics methods course can support prospective teachers in developing the knowledge and skills necessary for implementing a specific practice (i.e., revising high-level mathematics tasks to be culturally relevant) as a starting point towards becoming culturally relevant mathematics teachers. Also, this study will add to the small amount of literature on what a culturally relevant mathematics task is. Finally, these questions address the need for more research on how prospective teachers' conceptions are related to their developing mathematics teaching practices, particularly those they are introduced to for the first time (i.e., culturally relevant mathematics teaching practices) as their first exposure has the potential to be a crucial one for their future teaching.

Rationale for Qualitative Methodology

In this section, I describe qualitative methodology and argue its appropriateness as a research methodology to address my research questions. Qualitative research "is suited to promoting a deep understanding of a social setting or activity as viewed from the perspective of the research participants" (Bloomberg & Volpe, 2008, p. 7-8). In other words, the goal of qualitative research is to elicit deep understanding of the participants' views or experiences and is usually conveyed through very detailed and comprehensive descriptions (Merriam, 1998). Qualitative methodology is most appropriate to address the research questions because of the complexity of studying prospective teachers' conceptions and their relation to performance. As evidenced from the literature reviewed in the previous chapter, prospective teachers' can hold many different conceptions that can impact how they think about the teaching of mathematics to socio-culturally diverse students and it is important to be able to capture the potentially subtle variations in those conceptions to get a detailed and nuanced view of how they might relate to their performance on a specific part of their teaching practice. In addition, revising a high-level mathematics task to be culturally relevant for one student relies heavily on gathering specific and detailed information about that students' culture, interests, home and community experiences, and/or the mathematical practices that the student participates in related to these categories. Thus, it is important to capture rich descriptions from the participants regarding what they learned about their students. This methodology will give a voice to the participants that will allow for detailed and meaningful descriptions of their conceptions and performance.

Participants

The participants in this study were prospective teachers in the elementary teacher education program at a mid-Atlantic university. The prospective teachers eligible for the study were those in the middle school mathematics concentration of the elementary teacher education program and enrolled in the middle school mathematics methods course during the Fall 2013 semester. A total of twelve prospective teachers fit these criteria. There were eight (67%) prospective teachers who self-identified as female and four (33%) who self-identified as male. Eleven of the prospective teachers enrolled in the course self-identified as White and one female self-identified as Hispanic.

All twelve of the prospective teachers agreed to complete a survey given at the beginning and end of the semester regarding their conceptions of teaching mathematics to socio-culturally diverse students in urban, high-needs schools. However, only five of those prospective teachers agreed to participate in the pre- and post-interviews. All four of the male students and one female student agreed to participate in the entire study and they all completed the pre- and post-interviews. Of those five, four were chosen to be the participants for this study. These participants are John, Rick, Zane, and Janet. Note that these names are all pseudonyms. The one prospective teacher who was removed from the study was a male prospective teacher. He was removed because he was unable to shadow a student who was socio-culturally different from himself along the lines of race, gender, or socioeconomic status. The student he shadowed was a White, middle class male who is hearing impaired. While this is certainly a difference that he would have had to learn how to accommodate for when teaching, it is outside the scope of this study to consider students with disabilities.

Therefore, the prospective teachers who were included in the data analysis for this study consist of three self-identified White, middle class males and one self-identified White, middle class female. All of the participants with the exception of Zane grew up in a majority White, middle-class neighborhood. Zane reported growing up in a very diverse neighborhood that included large Latino/a, African American, and White populations. However, he reported that he went to a majority White high school. In addition, John reported growing up in a majority White neighborhood, but that there were Latino/a and African American populations within it. This information was reported by the participants in either a pre-post survey or pre-post interview, which will be discussed in later sections. Therefore, these participants mostly come from homogenously White, middle-class backgrounds and so, as discussed in the next section, may have had few, if any, experiences working with socio-culturally diverse people.

Participants' Prior Out-of-Program Experiences

The participants have all had some experiences outside of their requirements for the teacher education program working with students who are socio-culturally different from them that may have influenced the conceptions they held at the beginning of this study. John reported multiple experiences working with students socio-culturally different from him prior to field experiences at the university. These included playing soccer with as well as coaching soccer to many students from the Latino/a community and tutoring English language learners at a local elementary school for his high school Spanish class. Zane reported having one experience coaching at a soccer club that had a large population of Latino/a children prior to his field experiences at the university. Rick reported only one experience working with students who are socio-culturally different from him prior to field experiences at the university: working as a lifeguard "in a very diverse apartment complex." Finally, Janet reported being a substitute teacher in the district she attended as a child where she worked with students with severe disabilities and was a camp counselor for deaf students one summer.

Participants' Prior Experiences During their Teacher Education Program

The participants also reported having some experience working with students socio-culturally different from them through the field experiences they participated in as part of the university program requirements prior to the middle school mathematics methods course. These experiences may have also had an impact on the conceptions they held at the beginning of the semester and so are important to note. All of the participants reported having some experience tutoring students socio-culturally different from them in after school programs at either a Latino/a community center (John and Janet) or at a Boys and Girls club in an urban area (Rick and Zane). In addition to this particular field placement, John reported working with some Latino/a and African American low income students during his elementary methods field placement. Janet also reported on the conceptions survey that she worked in one of her field placements with "children who were more different than similar to me." Rick and Zane did not report any other experiences beyond their experiences at the Boys and Girls club, saying that their field placements were similar to where they grew up.

Participants' Prior Course Experiences

I decided to choose prospective teachers enrolled in the middle school mathematics methods course for reasons mostly related to the prior coursework and field experiences they have had at this point during their teacher education program. Prospective elementary teachers enrolled in this course are nearing completion of their teacher education program. All of the prospective teachers enrolled in the course were seniors in the program the semester prior to their student teaching. They had all already taken at least one course with a central focus on cultural diversity. I selected prospective teachers who had already taken such a course because research suggests that it is difficult to change prospective teachers' conceptions in one semester (Causey et al., 2000) and thus, more than one course where their conceptions are addressed is necessary for productive change (Cho & DeCastro-Ambrosetti, 2005; Kyles & Olafson, 2008; Pope & Wilder, 2005).

In addition, as prospective teachers with middle school mathematics concentrations, these participants had also taken (or were enrolled in during the Fall 2013 semester) a number of mathematics education and general education courses and have taken a number of mathematics content courses, including two courses in the teaching of middle school algebra and geometry and measurement. These prospective teachers had a number of prior experiences developing their mathematics content, pedagogical, and pedagogical content knowledge (Shulman, 1987), more than other elementary education majors in this particular program who were not middle school mathematics concentrations. Thus, they were selected for the focus of this study because they already had a multitude of experiences that may have contributed to developing their conceptions regarding mathematics teaching and learning for conceptual understanding. Also, it could be argued that if they struggled with learning how to revise a mathematics task to be more culturally relevant, it would not likely be due to a lack of mathematics content knowledge.

In this section I elaborate on some of these prior course experiences as they relate to this study and the selection of participants from this particular course. I aim to make clear what experiences the participants had prior to the middle school mathematics methods course that may explain and/or could have impacted the conceptions the participants held at the beginning of the semester. In addition, I clarify the experiences they may have had learning to teach mathematics for conceptual understanding so that it is understood what knowledge and skills they may have developed prior to the middle school mathematics methods course.

Mathematics Education Courses

The participants have already taken three elementary mathematics content courses that focus on the conceptual understanding of mathematics topics and how elementary school students can learn mathematics conceptually. The three courses covered topics in number and operations, ratios and proportional reasoning, and early algebra and geometry. Most prospective teachers in this teacher education program take these courses consecutively starting in their freshman year. The participants had also taken the elementary mathematics methods course as juniors the semester prior to taking the middle school mathematics methods course. This course focused on examining instructional methods, students' thinking and reasoning about mathematics, and other issues related to the teaching and learning of mathematics in grades K-6.

After reading over the course syllabi for all four of these courses, the researchers' personal experience teaching one of the content courses, and talking with other course instructors, it was determined that issues of equity and multicultural education were not discussed during any of these courses when the participants had taken them. In the syllabi for the three elementary mathematics content courses, the objectives included completing problems that would be posed to students in grades K-8 and predict how students would solve them, viewing video tapes of students doing mathematics to assess their mathematical thinking, and gaining insight into mathematics topics that promote reasoning and problem solving skills by solving novel problems (e.g., addition and subtraction of decimals in bases other than ten). However, none of these syllabi directly addressed or used words such as equity, diversity, diverse learners, socio-cultural, or racial and ethnic minority students. When asked directly whether they ever talked about or addressed issues of equity, diversity, or racial and ethnic minority students, the instructors all said they did not. Any talk of pedagogy in the courses was very general and related to all students. My own experiences teaching one of these courses corroborates with these accounts from the other instructors.

When analyzing the syllabus for the elementary mathematics methods course, I was again looking to see if the syllabus directly addressed or used words such as equity, diversity, diverse learners, socio-cultural, or racial and ethnic minority students. Most of the syllabus referred to the examination of instructional methods, students' reasoning and thinking about mathematics, and the mathematical content from grades K-6. In particular, the course goals mention developing prospective teachers' competencies in designing opportunities for students to learn on their knowledge of students' mathematical thinking only. However, one of the course goals was to develop the belief that *all* students can learn mathematics, which would include socio-culturally diverse students. However, the course calendar revealed that there were no in-class discussions of issues of equity, diversity, or socio-culturally diverse students specifically. In fact, the majority of the scheduled course sessions were directly related to mathematics content and good mathematics teaching for all students in general.

However, one of the course projects was similar to the *shadow a student* project in that the prospective teachers had to get to know one student who was socio-culturally different from them in some way during their field placement in terms of their mathematical thinking (through a problem solving interview) and their interests and home and community lives (through short interviews). They also had to write a reflection paper where they discussed next steps in instruction for this student based on what they learned about their mathematical thinking and their backgrounds. However, when asked whether the course or this project in particular addressed issues of equity and diversity, the instructors of the course said that it did not really address these issues beyond getting to know an individual student and these issues were not taken up before or after this project during class discussions. Therefore, the prospective teachers in this study had prior experience getting to know one student in terms of their mathematical thinking and their backgrounds, but this was never tied to larger issues of equitable mathematics teaching practices, particularly not culturally relevant teaching practices.

The above courses focused on supporting prospective teachers to develop a conceptual understanding of some of the mathematics topics they may have to teach in their future careers as well as how to teach mathematics for conceptual understanding. Having taken these courses means that they have already started and made progress in learning how to plan for and enact teaching mathematics for understanding in elementary mathematics classrooms. Also, in the elementary mathematics methods course, the prospective teachers have been exposed to writing and enacting lesson plans. Because the prospective teachers began to develop this knowledge and skill in their prior coursework, they were developed further and in more detail during the middle school methods course (rather than being introduced). This knowledge and skill was then related specifically to culturally relevant teaching practices with which they had no experience, in the context of teaching mathematics, prior to this course.

Cultural Diversity Courses

In addition to mathematics education courses, all elementary prospective teachers are required to take one of two courses in cultural diversity: *Cultural Diversity, Schooling & the Teacher* or *Cultural Diversity in Community Contexts*. All four of the participants reported taking *Cultural Diversity, Schooling & the Teacher* and one participant (John) reported taking both courses. During these courses, prospective teachers had the opportunity to explore issues of equity in education. In *Cultural Diversity, Schooling & the Teacher,* prospective teachers examined the roles and responsibilities of the teacher with regard to the demographic changes occurring in the United States and the public school population. They examined topics related to race, culture, ethnicity, social class, poverty, gender, and language of their future students. Learning about their students' backgrounds, interests, and competencies was emphasized.

During the other course, *Cultural Diversity in Community Contexts,* John also examined the roles and responsibilities of the teacher through critical examination of field experiences in diverse communities. Prospective teachers enrolled in this course spent time every week at a local community center where they worked with a diverse group of students. The students who go to the community center are African American, Latino/a, and White, mainly from working class families. Many of the students are bilingual (Spanish-English). The prospective teachers drew upon these experiences tutoring/teaching these students to discuss the teaching practices and perspectives that relate to the teaching of diverse groups of students.

Therefore, the prospective teachers enrolled in the middle school mathematics methods course had already spent time learning about cultural diversity and issues of equity in the school setting. The content of both of these courses was meant for all elementary prospective teachers and thus, these issues were not necessarily discussed in the specific context of teaching mathematics. However, taking one (or both) of these courses means that the participants already had experience discussing these issues in a classroom setting and so potentially brought some knowledge of these issues to the middle school mathematics methods course.

Intervention in the Middle School Mathematics Methods Course

In this section, I discuss the middle school mathematics methods course as the site of the intervention and data collection for this study. Data collection took place throughout the entire Fall 2013 semester during the middle school mathematics methods course. The middle school mathematics methods course was designed taking prospective teachers' prior mathematics, mathematics methods, and general education course experiences into account. Specifically, the course was designed to build upon the prospective teachers' prior experiences teaching mathematics for conceptual understanding to K-6 students in order to support their learning to teach mathematics for conceptual understanding to students in grades 6-8. More importantly, the methods course was designed to support prospective teachers' progress in (1) developing their conceptions of the teaching and learning of middle school mathematics and socio-culturally diverse students; and (2) learning about students' mathematics knowledge, cultures, interests, competencies, home and community lives, and the mathematical practices students participate in and using that information to revise a high-level mathematics task to be more culturally relevant for one socio-culturally diverse student.

In this section, I first discuss my rationale for the level of specificity of my research questions; namely, the choice to focus on revising high-level mathematics tasks to be more culturally relevant. Then, I discuss the methods course in more detail, describing the course assignments that constitute the intervention aimed to support prospective teachers in making progress in their conceptions and their performance.

Rationale for Level of Specificity

This study focused on one aspect of teachers' practice: being able to revise a high-level mathematics task to be culturally relevant for one student. My rationale for this level of specificity comes from a framework developed by Grossman and colleagues (2009) focused on the experiences prospective teachers can have during coursework and in the field. This framework has three parts: (1) representations of practice, (2) decomposition of practice, and (3) approximations of practice. Grossman and colleagues (2009) describe representations of practice as the different ways practice is represented in teacher education and what these representations make visible to prospective teachers. For example, representations of teaching include having a teacher educator model teaching practices with prospective teachers acting as students. Decomposition of practice involves breaking practice into smaller tasks or routines for the purpose of helping to make the complexity of teaching more learnable by beginning teachers. For example, teacher educators can focus on the elements of lesson planning or on types of questions to ask during whole class discussions. Finally, approximations of practice refer to the opportunities for prospective teachers to engage in practices that are close to the actual practices of in-service classroom teachers with the intent of supporting prospective teachers' learning aspects of practice that may be difficult for them. For example, having prospective teachers write very detailed lesson plans provides opportunities for them to experiment with new practices and skills and makes their thinking visible, but it is not likely an expert teacher would write such a lesson plan.

The rationale for focusing on one very specific part of practice comes mostly from the decomposition of practice component of Grossman and colleagues' (2009) framework. For this study, I decomposed the lesson planning part of practice. In particular, planning a lesson that focuses on teaching high-level mathematics for understanding while drawing on the prior knowledge, culture, interests, and competencies of students (Rubel & Chu, 2011; Tate, 1995). This can be a difficult task for prospective teachers to take on and is certainly one with many parts (e.g., Nicol & Crespo, 2006). One of the parts of writing a lesson plan is to select and/or revise a high-level mathematics task for students to work on that is culturally relevant.

It should be noted that prospective teachers who are able to revise a high-level mathematics task to be culturally relevant for one student and use such tasks in their instruction are not necessarily culturally relevant teachers. Cultural relevance develops in practice in many ways, including building relationships with students and communities, over time (e.g., Ladson-Billings, 2009). Therefore, by using the term "culturally relevant mathematics task" I do not intend to imply that this encompasses everything that a culturally relevant teacher is, rather that this is one small, but important part of the practice of culturally relevant teachers. Also, by learning to do this part of practice, the prospective teachers will engage in other practices reflective of culturally relevant teachers, such as getting to know their students' cultures, interests, home, and community lives for use in instruction (e.g., Rubel & Chu, 2011). However, the intent was not to develop culturally relevant prospective teachers, but provide the participants a focused opportunity to learn one particular decomposed part of culturally relevant practice.

Therefore, the course assignments for the middle school mathematics methods course were created around developing the knowledge and skills to do be able to complete this specific part of practice. Because the concepts in Grossman et al.'s (2009) framework "clearly overlap and underscore each other," I draw on the other components besides decomposition as well (p. 2091). First, a *representation* of this practice was provided for the prospective teachers by the instructor in the form of a *task revision activity* (described in a later section) where prospective teachers analyzed examples of "good" and "bad" culturally relevant tasks based on the theoretical framework presented in the literature review (see Table 1). This was done to make visible the key parts of a culturally relevant mathematics task so the prospective teachers could eventually *approximate* this practice on their own. This activity will be discussed in more detail with examples of revised tasks in a later section.

Also, the prospective teachers were asked to revise a high-level task for one specific student that they spent time getting to know during their first (and potentially second and third) week of their field experience. While it is a potentially less authentic approximation of practice because of the rarity that an in-service teacher would revise a mathematics task for only one student, this can serve as a further *decomposition* and *approximation* of practice for prospective teachers who have not had an opportunity to revise a task to be culturally relevant before. That is, the prospective teachers enrolled in this methods course did not have an opportunity to revise a high-level mathematics task to be culturally relevant before and thus, they *approximated* this practice by revising a task for a single student that they had time to get to know.

It is important to note that while there may be instances where an in-service teacher would revise a task for one student (e.g., to provide one particular struggling student with access to the mathematical ideas), this may not always be the case. For this study, however, revising a task for one particular student was a more doable *approximation* of practice in the context of a one semester course with a three week field experience as the prospective teachers did have time to learn at least some information about the culture, interests, competencies, and home and community lives of one student during their brief time in the field. This *approximation* and *decomposition* of practice can provide the prospective teaches with opportunities to learn a part of practice because it provided the prospective teachers with time to develop the skills necessary to understand what a culturally relevant task is and provided part of the building blocks to eventually more closely approximate actual practice.

Design of the Middle School Mathematics Methods Course

Over the course of the semester, there were class readings, discussions, and assignments to support the prospective teachers in making progress towards having the conceptions and performance necessary to be more effective teachers of mathematics to students who are socio-culturally different from them. Some of the course assignments served as sources of data. In the sections below, I discuss the design of the course in detail including the main objectives for the course, the readings and class discussions related to this study, their field placement assignments, and the task revision activity used to support the prospective teachers in learning to revise a high-level mathematics task to be more culturally relevant for one student. The course assignments specifically used for data collection will also be discussed.

Main Ideas and Objectives for the Course

The course readings, discussions, and assignments were designed and structured purposefully throughout the semester in order to provide support to the prospective teachers in developing the conceptions and skills necessary to be successful in learning to revise a high-level mathematics task to be more culturally relevant for one student. In order to be clear about when the course assignments and parts of the intervention were implemented, a timeline is provided in Figure 2. The assignments that are sources of data are shaded and the other pieces of the intervention are left white. The purpose of the course was to examine teaching methods, students' reasoning about mathematics, and ways of thinking about the teaching and learning of mathematics in order to promote the skills, habits, and knowledge of effective mathematics teaching in the middle school. The course promoted a particular view of effective mathematics teaching. This included teachers having knowledge of mathematics content, instructional strategies that emphasize reasoning, communication, building on students' prior knowledge, and maintaining the cognitive demand of mathematics tasks in the classroom. In addition, knowledge of students' mathematical thinking, skills for analyzing effects of instruction on students' learning, and developing dispositions to continue to learn from one's own teaching practice were included in this view of effective mathematics teaching. In particular, the course promoted instructional practices that emphasize equity. This included learning about students cultural and community funds of knowledge as well as instructional practices related to complex instruction and culturally relevant pedagogy.

Relevant Course Readings and In-Class Discussions

The methods course was organized around the three field experience weeks of the prospective teachers. Overall, the weeks prior to each field experience week were designed to prepare the prospective teachers for the assignments they needed to complete in the field as well as support their progress towards meeting the course goals and the goals of the research study.

Prior to the First Field Experience Week

The first three weeks of the semester prior to the prospective teachers' first week in their field placement schools were structured to give the prospective teachers an introduction to complex instruction and culturally relevant pedagogy as well as discussing the importance of getting to know their students in this context. This was done because the prospective teachers were charged with shadowing one student in their first field placement to get to know their mathematics knowledge (*problem solving interview* project), culture, interests, home and community lives, and the mathematical practices that take place in these settings (*shadow a student* project). The *problem solving interview* and *shadow a student* project will be discussed in detail in later sections.

First, the prospective teachers were introduced to complex instruction through course readings and class discussions as a way to promote equitable mathematics teaching (Horn, 2010). The prospective teachers read the first two chapters of Horn's (2010) book on collaborative learning in secondary mathematics classrooms and a chapter on the benefits of group work as defined in complex instruction from Cohen's (1994) book on strategies for designing heterogeneous group work. Discussions around components of complex instruction were intended to provide a foundation of good mathematics teaching that can support equitable mathematics teaching and learning. During the introduction to complex instruction, the prospective teachers discussed the benefits of collaborative learning in contrast to more traditional mathematics teaching (i.e., direct instruction). They also created a concept map on the benefits of heterogeneous group work to synthesize what they read in Cohen's (1994) chapter.

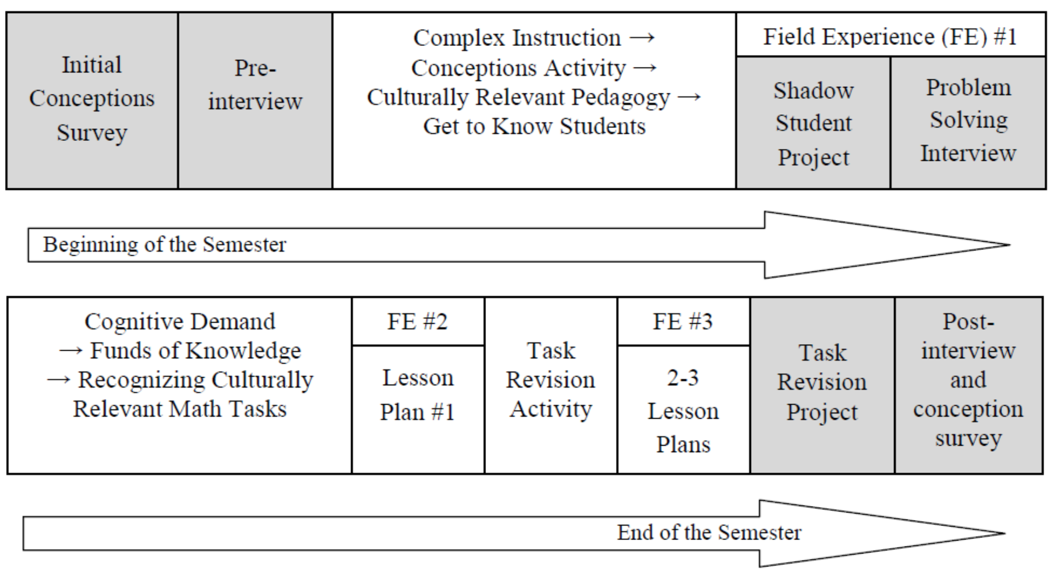


Figure 2 Middle School Mathematics Methods Course Timeline

Four classes later, the prospective teachers read about and discussed status issues in the mathematics classroom in terms of being able to recognize them in the classroom. They read another chapter from Horn's (2010) book regarding the multiple ways there are to be "smart" in mathematics. In particular, this chapter included a discussion of different "status treatments" (Cohen & Lotan, 1995) that could be used by thinking about what it means to be "smart" in mathematics, how they as teachers can promote multiple abilities and competencies in their classrooms, and how they can assign competence to low status students during collaborative work. The prospective teachers worked in small groups to fill out a table on where they can see status issues among students (in participation, listening, body language, etc.), how they manifest in student behavior (e.g., high status student taking control of the group), and what they can do to create equal-status interactions. Then we had a whole class discussion around these issues. The prospective teachers also participated in an activity where they had to pick out ways that they were smart in mathematics from a list and then they engaged in a brief discussion about how everyone is smart in mathematics in some ways and how they can value different strengths in the classroom.

On a different day, the prospective teachers also read and discussed an article written by Jo Boaler (2006) on the success teachers at Railside High School, a school in a low income urban area, had on student learning while implementing complex instruction. This allowed the prospective teachers to start to think about how complex instruction can be used in all school settings with all students, particularly culturally and linguistically diverse students in low income, urban schools.

In addition, during the same class when prospective teachers discussed status issues in the classroom, they completed a reading by Dweck (2010) on growth and fixed mind-sets. To engage the prospective teachers in thinking about what the difference is between a growth and a fixed mind-set in mathematics, the prospective teachers participated in a small group activity where they had to sort different statements from the teacher's perspective as growth (e.g., "I prefer to give my students challenging mathematics tasks to push their thinking.") or fixed (e.g., "It is ok that some of my students are bad at math. This is true for many people."). Then we had a whole class discussion on how to classify each statement and the benefits of having a growth mind-set towards students (Mueller & Dweck, 1998). The readings, discussions, and course activities surrounding complex instruction and mind-sets were used to support the prospective teachers to move away from a deficit perspective of students. The use of high-level mathematics tasks was not specifically discussed until the weeks after the first week of their field experience.

During the second week of the course, prospective teachers read about and briefly discussed diversity pedagogy to support their thinking on the "critical role culture plays in the teaching-learning process" (Sheets, 2009, p. 11). This was an important idea to help support the prospective teachers in learning about culturally relevant pedagogy and served as an introduction to the idea that students' culture is linked to mathematics teaching and learning (Nasir et al., 2008). The prospective teachers also completed a conceptions activity (called the Mythtakes activity) where they had discussions around common beliefs that help or hinder teachers' work with racially and ethnically diverse students (Hawley, Irvine, & Landa, n.d.). The Mythtakes activity required the prospective teachers to agree or disagree with thirteen statements regarding the teaching of racial and ethnic minority students (e.g., "Teachers should adapt their teaching to the distinctive cultures of African American, Latino, Asian and Native American students.”), low income students (e.g., “The gap in achievement among students of different races is about poverty, not race.”), and other teaching practices (e.g., “I try to keep in mind the limits of my students’ ability and give them assignments that I know they can do so that they do not become discouraged.”) and conceptions (e.g., “I don’t think of my students in terms of their race or ethnicity; I am color blind when it comes to my teaching.”). Then during class, the prospective teachers were given a set of responses, one for each of the thirteen statements, which they had to read and give reactions to. For example, the response to the statement regarding the achievement gap stated that income is related to student achievement but that when taken into account, race does explain some of the differences (e.g., Lubienski, 2002). This activity was structured to help prospective teachers begin to confront and discuss some of the deficit, color-blind, and/or productive beliefs they and others might have held about the teaching and learning of racial and ethnic minority students and to strengthen their awareness that students’ cultural backgrounds and home and community lives play a role in teaching and learning.

This activity was not finished on this particular day and was returned to on numerous occasions throughout the semester when particular conceptions about students or mathematics teaching and learning may have been related to the topic for that day. For example, during the class on the benefits of whole class discussions, we discussed the statement and response that addressed cultural differences that could contribute to students being shy, quiet, or embarrassed to speak during whole class discussions. Specifically, the prospective teachers discussed how it was important to be sensitive to cultural issues, but that they needed to support students in learning how to communicate their thinking.

The next class meeting, prospective teachers were charged with writing a working definition of culture for the course based on readings they completed for class and on their prior knowledge. This activity was important because in order to understand culturally relevant pedagogy, it is essential that the prospective teachers recognize that a person's culture is not just the visible aspects that we can see (food, race, holidays, etc.), but includes the way people view the world and how they interact with others (Ascher, 1994). This is because the invisible parts of culture "are more important for teachers to know than others because they have direct implications for teaching and learning" (Gay, 2002, p. 107). After much discussion, a definition of culture was produced and served as the definition of culture for this study. Culture is the worldviews, values, perspectives, geography, beliefs, rules of interaction, personality and family patterns, and "ways of organizing, interpreting, conceptualizing, and giving meaning to their physical and social worlds" (Ascher, 1994, p. 2) Artifacts, traditions, race, and ethnicity are a part of a students' (visible) culture, but culture goes beyond just these easily observed traits. This definition of culture was referred to periodically throughout the semester when discussing issues related to student culture and culturally relevant pedagogy.

That same day, an introduction to culturally relevant pedagogy was made through readings (Irvine, 2009; Ladson-Billings, 1997), watching a short video (Garcia, 2010), introducing definitions, and a class discussion. It was important to introduce students to culturally relevant pedagogy as this was the foundation for this study. The goal for this class meeting was for prospective teachers to understand what culturally relevant pedagogy is, some of the practices associated with it, and to see some examples of it through readings. Prospective teachers first watched a short video to introduce culturally relevant pedagogy (Garcia, 2010) and then definitions of culturally relevant pedagogy (Ladson-Billings, 1995a) and culturally relevant mathematics pedagogy (see, Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Rubel & Chu, 2011) were given to them. These were the same definitions as discussed in the literature review. While the critical consciousness component of culturally relevant pedagogy was briefly discussed at the end of the semester (it was only mentioned on this day), the discussions during the majority of the semester focused on the other two components of culturally relevant pedagogy (academic success and cultural competence). As described in the literature review, the critical consciousness component is the most difficult for prospective (and in-service) teachers to understand and enact (e.g., Young, 2010) and given the limited time in the course, focusing on the other two components provided an opportunity for the prospective teachers to engage with these ideas in more depth than if focus was given to all three components.

Finally, the prospective teachers completed readings around the importance of getting to know students both as learners of mathematics as well as the students' culture, interests, competencies, and home and community lives (Philipp & Thanheiser, 2010). Particularly emphasized was the importance of doing so to maintain and develop students' cultural competence (Ladson-Billings, 2001). These readings were included on this day because the prospective teachers were about to go into their first week in the field where they were asked to get to know one student in these ways. Thus, it was important to discuss the reasoning behind why they would want to get to know their students in this capacity, particularly from a culturally relevant standpoint of maintaining and developing students' cultural competence as they would be using the information they gathered to revise a high-level mathematics task to be culturally relevant for this student. It is important to note that during this class and frequently throughout the semester, it was made clear to the prospective teachers that it is important to not generalize students based on certain characteristics. In other words, while a student's race, culture, socioeconomic status, etc. are part of who that student is, it is important to get to know students as individuals rather than make assumptions about them based on particular characteristics. Because of this, class discussions were held around strategies for getting to know students' mathematics knowledge in a one-on-one problem-solving interview setting as well as how to approach talking to their students about their culture, interests, competencies, and home and community lives.

Prior to the Second Field Experience Week

The goal for the three weeks prior to the prospective teachers' second week in the field was to prepare them to write and teach their first middle school mathematics lesson plan for the semester. A large focus during these weeks was recognizing and selecting high-level mathematics tasks for use with students. Another focus was for the prospective teachers to begin thinking about how high-level mathematics tasks can incorporate students' culture, interests, competencies, and home and community lives. The connection to complex instruction was made when discussing these types of high-level mathematics tasks as the ones that can be considered "groupworthy" (Horn, 2010). How these issues were addressed during the course will be discussed in what follows.

One class meeting was focused on sorting mathematics tasks by level of cognitive demand. The prospective teachers had to sort a variety of mathematics tasks as memorization, procedures without connections, procedures with connections, and doing mathematics (Smith & Stein, 1998). This was done so that the prospective teachers could understand what a high-level mathematics task looks like at the middle school level so that they would be able to select such tasks for their lesson plans and so that they could recognize these tasks when they were asked to revise such a task to be more culturally relevant for one student.

Another class meeting was focused on culture and community funds of knowledge where the prospective teachers had to complete readings, a class discussion of those readings, and an activity. This body of research suggests that children's funds of knowledge, which are the "diverse cultural and linguistic knowledge, skills, and experiences found in children's homes and communities" (Turner et al., 2011, p. 68), can and should be utilized to promote the academic achievement of those children. It was important for the prospective teachers to understand how the knowledge and skills that children have specific to their home cultures and communities can be seen as student strengths instead of weaknesses and can be a foundation for future learning (González et al., 2001). Specifically, the prospective teachers were asked to read about and examine some examples of mathematics tasks that drew on students' culture and community funds of knowledge (see, Klein & Hendrickson, 2011; Kyle, McIntyre, & Moore, 2001) as a way to start thinking about how they can do this for their own students. One article provided an example of a task related to volume and area of a barn that drew upon rural students' experiences working on farms (Klein & Hendrickson, 2011). The other article discussed how the teachers used students' family recipes to create mathematics word problems (Kyle et al., 2001). These readings started a discussion of how these funds of knowledge can be used in their mathematics instruction. Then the prospective teachers completed an activity where they had to determine how different elements related to funds of knowledge were handled in their own homes (e.g., care of siblings, cooking) in order to start a discussion about how their students might have different experiences and what the implications are for their mathematics instruction. These discussions were important for the prospective teachers to start to develop a sense of how to go about taking students' backgrounds into account in their mathematics instruction, particularly in mathematics tasks.

Also, another class meeting was focused on culturally relevant pedagogy and its importance to mathematics teaching. For this class meeting, the prospective teachers read specific examples of culturally relevant tasks being used in mathematics classrooms (see, Barta, Sanchez, & Barta, 2009; Leonard & Guha, 2002; Torres-Valasquez & Lobo, 2005) in order to gain more exposure to mathematics tasks that take students' backgrounds into account. During the class session, the prospective teachers discussed these readings and, between what they learned the previous class session and in these new readings, they had to discuss what they thought a good culturally relevant mathematics task looks like. This discussion (and the previous discussion of funds of knowledge) served to introduce the prospective teachers to being able to recognize what a culturally relevant mathematics task is. What I highlighted during this discussion was that culturally relevant mathematics tasks have the properties of high-level mathematics tasks in general (i.e., high level of cognitive demand, multiple entry points, requires explanations, open-ended (Stein & Lane, 1996)), but that they also drew upon students' culture, interests, and/or home and community lives. These ideas were brought up by the prospective teachers, but I made sure to highlight them at the end of the discussion. In addition, the ideas surrounding culturally relevant pedagogy and funds of knowledge were brought up during other class meetings where appropriate so that the prospective teachers could continue to develop more positive conceptions towards students who are socio-culturally different from them and the practices that will be effective with those students.

Prior to the Third Field Experience Week

During the weeks leading up to their third week in their field placement schools, the focus was for the prospective teachers to learn how to revise a high-level mathematics task to be culturally relevant for one student. One class was focused on a reading by Jo Boaler (1993) that discussed the role of contexts in mathematics tasks and whether or not they make mathematics more meaningful for students. The purpose of this discussion was to have the prospective teachers realize that simply having a "real-world" context in a mathematics task does not necessarily make it interesting or motivating. In particular, it may also not realistically portray how a person would do mathematics in that real-world context. The difficulty comes "when students are required to engage partly as though a task were real whilst simultaneously ignoring factors that would be pertinent in the 'real life version' of the task" (Boaler, 1993, p. 14). It was an important distinction to make between problems that may not draw realistically on the mathematical, cultural, and home/community experiences that students may have and culturally relevant mathematics tasks that do draw on these things. Additionally, the purpose of this discussion was to illustrate to the prospective teachers how real-world contexts in curriculum materials do not necessarily motivate and/or engage students, draw on their prior knowledge, or provide opportunities to learn mathematics for conceptual understanding.

Once this idea was established, the prospective teachers engaged in an activity during the next class meeting to learn to revise a high-level mathematics task to be more culturally relevant for one student. I describe this activity in a later section (Task Revision Activity). To prepare for this activity, the prospective teachers read an article on how to tailor tasks to meet students' needs by taking into account the context, reading levels of the students, the overarching goals the teacher has for their students, and making sure to supplement the task with the content knowledge needed to engage in the task (McDuffie et al., 2011). This article was read to support the prospective teachers in understanding what they needed to consider when revising mathematics tasks to be culturally relevant for their students in addition to revising the context, which is what we focused on for the rest of the class meeting. In addition, the prospective teachers read and discussed how to launch culturally relevant tasks in the classroom (Jackson, Shahan, Gibbons, & Cobb, 2012). The critical aspects to launching such tasks that Jackson and colleagues (2012) discussed as being essential are: discuss the key contextual features, discuss the key mathematical ideas, develop a common language to describe the key features, and maintain the cognitive demand (e.g., Stein et al., 1996). It was important for the prospective teachers to take the launch of a task into account when they planned lessons because the opportunities given for students to engage with the task are just as important as the task itself. In addition, the prospective teachers had to draw on this article in their *task revision* projects as discussed in later sections. Other relevant course activities and assignments are discussed in the following sections.

Field Experience

The field placements the participants had during the middle school mathematics methods course varied. Janet and John were both placed in the same local 6-12 magnet school in a suburban middle-class neighborhood. The school is made up of approximately 65% White students and 19% Hispanic students with the rest split between Asian (4%), African American (11%), and multiracial (1%) students. In addition, approximately 36% of students come from low income households and 8% are English language learners. Rick was placed in a middle school in a suburban middle-class neighborhood. The school is made up of approximately 58% White students and 31% African American students with the rest split between Asian (3%), Hispanic (6%), and multiracial (2%) students. In addition, approximately 24% of students come from low income households. Zane was placed in a large middle school located in a rural area outside of a suburban neighborhood. The school is made up of approximately 48% African American students and 37% White students with the rest split between Asian (5%), Hispanic (8%), and multiracial (2%) students. In addition, approximately 51% of students come from low income households.

Therefore, with the exception of Zane, the prospective teachers in this study were placed in majority White schools in suburban, middle class neighborhoods which closely resembled the demographics of the schools they attended as K-12 students. This should be kept in mind as it may have had an impact on the progress the prospective teachers made in their conceptions. In other words, the fact that the participants were placed in schools that resembled their experiences as children indicates that their field placements may not have provided them with additional opportunities to develop or confront their conceptions as it would have if the participants were placed in schools in low income urban areas or schools where White students are in the minority.

Lesson Plans

During the second and third field placement weeks the prospective teachers implemented three or four lesson plans (one during the second week and two or three during the third week) that they wrote following a specific lesson plan template that included describing the prior knowledge of the students in the class, the learning goals for the lesson, the planned activity, and any assessments. Lesson plans had to include high-level mathematics tasks. Thus, the prospective teachers had to write, select, or edit a mathematics task so that it was cognitively demanding and appropriate for the class that they would be teaching it in. They were not required to make these tasks culturally relevant because it was the first and second chance they got to select and teach high-level middle school mathematics tasks on their own. These lesson plans and field placements served to further support the prospective teachers' understanding of high-level mathematics tasks and provided them a chance to learn how to select high-level tasks that were appropriate for the classroom they taught them in.

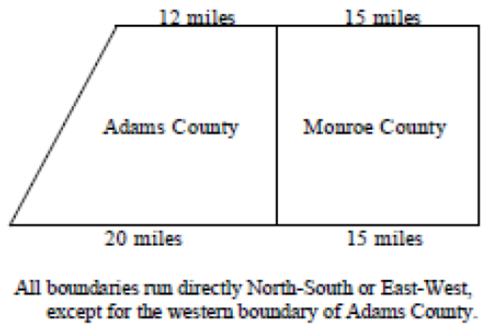
Task Revision Activity

The task revision activity took place over two class meetings prior to the third field experience week (see Figure 2) and was designed to prepare the prospective teachers to complete the *task revision* project which is described in a later section. Small groups of prospective teachers were given an opportunity to decide whether or not a written task was culturally relevant for a particular student and then to revise a high-level mathematics task to be more culturally relevant for that student. The rationale for revising a high-level mathematics task as opposed to any mathematics task (at a low or high level of cognitive demand) is that raising the cognitive demand of a low-level mathematics task is a different skill and because this activity is the participants' first time learning to revise tasks for cultural relevance, I felt it better to focus on one skill set rather than both.

Specifically, the prospective teachers were first given a fake profile of an African American, female middle school student (see Appendix A) that contained information that reflected the kinds of information the prospective teachers found out about the student that they were required to get to know during their first field placement week (see *shadow a student* project description in later section). The information regarded demographic information, her family, her interests, her behavior at school, her favorite school subjects, and the home and community activities she engages in. Then the prospective teachers were provided with a number of high-level mathematics tasks that had one or two revised versions of that task. Using the criteria for how to revise a culturally relevant task as discussed in the theoretical framework in Table 1, the prospective teachers had to determine to what extent the revisions were good culturally relevant revisions for this student.

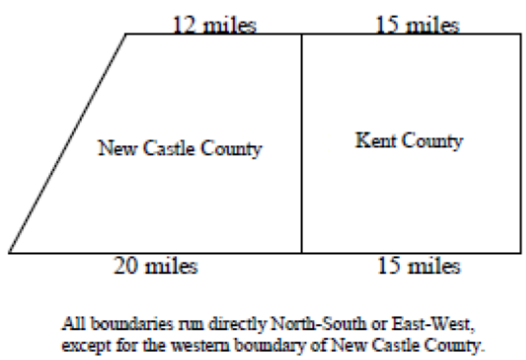
Figure 3 shows an example of one original task and two revisions; one not ideal and one more ideal. The original task (Figure 3a) is a high-level mathematics task that requires students to argue whether the area of one polygon is larger than another polygon of the same height when the height measurement is missing. Figure 3b shows one revision that can be described as not ideal. This is because the revision that was made just changed the names of the counties to counties in the state where the student lived and may be familiar with. This is an example of a surface level change based on component 2 of the theoretical framework (Table 1). In addition, the revision does not necessarily draw on a meaningful context (component 1) or the mathematical practices of the student (component 3) based on the information given.

a)



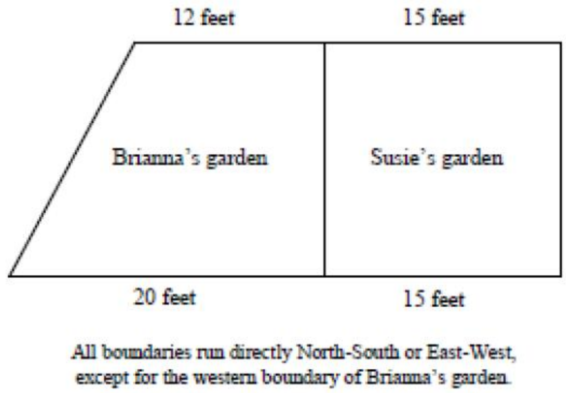
The Sheriff of Adams County and the Sheriff of Monroe County are having an argument. Each of them believes that their own county is larger than the other county. Who is right? Write an explanation that would settle the argument.

b)



The Sheriff of New Castle County and the Sheriff of Kent County are having an argument. Each of them believes that their own county is larger than the other county. Who is right? Write an explanation that would settle the argument.

c)



Brianna and Susie have split the church's community garden into two pieces. They want to know if they have fairly split up the garden in terms of how much work it would take to take care of. Determine if the garden has been split up fairly. Explain how you can tell.

Figure 3 Example of a) an original task (Balanced Assessment - Harvard Group, 2000a); b) one less ideal revision; and c) one more ideal culturally relevant revision

Figure 3c shows a more ideal revision. This revision drew upon something meaningful for the student (the student helped tend to the church community garden) which addresses component 1 of the theoretical framework (Table 1). What is also important to point out here is that not only is the community garden a meaningful context for the student, the task revision also draws upon what is potentially the students' invisible culture (i.e., the student works well with her peers). Instead of the context being around an argument she is having, the task instead asks the student to consider working with her friend to determine what is fair. The revised task also draws upon the mathematics in the context (the dilemma in the task is something that may need to be considered as it is a community garden) which addresses component 2 of the framework. However, it is not a perfect task revision in that the task may be related to mathematical practices the student has experience with (component 3), but it is not clear from the profile whether the student has experienced this particular context surrounding taking care of a garden. Most of the task revisions the prospective teachers had to consider were similar to the ones in Figure 3 in that they had some good and some not as good characteristics so that the prospective teachers had an opportunity to argue and discuss what was more ideal and less ideal in terms of the revision.

Then, the prospective teachers worked in groups to revise a different high-level mathematics task to be more culturally relevant for the student described in the fake profile. As a class, we discussed each group's revision and provided feedback to each group on how to improve it. Finally, the students discussed in their groups how to launch the revised version of the task if they were to use it in a classroom setting by using the framework presented by Jackson and colleagues (2012). The purpose of this activity was to prepare the prospective teachers to revise a high-level mathematics task on their own for the student that they shadowed.

Course Assignments

In this section, I discuss the three main course projects that served as data for this study. The specific data collected are discussed in the data collection section.

Shadow a Student Project

The *shadow a student* project was completed by the prospective teachers during the first week of their field experience. This project was adapted from a version provided by the TEACH MATH project (http://mathconnect.hs.iastate.edu/) and a project written by a previous course instructor of the middle school mathematics methods course who is a TEACH MATH project co-PI. This project required the prospective teachers to shadow a student who was socio-culturally different from them in some way and labeled as struggling in mathematics (by the cooperating teacher) for at least five hours. They were instructed to observe the student in their classes (at most two hours in their math class) and to informally interview them in the hallways, before or after school, during breaks, or at lunch.

The prospective teachers were also instructed to learn about their students' interests, culture, and home and community lives and to look for ways that the student demonstrated his or her competence in these areas. For example, they had to ask their students questions like "What do you like to do after school?" and "What kinds of things do you do with your family/friends at home?" and "What are some places in the community that you like to go to with your family?" In particular, the prospective teachers were instructed to determine the mathematical practices that their student engaged in outside of the mathematics classroom. For example, the prospective teachers were to find out the activities the students engaged in where they had to use mathematics such as shopping, cooking, and playing sports. This project also required the prospective teachers to think about how they could use what they learned about their student to inform their mathematics teaching. This included problem contexts or instructional strategies to include and involve that student in mathematics class. The prospective teachers were required to write a paper, make a poster, or create a slide show that represented what they learned about the students' interests, families, and home and community lives; the mathematical practices that occur in these categories; students' competencies and behavior in school; and how what they learned would inform their mathematics teaching.

One purpose of this project was to help the prospective teachers understand the importance of getting to know and building relationships with their students. In particular, prospective teachers should have developed an understanding that learning about their students' interests and cultures can support students' mathematics learning (Philipp & Thanheiser, 2010). Another purpose was for the prospective teachers to address deficit views of students and focus on student competencies. By having the participants follow students who struggle in mathematics with explicit instructions to focus on what their students were good at, I hoped that they would start to realize how all students are competent in some ways and that they can use these competencies in their mathematics instruction to support student learning. In order to be an effective mathematics teacher for all students, including racial and ethnic minority students in urban, high-needs schools, it is essential to focus on the competencies, skills, and knowledge of students and their homes and communities (e.g., Gutstein et al., 1997; Ladson-Billings, 1997). Getting the participants to think about how to use what they learned in their mathematics instruction more generally was a stepping stone towards learning to revise a high-level mathematics task to be culturally relevant for the student that they shadowed.

Problem-Solving Interview

In addition to shadowing a student during the first field experience week, the prospective teachers were asked to conduct a problem-solving interview with their chosen student. The prospective teachers were provided with the mathematics tasks for their student to complete during the interview. They were word problems on growth patterns, division of fractions, and proportional reasoning. The problems were written by a previous instructor of the middle school mathematics methods course with the exception of the proportional reasoning problem which came from the NCTM yearbook on fractions, ratios, and proportional reasoning (Khoury, 2002). Interviews generally take between 20 and 30 minutes. The prospective teachers had to conduct the interview, record the student's responses (by audio recording, taking handwritten notes, collecting the student work), and analyze and make claims about the student's mathematical thinking in a project write-up. The prospective teachers were asked to specifically write claims and provide evidence for the strengths they saw in their student's mathematics problem-solving ability. Based on these claims, the prospective teachers had to describe what they would teach this student next to support the development of their mathematical understanding. They had to describe how they would teach this student and provide multiple examples of specific mathematics tasks they would give the student.

The purpose of this interview was for prospective teachers to practice interpreting and assessing students' thinking about mathematics. This interview also served to help the prospective teachers to not just look for student strengths and competencies outside of school and/or mathematics (*shadow a student* project), but with respect to mathematics content as well. In this way, the prospective teachers were provided a chance to specifically look for student competencies in their mathematical thinking to help them see that students from all backgrounds, cultures, and achievement levels have some strengths related to mathematics and that it is important to find out what their students know so they can build upon that.

This project, along with the *shadow a student* project, was designed to help the prospective teachers build towards being able to revise a high-level mathematics task to be more culturally relevant for one student. The prospective teachers had to learn enough details about one student to complete the *task revision* project successfully and in a meaningful way. In addition, by having the prospective teachers think about how they can use what they learned in their mathematics instruction more generally, they may have been better prepared to engage in the task revision activity (described above) and the *task revision* project where they had to use the information they gathered in a more specific and focused way.

Task Revision Project

The *task revision* project served to give the prospective teachers a chance to apply what they learned throughout the semester to revise a high-level mathematics task to make it culturally relevant for one student. The prospective teachers were provided with five high-level mathematics tasks and were asked to choose one to revise to be culturally relevant for the student they shadowed. Two of these tasks came from a cognitive demand task sort activity (Smith, Stein, Arbaugh, Brown, & Mossgrove, 2004), two from teacher resource websites (Balanced Assessment - Harvard Group, 2000b; The Franklin Institute, n.d.), and one I designed on growth patterns based on similar tasks encountered in one of the elementary mathematics content courses taken by the participants (see Appendix B). Four of the tasks were classified at the "doing mathematics" level of cognitive demand and the task on growth patterns was classified as "procedures with connections." These ratings were confirmed by another graduate student with experience studying cognitive demand of tasks.

A choice of tasks was given because it was unlikely that one task would be at a similar level of difficulty to revise for all of the students that were shadowed. In other words, the prospective teacher could select a task to revise that made the most sense according to what they learned about their student. The prospective teachers were required to revise the task to make it culturally relevant for their student by addressing each component of the theoretical framework on revising high-level mathematics tasks to be culturally relevant discussed in the previous chapter (see Table 1).

The prospective teachers also had to write a short paper to explain how they revised the task and why. More specifically, they had to describe why they chose the particular task they did to revise, how their revision of the task appropriately addressed something about the students' culture, interests, and/or competencies, why they chose that characteristic to focus on, and how they maintained (or raised, if possible) the cognitive demand of the task. They also had to describe how they would launch and implement the task in a classroom with this student and provide a rationale for their choices based on what they learned about their student and what they know about good mathematics teaching and learning. For the launch, the prospective teachers were required to respond to each of the critical aspects that Jackson and colleagues (2012) discussed as being essential to launching high-level mathematics tasks (i.e., discuss the key contextual features, discuss the key mathematical ideas, develop a common language to describe the key features, and maintain the cognitive demand). This was meant to enable me to make connections between the prospective teachers' conceptions of mathematics teaching and learning and of socio-culturally diverse students and the prospective teachers' performance on this project based on their discussion of and rationales for their choices.

Data Sources and Data Collection Procedures

Some of the prospective teachers' course assignments, pre- and post-interviews, and pre- and post-surveys served as the sources of the data for this study.

The data collected from the course assignments, interviews, and surveys is described below and data analysis procedures are described in the next section.

Pre-Post Interviews

Semi-structured pre- and post-interviews were conducted with all four of the participants at the beginning and end of the semester. The purpose of the pre- and post-interviews were to provide evidence for the research questions in terms of the progress that the prospective teachers made over the semester and for comparing their conceptions as measured by these interviews with their ability to revise a high-level mathematics task to be more culturally relevant for one student. All interviews were audio recorded and then transcribed in their entirety. The pre-interview occurred during the second week of class prior to any discussions of culturally relevant pedagogy by three mathematics education graduate students. This was done to keep the identities of the participants hidden from the instructor/researcher. The post-interview was conducted at the end of the semester after final grades were submitted by the instructor of the course.

First, the participants were asked to discuss their mathematical experiences as middle school students, what they felt their strengths and weaknesses in mathematics were, and how they viewed themselves as mathematics learners (e.g., good at procedures, likes "real-world" mathematics tasks) in order to gather some evidence of the participants' prior experiences with mathematics. Then the participants were asked to discuss their conceptions about (1) the relevance and impact of culture in mathematics teaching and learning, (2) the nature of mathematics and who can do math, (3) urban, high-needs schools, (4) students (to determine if they have deficit or stereotypical conceptions), and (4) the importance of getting to know their students.

This was done by providing the participants with different teaching scenarios and asking them to respond to the scenarios (See Appendix E).

Table 2 provides an example of a scenario and the questions they were asked in response to the scenario. The prospective teachers were given a card with each scenario printed on it and were asked to read it as the interviewer read the scenario out loud. Then the interviewer would ask the prospective teachers to respond to the scenario. Probing and follow-up questions were asked when necessary in order to get more detailed responses. Specifically for the teaching scenarios, the questions on the protocol (see Appendix E) in bold were ones they had to ask the participants and the others in plain text were probing questions.

The intent of these scenarios was to avoid asking the participants direct questions about culture, students, urban, high-needs schools, etc. in order to ensure that the "correct" response was not apparent to the participants. In other words, if I had asked the prospective teachers directly about their conceptions of racial and ethnic minority students and mathematics teaching and learning, they may have given responses based on what they thought I wanted to hear (e.g., they would avoid stating stereotypes, even if they held them) and therefore, may not have been honest about what they really thought. For example, instead of asking the participants the extent to which they need to be aware of students' cultures as mathematics teachers (i.e., whether mathematics is culture-free), they had to respond to the scenario in Table 2. Also, the scenarios and follow-up questions were open enough to allow for probing questions (e.g., "Why do you feel that way?" and "What would you do as the teacher?") which allowed the prospective teachers to expand more deeply upon their thinking and hopefully give responses relating to their actual conceptions as it was less apparent what the "correct" answer was.

Table 2 Pre-Post Interview Example Teaching Scenario and Interview Questions

Teaching Scenario	Interview Questions
Imagine you are a seventh grade mathematics teacher at a professional development on multicultural education. One of your colleagues turns to you and says: "I don't see why I have to worry about student's culture in my teaching because mathematics is a universal subject. It's the same everywhere!"	**What is your reaction to your colleague's comment?** *Probing Questions:* Do you agree or disagree? How would you respond to that teacher and why?

In addition, during the post-interview only, the prospective teachers had the opportunity to revise their *task revision* project tasks and write-ups in response to the feedback given to them by the instructor. This part of the interview was different for each participant because they all received different feedback from the instructor. Specifically, the prospective teachers were asked to read the feedback written on the project and then the instructor (who was conducting the interview) explained the feedback given. Then the instructor asked the participant to respond to that feedback. For example, one participant (John) made surface level changes in his revised task and so the instructor explained to him why his task revision was at a surface level (he replaced some nouns with others but left the task mostly in tact) and asked him how he would revise the task differently. Other participants had to elaborate on their rationales for the launch and implementation of the task (Rick and Zane) and on the fact that their revised task addressed a slightly different mathematics topic (Zane). One participant (Janet) received mostly positive feedback and so was asked to elaborate on why she chose the particular student interest to focus on in her revision. She was also asked how realistic she felt her task was for her student as this was a concern that she had brought up in her project write-up.

This part of the interview was used to determine whether the prospective teachers could learn from and apply the feedback given to them within their zone of proximal development (Vygotsky, 1987) to make the task more culturally relevant. In other words, the participants were able to make more progress in their knowledge and skills of revising a high-level mathematics task to be more culturally relevant when given feedback and probed to respond to it. This part of the interview provided evidence for the first research question regarding the progress the participants made in terms of being able to use what they learned about a particular student to revise a high-level mathematics task to be culturally relevant for that student.

Conceptions Survey

For homework after the first class meeting and again on the last day of the semester, all twelve of the prospective teachers enrolled in the course were given a survey to complete online using Qualtrics software to get an idea of the conceptions the prospective teachers had regarding teaching mathematics to socio-culturally diverse students, including those in urban, high-needs schools at the beginning and end of the semester. The survey consisted of open-ended questions as well as five-point Likert-type items where the prospective teachers had to rate statements from strongly disagree to strongly agree.

This survey is a slightly modified version of a survey administered for a pilot study with 115 elementary prospective teachers at various stages of their teacher education programs (Gallivan, 2012). The pilot study survey items were purposefully created by the researcher based on relevant literature on prospective teachers' conceptions (e.g., stereotypes they may hold about students of color and/or urban, high-needs schools) as well as conceptions about the nature of mathematics in relation to issues of equity (e.g., culture does not play a role in mathematics learning). Five more Likert-type items were added to the pilot study survey to address conceptions about English language learners, low income students, ability grouping, the need to develop basic skills first, and color- and culture-blindness. In addition, four more open-ended questions were added to gain insight into how the participants viewed mathematics as a subject, what makes a successful mathematics student and teacher, and to gather information about the participants' field placement classrooms prior to this course (at the beginning of the semester) and their middle school field placement (at the end of the semester). The purpose of this survey was to help answer the first research question regarding the progress the participants could make over the one-semester middle school mathematics methods course. In particular, the data from this survey was used to support the claims made about the participants' conceptions based on the pre-post interview data.

Likert-Type Items

The survey given to the participants consisted of 32 Likert-type items which consisted of 5-point scales from strongly disagree to strongly agree. Examples of these items include: "Students' success in mathematics depends on the support they receive at home" and "It is necessary to incorporate the diverse cultures of students into mathematics curriculum" (see Appendix D for the entire survey). Based on a factor analysis of 115 prospective teacher responses to 18 of the Likert-type items on this survey (Gallivan, 2012), three different subscales were determined: importance of culture (6 items), intentions to teach in urban schools (4 items), and factors influencing student achievement (student characteristics and environment characteristics) (8 items). These three subscales were used in the analysis of the current study participants' responses as described in the data analysis section.

Reliability and validity were found for each of the three subscales based on the 115 participants from the pilot study (Gallivan, 2012). Internal consistency estimates of reliability were computed using Cronbach's α. Internal consistency reliability for intentions to teach in urban schools was 0.80, for importance of culture was 0.73, and for student achievement was 0.76. The reliability for the intentions to teach in urban schools subscale is at an appropriately high level. The reliability for the importance of culture scale and the student achievement scale are slightly lower than ideal, but they are acceptable given the relatively few items in each. Internal consistency reliability can also be seen as a measure of content validity because high internal consistency implies that it is likely these items measure the same thing. Also, content validity was assessed for the entire survey by the researcher as well as an expert of equity in mathematics education when the survey was developed to determine that the survey items would measure the prospective teachers' conceptions as intended.

Open-Ended Questions

There were a number of open-ended questions on the survey. There were questions that addressed the demographic make-up of the prospective teachers' home neighborhood and the demographic make-up of the high school they attended to get an idea of how much exposure to socio-culturally diverse people the prospective teachers may have had growing up. In addition, two questions were asked about the prospective teachers' prior experiences with socio-culturally diverse children: (1) their experiences outside of teacher education program requirements and (2) their experiences gained through teacher education field experiences. Three questions addressed the challenges they believed they would face teaching mathematics to (1) students with different cultural and racial backgrounds; (2) economically disadvantaged students; and (3) students in urban, high-needs schools. Two questions addressed whether or not they intended to teach (1) in a school with a majority students of color or (2) in an urban, high-needs school. Finally, the participants answered the four added questions as described above.

Course Assignments

The data collected from the *shadow a student* project, *problem-solving interview* project, and *task revision* project consisted of the participants' written reflections. For the *shadow a student* project write-up, the participants either wrote a reflection paper or created a slide-show based on what they learned about the student, their initial ideas for mathematics instruction, and personal reflection on the experience itself. This reflection paper or slide show served as the source of data. For the *problem-solving interview* project, the data consisted of the reflection paper where they were required to write claims about their students' mathematical thinking and their ideas for next steps of instruction for their students. Finally, for the *task revision* project, the data consisted of the participants' revised tasks and the reflection paper for their rationale of the choices they made revising the task and ideas for the launch and implementation of the task in a classroom.

Teacher Researcher

In addition to being the researcher for this study, I was also the instructor for the middle school mathematics methods course. The reason was that I wanted to ensure that all of the interventions during the semester were conducted in the way that I intended, particularly the lessons on culturally relevant pedagogy. Because the middle school mathematics methods course was the first time these prospective teachers were exposed to the ideas of culturally relevant pedagogy and issues of race and culture more generally in the context of mathematics, I wanted to provide opportunities for the prospective teachers to think about and address these issues throughout the semester, even if it was not the main goal for that class period. As the instructor, I controlled the implementation of these opportunities throughout the semester.

There are, of course, some limitations to being the teacher and the researcher of a study. I had to carefully address concerns regarding whether the prospective teachers felt pressure to participate in the study or were worried how their grade was affected because I was the one who assessed them throughout the semester. From the beginning of the semester, I made it clear that participation in this study was completely voluntary and that they could drop out of the study at any time during the semester. In addition, I trained three other mathematics education graduate students to conduct the pre-interviews with the prospective teachers which enabled me to hide the identities of the prospective teachers participating in the study from me until the semester ended. To train these graduate students, they first read over the interview protocol in its entirety. Then, I gave explicit instructions on how to conduct each part of the protocol. I explained that I wanted them to go through each scenario by reading it out loud to the participant while the participant read along on an index card. Then the interviewer had the participant respond to the scenario by asking a series of questions (see Appendix E). The interviewers were told that they could ask the participants to elaborate on their responses by asking “Why?” or “Can you say more about that?” but they were told not to ask any other questions to avoid leading the participants to answer in particular ways and to ensure that all of the participants received the same interview questions regardless of who interviewed them.

The prospective teachers were assigned a number (by one of the interviewers) and those who agreed to participate in the full study were contacted by the person conducting the pre-interview. None of the interviews or course assignments were analyzed for the study (beyond assigning course grades) before the end of the semester. In addition, I conducted the post-interview with the participants immediately after final grades were submitted so that there was no concern that their final grade was influenced by their participation in the final interview.

Another concern was that during the post-interview, they may have been more inclined to answer the questions based on what they thought I wanted to hear. This was a concern because they had heard me speak about the issues addressed in the interview numerous times during the semester and so may have felt pressure to say certain things. To address this issue, the interviews contained teaching scenarios the participants had to respond to as explained in a previous section (see Appendix E for the interview protocol).

Data Analysis

All of the data were analyzed using different methods depending on the sources of the data. I elaborate on each of these data analysis methods in this section. In addition, all of the data were analyzed at the end of the semester to ensure the identities of all of the participants were hidden until final grades had been posted.

Pre-Post Interviews

Pre- and post-interviews were audio recorded and transcribed in their entirety. Appendix F shows an analytical framework of prospective teachers' conceptions that was developed specifically for this study based on relevant research presented in the literature review chapter and the results of the pilot study (Gallivan, 2012). This framework is organized by broad categories (*unproductive conceptions, color- or culture-blind conceptions, missionary conceptions,* and *productive conceptions*). These categories mirror the conceptions discussed in the literature review. The distinction between the productive conceptions and the other categories is in reference to the potential for these conceptions to positively (or negatively) impact the teaching practices a teacher might use to provide students with opportunities to learn. For example, as discussed in the literature review, a teacher who holds a growth mind-set regarding her students' intelligence (Dweck, 2010) may be more inclined to provide opportunities that push and challenge students to learn at higher levels.

In addition, sub-categories were initially developed for each of these broad categories. For example, sub-categories for the *unproductive conceptions* category include *stereotypes based on income, deficit conceptions (low motivation, lower ability, behavior problems)*, and *direct instructional practices*. Each interview transcript was coded using NVivo10 data analysis software. The transcripts were analyzed using open coding and analytic induction (Bogdan & Biklen, 1992; Merriam, 1998) in order to identify patterns in each interview for each prospective teacher. The transcripts were coded twice to look for instances of the prospective teachers' conceptions related to the sub-categories of the analytical framework. For example, when John said "I think because she doesn't get any help at home…her parents are working full time" about a low income student, this got coded as sub-category *stereotypes based on income,* under the broad category of *unproductive conceptions* because John made an assumption that low income students often do not have parental support.

When coding the interview transcripts, the analytical framework remained flexible and open to change throughout the analysis to account for unexpected responses or responses that did not fit into the predetermined categories (Bloomberg & Volpe, 2008). This means that some sub-categories were added to the framework and some were deleted. In other words, if there was something a participant said during an interview that did not match one of the sub-categories, but fit under one of the broader categories, a new sub-category was added. For example, Rick expressed numerous times in his pre- and post-interviews that the teacher should be held responsible for student learning (as opposed to blaming out-of-school factors like family income) and so a new sub-category was added to the *productive conceptions* category: *teacher responsible for student learning*. In addition, if a sub-category in the original analytical framework was not used, it was removed from the framework. For example, the sub-category *challenging curriculum appropriate for all students* under the *productive conceptions* category was not addressed by any of the participants, so it was removed. In Appendix F, the added sub-categories are in bold and those that were removed are in strike-through font.

All of the changes to the analytical framework were made in the first coding of all of the interviews. In other words, each interview was coded once with the framework, adding codes as needed. Then, the interviews were all coded a second time with the revised framework to determine (1) whether other codes needed to be added to, modified, or removed from the framework and (2) whether the codes were applied consistently by the researcher. Finally, the codes that were not applied to any interview were removed from the framework. After the second coding, it was determined that no adjustments needed to be made to the framework and that the codes were applied consistently throughout. It should be noted that, after the framework was finalized and all interviews had been coded twice, one of the interviews was coded again by the researcher a week later. This was done to ensure that the researcher was consistent in applying the codes to the interview transcripts over time. Also, the prospective teachers' are complex cases and thus, their responses to the interview scenarios did not all fit under one of the broad categories of the analytical framework. In other words, one prospective teacher's responses may have been coded under multiple broad categories and several of the sub-categories.

During the post-interview only, the prospective teachers were asked to look at their *task revision* project again to see if they could make more progress in their ability to revise a high-level mathematics task to be more culturally relevant for one student after they had received graded feedback from the instructor. Thus, the post-interview transcripts were analyzed for evidence that the prospective teachers understood the feedback given to them and how they addressed some of that feedback. The evidence for making sure the prospective teachers' understood the feedback included repeating the feedback in their own words and attempting to address the feedback in the way that the instructor intended. For example, if the feedback was to elaborate on one of the components for launching the revised task (Jackson et al., 2012), evidence that they understood this included naming the component that needed to be addressed, stating what was lacking in their explanation, and then elaborating on that component beyond what they wrote in their *task revision* project write-up.

As stated in a previous section, the prospective teachers received different feedback on their *task revision* projects and so were analyzed differently. Those participants who were given feedback on the task revision itself (John, Zane, and Janet) had their responses analyzed using the theoretical framework presented in Table 1 of the literature review. For example, Zane's revised task did not address the same mathematics content as the original task (component 5 of the framework) and so he was asked to rectify this during the post-interview. His response was coded according to whether or not he could revise his task again so that it did address the same mathematics content as the original task. In addition, John had to respond to the fact that his task revision was based on surface level changes (component 2) and Janet elaborated on what she learned that was meaningful for her student (component 1) and the extent to which her revision was realistic given the context (component 2). Rick, who did not receive feedback regarding his revised task, chose to provide an unprompted discussion regarding the realistic nature of his task (component 2). See the analysis for the *task revision* project in a later section for a more detailed account of how Table 1 was used to analyze the revised tasks. Also, two of the participants (Zane and Rick) also had to address feedback on their *task revision* project write-up pertaining to their rationale for their proposed plans for launching and implementing their revised tasks. These interactions during the post-interview were coded based on the relevant parts of a different analytical framework for the *task revision* project identically to what is described in a later section (see Appendix I).

Conceptions Survey

In this section, I discuss how the responses to the conceptions survey for the 12 study participants were analyzed. Because the sample was so small, factor analysis could not be completed on the Likert-type items. These prospective teachers were from a similar population of students as the pilot study (they were enrolled in the same elementary teacher education program at the same university). Therefore, the three subscales determined from the pilot study (Gallivan, 2012) were used to analyze the data for these participants. Note that negatively worded items (e.g., "Issues of diversity and equity do not matter in the teaching of mathematics.") were reverse-coded (i.e., a rating of 1 got coded as 5, 2 got coded as 4, 3 got coded as 3) so that higher ratings meant more productive conceptions. Then the prospective teachers' total scores were determined for each of the subscales by adding their ratings on each Likert-item so that higher scores indicate more productive conceptions. For example, the importance of culture subscale contained six Likert-type items so each of the participants received a score out of a possible 30 points. The closer to 30 points they received, the more positively they rated each of the statements. In this case, scores closer to 30 mean the prospective teacher felt that culture does matter in the sense that it needs to be taken into account in their mathematics instruction. For the extra Likert-type items that did not factor load onto a particular subscale, the participants' ratings on each item were noted in a spreadsheet.

Open-Ended Questions

Three of the open-ended items on the conceptions survey (i.e., challenges related to students with different cultural and racial backgrounds, economically disadvantaged students, and students in urban, high-needs schools) were analyzed for this study using the same analytical framework for the pre-post interviews (see Appendix F). The participants' responses to the open-ended items were coded identically to the pre-post interview responses. The responses were coded to look for evidence of the participants' conceptions using the framework. The responses to the survey were coded after all of the pre-post interview transcripts were analyzed. The responses for each participant were coded twice to ensure that the codes were applied consistently and that no changes to the framework needed to be made. While the framework was open to being modified while analyzing this survey (Bloomberg & Volpe, 2008), no changes were made to it.

Use of these Analyses in Results Chapter

The analyses of the survey responses (both Likert-type and open-ended) were only used if supporting data were needed for the interview responses. This was determined on a case-by-case basis and is made clear in the results chapter when data from this survey are referred to. In other words, if a participant expressed a particular conception in their interview responses, their responses to the open-ended questions and/or the Likert-type items were used to provide additional evidence of that conception if more evidence was necessary to fully support the claim. It is important to note that I compared the summaries from the conceptions survey to the interview analyses and found no instances where the participants' responses on either the survey or the interview conflicted with each other. In other words, the conceptions they expressed on the pre- and post-survey corroborated with the responses given during the pre- and post-interviews.

Shadow a Student Project

An analytical framework (see Appendix G) was developed based on the grading rubric created by past instructors of the methods course and modified by me to fit the specific changes made to the project from past semesters. The framework was developed by starting with the grading rubric for the project and removing the two unnecessary parts that do not pertain to the analysis for this study: (1) the participants' description of how they shadowed their student, for how long, in what settings, etc. and (2) their personal reflection of the shadowing experience. The other two parts of the rubric were used as the basis for the framework: (1) what the participants learned about the student and (2) their initial ideas on how to use that information in mathematics instruction more generally, which could have included teaching strategies or efforts to involve the student, problem contexts, or types of problems. Each part of the rubric was separated into categories and sub-categories.

In order to code what the prospective teachers' learned about the student they shadowed, broad categories were developed based on what the participants were asked to learn about their students in different settings (*demographic information, interests, culture, home/community practices, behavior/personality at school*, and *mathematics that occurs in these places*). Then these broad categories were broken into sub-categories. These sub-categories were developed through open coding and analytic induction (Bogdan & Biklen, 1992; Merriam, 1998) by first reading through the participants' written responses multiple times (each got read at least twice) and coding them using the broad categories. Then, for each broad category, the coded responses were grouped into sub-categories. For example, the *interests* category had two sub-categories: *school/subject topics* and *hobbies/sports* because the participants either wrote about their students' favorite school subject or a particular sport or activity they liked. For instance, when Rick wrote "Aaron loves to play basketball with his friends after school," it was first coded under the broad category of *interests* and then sorted into the sub-category *hobbies/sports*. Then the participants' responses were coded a second time using the framework and compared to the first round of coding (after the sub-categories were developed) to ensure they were coded consistently. No changes were made to the framework when coding the second time and there was 100% agreement between the first and second coding. It should be noted that some pieces of information were coded by multiple codes. For instance, Janet determined that her student enjoyed cooking traditional Indian food with her mother. This received a code of *hobbies/sports* under *interests* because it was an interest of hers and also received a code of *visible culture* under the category *culture* because the interest is related to the students' visible Indian heritage.

Then the prospective teachers' descriptions of what they learned as a whole (i.e., all of the coded parts of their written response where they discussed what they learned about their student) were rated *no detail*, *some detail*, and *specific detail* based on the level of detail they gave about each of the categories and if multiple categories were addressed in the paper. A *specific detail* rating was given if the participant wrote in detail about and gave specific examples of the students' interests, culture, home/community experiences, and the mathematical practices that occur in more than one of these settings. A *some detail* rating was given if their description included some details about the students' interests, culture, home/community experiences, and few examples of mathematical practices that occur in these settings. Also, this rating was given if specific details were given about some characteristics and no details were given about others. A *no detail* rating was given if the participant did not provide any details or provided only superficial information about their students' interests, culture, home/community experiences and gave little or no discussion of the mathematical practices that occurred there. An example of superficial information would be to say that their student likes to cook. An example of a more detailed response connected with a mathematical practice would be that the student likes to help her mother cook traditional Indian food for her family and is learning how to make conversions from recipes written in metric units to standard units so she knows how much of each ingredient to use. To be rated as *specific detail*, the participants needed to provide detailed responses like this regarding most or all of the information they learned about their student.

Another part of the analytical framework (see Appendix G) was created to code what the prospective teachers wrote in regards to how they would apply the information they learned in their mathematics instruction. First, broad categories were developed based on some of the components of the culturally relevant task framework (see Table 1). These categories included the extent to which the chosen problem or strategy was related to or drew upon something that they learned about the student (*draws upon student information*), the extent to which the chosen problem or strategy draws on the mathematics related to the contexts they learned about the student *(math in context*), and the extent to which the chosen problem or strategy related to the mathematics the student actually does in that context (*math student does*). The participants' written responses were analyzed through open coding and analytic induction (Bogdan & Biklen, 1992; Merriam, 1998) by reading them multiple times (each got read at least twice) and coding them using the broad categories of the framework. While coding the participants' responses the first time, another broad category (*general teaching strategies*) was added to analytical framework as some of the participants discussed general teaching practices (e.g., group work) they would want to use with their student based on what they learned about that student. Then the responses were coded for a second time to account for this new broad category. No broad categories were added or removed during this second coding. Then the broad categories were broken into sub-categories. For each broad category, the coded responses were grouped into sub-categories in the same way as described for the first part of the framework. For example, the responses coded under the *draws upon student information* category were sorted into five sub-categories for the different characteristics the participants could have drawn upon: *interest, culture, home/community life, personality trait,* and *school/mathematics behavior/learning*. Finally, the participants' responses were coded for a third time using the framework and compared to the second round of coding (after the sub-categories were developed) to ensure they were coded consistently. No changes were made to the framework when coding the third time and there was 100% agreement between the second and third coding.

When the participants wrote about a mathematical application of something they learned about their student, I assigned a code from each of the first three broad categories. It should be noted that participants' responses can be coded as more than one category and/or sub-category. For example, John wrote that Molly and her family have traveled a lot and that she "has looked up flights [to England and Scotland] but has never committed…one problem that could be used would be having the students do research as to which flight would be cheapest for them to fly on." This response got coded as *interest* and *home/community life* under the broad category *draws upon student information, does draw on math in context* under *math in context,* and *math student actually does* under the broad category *math student does*. Then, for each instance where the participant wrote about a general teaching practice they would use with their student, I coded it using the *draws upon student information* and *general teaching strategies* categories to capture what strategy they wanted to use and their rationale for that strategy. For example, Zane wrote "I would try to fit a lot of hands-on activities, have constant cool visuals with the math problems, and promote discussion that forces every student to talk" because of Ben's behavior and perceived lack of interest in math class. This was coded as *personality trait* under broad category *draws upon student information* as well as *manipulatives/multiple representations* and *whole class discussions* under *general teaching strategies*.

The two parts of the analytical framework measure how well the participants were able to attend to students' backgrounds and how well they could describe how they would use that information in their instruction prior to being introduced to culturally relevant mathematics tasks. This *shadow a student* project was also a starting point for measuring the progress they can make towards explicitly attending to students' culture in their mathematics instruction (i.e., towards revising a high-level mathematics task culturally relevant for that particular student).

Problem-Solving Interview

The *problem-solving interview* project was analyzed through an analytical framework (see Appendix H) that was initially developed based on the components of the project write-up to specifically find places where the participants discuss their student's competencies and/or struggles in their mathematics thinking and/or problem-solving. This framework is organized by broad categories (*claims, instructional approaches*, and *rationale*) and sub-categories were developed for each. For example, sub-categories for the *claims* category included *understanding, strategies used, persistence, student questions,* and *misunderstanding/struggle*.

The responses were coded twice using open coding and analytic induction (Bogdan & Biklen, 1992; Merriam, 1998) to refine the sub-categories by adding or deleting categories (Bloomberg & Volpe, 2008). To code the responses for the first time, the write-ups were read through multiple times (each participant's response was read at least twice) and codes were applied to appropriate parts of the write-up. Specifically, the project write-ups were analyzed by first looking for instances of where the participant mentioned claims about their students' thinking (*claims*) and their next instructional steps to further student understanding (*instructional approaches*). For example, Janet wrote that her student "accurately creates and uses a diagram to help solve word problems about dividing fractions." This got coded as *strategies used* under the broad category *claims*. Then, each instance of *instructional approaches* mentioned in the write-up also received a code under the category *rationale* to determine whether the proposed instructional decision was based on one (or more) of the student's competencies (*builds on competency*) or on one (or more) of their weaknesses (*addresses weakness*). For example, John wrote "Since Molly showed a lot of strength in writing and verbalizing the division problems…we could use that strength to translate into drawing accurate pictures that represent story problems" by giving her different division word problems. This was coded as *mathematical task examples* under *instructional approaches* and *builds on competency* under *rationale* because John wanted to use other mathematics tasks (and gave some examples) to build on Molly's strength of writing division statements. Some sub-categories were added through this first coding of the responses. For example, the sub-category *confidence* was added to *claims* because some of the participants wrote about the confidence students had in their work and/or solutions to the tasks. Then, each of the responses was coded a second time by applying the revised framework to ensure that no more changes to the framework needed to be made and that the researcher was consistent in applying codes. There was 100% agreement between the first and second coding. Finally, codes that were not used were removed from the framework. For example, the sub-category *student questions* under the broad category *claims* was not used for any of the participants' write-ups so it was removed from the framework.

Task Revision Project

The *task revision* project was analyzed using the theoretical framework discussed in the literature review regarding revising high-level mathematics tasks to be culturally relevant (see Table 1). The framework was used to determine how well the prospective teachers were able to revise a given high-level mathematics task to be culturally relevant for one student. The revised tasks were coded according to each component of the framework. First, the task was analyzed using component 1 of the framework to determine whether the participants drew on something meaningful for the student and what that was (e.g., an interest, cultural practice, etc.). This was determined by first analyzing the *task revision* project write-up where the participants justified their choices for revising the task. Analytic induction (Bloomberg & Volpe, 2008; Merriam, 1998) was used to code the participants' responses to the *task revision* project write-up in the places where they described what they learned about their student. The context of the task revision was coded under the sub-categories of component 1 of the framework as a *student interest*, a *home/community experience*, a *cultural practice/experience*, and/or *regarding the students' mathematical knowledge* based on the analysis of the project write-up. In other words, the context of the task was coded as one of these sub-categories based on what the participant wrote about that particular context in the project write-up. For example, the context of Zane's revised task is the speed of a cheetah. In Zane's project write-up, Zane explained that his student had an interest in science and his favorite animal is a cheetah. Thus, the context of Zane's revised task got coded as a *student interest* because the description in his project write-up was also coded as a *student interest*. Again, the task could have drawn upon more than one of these codes as a student's interest could also be a cultural practice and/or something they do at home with their family or the participant may have drawn on two or more things they learned about the student.

To determine whether the particular characteristic the participant drew upon in the *task revision* project was meaningful for the student, the analysis of the *shadow a student* project was consulted first. This was done to determine if the participant discussed a particular characteristic in the *shadow a student* project and with what level of detail (*no detail, some detail,* or *specific detail*). In addition, the ratings of *no detail, some detail,* or *specific detail* as described in the *shadow a student* project analysis were given to the participants' *task revision* project write-up on their choice and rationale of characteristic to draw upon. The ratings given to both write-ups determined how meaningful this particular characteristic was for this student.

Then, the revised task was coded for whether or not it drew directly upon the mathematics used in the overarching context (component 2). Specifically, if the revised task drew upon a students' interest in soccer, I looked to see if the revised task drew upon the mathematics in soccer in a realistic way. For example, if the original task addressed a speed/time graph of a student walking to his friends' house, a revised task could draw on the math in soccer realistically by making the graph be the speed a person runs over the course of a soccer game (with speeds that are realistic for someone to be able to run at). A potentially less realistic revision would be for the speed time graph to have the player running so fast as to be impossible or to make the graph at a constant speed over the course of the game. A surface level change would be if the context was changed to the student walking to soccer practice which does not use the game of soccer to highlight the mathematical concepts.

Then the revised task was coded for whether it drew on the actual mathematical practices/knowledge of the students and/or the people in their family/community (component 3). This was done by again looking over the *shadow a student* project analysis and coding the *task revision* project write-up to find evidence that the students did have experience with or knowledge of the mathematics (either formally or informally). Specifically, the parts of the *task revision* project write-up that addressed the participants' choice of context to revise the task with were coded based on the sub-categories of component 3. The revised task itself was then coded using that same sub-category. For example, Rick discussed in his *task revision* project write-up how his student had experience tracking changes in his walking speed over multiple days and so that response and Rick's task revision were coded as *revisions related to the mathematical practices the student engages in*.

Next, I determined whether the cognitive demand of the task was reduced or kept at a high level (component 4). The original tasks were all at a high-level of cognitive demand (procedures with connections or doing mathematics) and so I used the cognitive demand framework (Smith & Stein, 1998) as a guide to help determine whether the revisions altered the task such that the cognitive demand changed. First, I looked to see if the student had removed words or phrases like "Explain your reasoning" as this could lower the cognitive demand by not requiring as much cognitive effort, which is part of the cognitive demand framework for high-level tasks. I also looked for added or deleted words or sentences that may have impacted the potential ways to solve the task. For example, the original task on growth patterns could be represented in a number of ways (e.g., graph or an equation) where none of the solution strategies are implied in the wording of the problem, leaving it open-ended for students to use the strategy and/or representation that makes sense for them. One way to change the task would be to add a sentence that tells students to write an equation to solve it. This changes the cognitive demand because it reduces the amount of cognitive effort by telling the student what representation or procedure to use. In addition, I examined the revised tasks to ensure that the participants did not change the task so that it specifically stated to use a procedure without any connection to meaning or concepts which, according to the cognitive demand framework, would put it at a low level of cognitive demand. For example, the budgeting and unit pricing task could have been revised by stating the procedure for finding the unit rate and providing directions to find the unit rate for each of the items.

Then, I determined whether or not the revised task addressed the same mathematics content as the original task (component 5). For example, if the original task required a comparison of three linear functions, the revised task should have also required a comparison of three linear functions. I determined this by first looking to see if only certain nouns, numbers, or other words were changed as this would not have altered the mathematics addressed in the task. For example, changing names to other names or changing prices to fit the context would be evidence that the mathematics addressed in the task had not been altered. Then I solved both the original and revised tasks in as many ways as I could think of to determine if they required the same mathematical procedures and concepts to be solved. I solved both problems to help me decide if the revised task had any additional constraints that the original task did not have so as to change the mathematics. One example of changing the mathematics addressed is if the original problem was about writing a story based on a given graph and the revised task provided the story and asked students to draw the graph. While related, these tasks address slightly different skills.

Finally, the participants' *task revision* project write-ups were analyzed using an analytical framework (see Appendix I) for both the choices they made for launching and implementing the task and the rationales for those choices. The analytical framework consists of predetermined categories (*launch, implementation, rationale*) based on the major requirements for the write-up. The sub-categories for the *launch* and *implementation* categories consisted of the specific instructional strategies they would use for each. The sub-categories for the *launch* category were predetermined using Jackson and colleagues' (2012) four critical aspects of launching a task as discussed in a previous section (*maintain cognitive demand, introduce problem context, key mathematical ideas, develop common language*) as the participants were specifically required to address each of these in their write-ups. The sub-categories for the *implementation* category were predetermined based on instructional strategies that were emphasized during the course. These sub-categories included *group work*, *whole-class discussions*, and *manipulatives*. The project write-ups were then coded using open coding and analytic induction (Bloomberg & Volpe, 2008; Merriam, 1998) by reading through the participants' write-ups multiple times (each write-up was read at least twice) and coding the instances where they wrote about a specific teaching strategy they would use. The specific sentences/paragraphs in the participants' write-ups were coded as one of the sub-categories under *launch* or *implementation*. One sub-category, *facilitating questions*, was added to the *implementation* category after the first coding. The project write-ups were coded a second time using the framework and compared to the first round of coding to ensure they were coded consistently. No changes were made to the framework when coding the second time and there was 100% agreement between the first and second coding.

Finally, the write-ups were analyzed for the rationales they gave for these choices. The sub-categories for the broad category *rationale* were predetermined based on the requirements for the project write-up. One sub-category, *learned about student*, included rationales based on what they learned about the student (e.g., the students' shy behavior at school led to working on the task individually). The other sub-category, *math teaching and learning*, included rationales based on what they know about good mathematics teaching and learning (e.g., use of group work is beneficial for all students). Open coding and analytic induction (Bloomberg & Volpe, 2008; Merriam, 1998) was used to code the data by reading through the participants' write-ups multiple times (each were read at least twice) looking for instances of where they justified their choice of instructional strategy. No sub-categories were added or removed from the *rationale* category when coding the first time. Each response was coded a second time to ensure that the researcher was consistent in applying codes. There was 100% agreement between the first and second coding. Every instructional strategy coded under *launch* and *implementation* also received a code for the *rationale* for that instructional choice (if the participant provided a rationale).

It should be noted that the analysis from the *task revision* project write-ups was used to answer the second research question regarding how the participants' conceptions were related to their performance. In other words, the performance considered for this research question is their ability to create their revised tasks and their rationales for how they would launch and implement the task in a classroom containing the student they shadowed. It is not just the choice of task, but how teachers choose to implement the task that can impact the opportunities provided for students to learn (Sztajn, 2003).

Measuring Progress

After analyzing each data source as described above, I looked across the analyses of each to determine the progress that was made in order to answer the first research question. In this section, I discuss in detail how each part of the research question was answered using the analyses described in the previous sections.

To determine progress made in the participants' conceptions, their responses to the pre-interview were compared to their responses to the post-interview to determine similarities and differences. One way this was done was to compare the total number of references at each sub-category of the pre-post interview analytical framework (see Appendix F) in order to determine whether the frequency of the conception mentioned differed from the pre-interview to the post-interview. For example, if one participant mentioned a particular stereotype fewer times or not at all in the post-interview as compared to the pre-interview, this could suggest a shift in their conceptions.

It was not anticipated that the participants' conceptions would change drastically and so the participants' responses were also analyzed more carefully within each sub-category to determine whether the way in which they discussed their conceptions was similar or different between the pre-interview and the post-interview. To do this, all of the responses coded at each sub-category were collected from the pre-interview and the post-interview and were placed side by side. Then I looked for instances of where the participants' responses were similar and different and how they were different. For example, during the pre-interview a participant may have discussed the importance of getting to know their students individually in a general sense (e.g., "I think it is important to get to know my students"), but during the post-interview they may have also emphasized getting to know their students using more detailed and practical strategies for doing so (e.g., "I think it is important to get to know my students by developing relationships with parents").

Progress towards revising a high-level mathematics task to be more culturally relevant was measured in terms of their performance on the different course assignments they completed throughout the semester and during the post-interview. I analyzed progress in this way because the participants started the course with no knowledge of how to revise a task to be culturally relevant and so the participants may have been unsuccessful if asked to do so at the beginning of the semester. Therefore, as described in earlier sections, different skills that are required for revising a high-level mathematics task to be culturally relevant were introduced one at a time during class meetings throughout the semester and then practiced during their field placements and in course projects so that they could build up the skills towards being able to revise a task well.

Figure 4 illustrates how progress was measured and how the results are presented in the next chapter for each participant. The first stage of progress (as I have defined it) in learning to revise a high-level mathematics task to be more culturally relevant for one student is to get to know a student well. Therefore, the *shadow a student* project (and potentially the *problem-solving interview* project) analyses were written up as a profile of what the participants learned about their students and with how much detail. Then the analysis of their initial ideas of how to use what they learned about their student in their mathematics instruction more generally (*shadow a student* and *problem solving interview* projects) was considered as it illustrates some progress by presenting how the participants were thinking about this prior to learning how to revise tasks to be culturally relevant. Then the analysis of their revised tasks was presented as this illustrates progress in how the participants were able to take what they learned about their student to demonstrate a specific teaching practice. Finally, the analyses from the post-interview data were reviewed as the data illustrated the progress the participants made in being able to improve their revised task and/or their proposed launch and implementation with supportive feedback from the instructor.

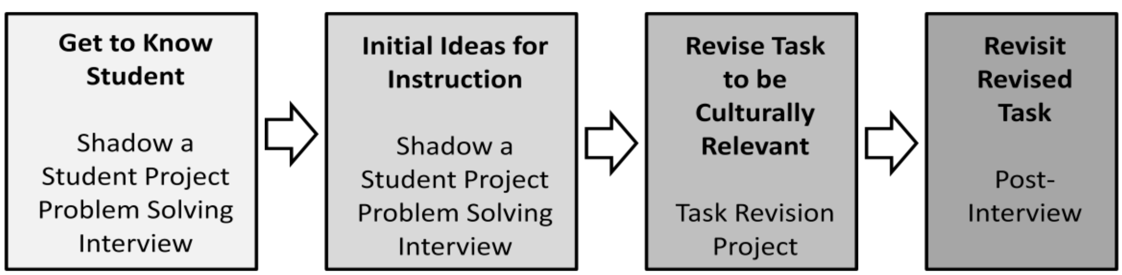


Figure 4 Measuring Progress towards Revising a High-Level Mathematics Task to be Culturally Relevant for One Student

Conceptions Related to Performance

Finally, the coded responses from the analyses of each of the course projects were compared to each participant's coded responses to the post-interviews to determine whether there were any relationships between the participants' conceptions and their performance on these projects. In other words, the participants' conceptions were compared not only to the participants' revised task, but to how well they got to know their student (*shadow a student* and *problem solving interview* projects), their initial ideas for mathematics instruction on the *shadow a student* project, how they would launch and implement their revised task in the classroom with their student (*task revision* project), and how they engaged with and responded to the instructor feedback on the *task revision* project during the post-interview.

To make these comparisons, the coded responses from the pre-interview were matched with the same or similar coded responses on one or more of the course projects. For example, a participant's expressed conception that using group work is beneficial for all students was linked with their coded response on their *task revision* project write-up that they would use group work to implement the task with an entire class. This also included the codes created for the shadow a student project to evaluate their entire write-up related to what they learned about their student (*no detail*, *some detail*, and *specific detail*). For example, a participant's expressed conception that it is important to get to know their students was linked with the code *specific detail* or *some detail* as this provided evidence that this conception may be related to their success getting to know their student. Note that the relationships presented in the results were inferred by the researcher making these comparisons across the data sources and were not necessarily directly stated by the participants.

Trustworthiness

Qualitative researchers (Merriam, 1995, 1998; Shenton, 2004) have addressed the issue of trustworthiness in qualitative research by stating three criteria to consider:

credibility, dependability, and transferability. In the sections below, I discuss how I have addressed each of these in my study.

Credibility

Establishing credibility means ensuring that the findings are in line with reality. In other words, the researcher needs to collect and analyze data that presents participants' thoughts, feelings, and actions accurately (Merriam, 1998). One way to help ensure that the findings are an accurate representation of the participants' conceptions and performance was to use well established and appropriate qualitative research methods (Shenton, 2004). For this study, the use of pre-post surveys and interviews are appropriate qualitative means for measuring the participants' conceptions. Also, the use of multiple course projects as described in previous sections were appropriate in that they allowed me to collect an abundance of data that specifically answered the research questions with sufficient detail. In addition, peer scrutiny of the research project took place with individuals within and outside the dissertation committee in the design of the study to ensure that the measures used would provide accurate data for answering the research questions.

Credibility was also established through the triangulation of data (Merriam, 1998; Shenton, 2004). The pre-post interview data analyses were compared to the pre-post survey analyses to ensure that the participants' responses were the same on questions that were intended to measure the same things and that the conceptions they expressed in both sources did not conflict with each other. In addition, the course project write-ups were compared to ensure that the participants were consistently describing characteristics they learned about the students they shadowed and noted where they were presenting new information that they learned later in the semester.

Also, credibility was established in the detailed presentation of my findings (Shenton, 2004). In the results chapter, for each claim, nearly all instances of supporting data were presented. In this way, the reader is able to assess the extent to which the data support the claims made.

Dependability

Establishing dependability in qualitative research means to ensure that the results of a study are consistent with the data that were collected (Merriam, 1995). One way this can be done is through peer scrutiny on the results of the study (Merriam, 1998; Shenton, 2004). Peer scrutiny took place throughout the writing process with individuals within the dissertation committee to ensure accuracy in how I interpreted and presented the data. Triangulation of the data as described in the previous section can also lead to dependability (Merriam, 1995). Additionally, presenting the research design in enough detail so that another researcher can replicate the study as well as assess the extent to which proper qualitative research practices have been followed can address dependability (Shenton, 2004). This is also called providing an audit trail (Merriam, 1998). In this chapter, I have provided a detailed account of the design of the methods course, my data collection materials, description of how data were collected and analyzed, and the analytical frameworks (see the relevant appendices) where the changes that were made throughout data analysis were made visible.

Transferability

Establishing transferability means presenting the study in a way that readers can determine how applicable it is in other contexts (Merriam, 1998; Shenton, 2004).

In other words, it is up to the researcher to provide enough detail about the study context for the reader to be able to determine whether the findings would be applicable in their context (Merriam, 1995). I have provided a rich description of the context of the study, the participants, the data that were collected, and the time period over which data collection took place. Details about the procedures for collecting and analyzing the data were also described in detail.

Chapter 4

RESULTS

In this chapter, I present the findings from the two research questions based on the four participants. In response to the first research question, I present the major themes that reveal the conceptions that all of the participants held in common at the beginning and end of the semester in order to illustrate the similar progress they made in their conceptions. Although the participants' conceptions differ slightly within each major theme, the findings are presented in this way to better highlight the particular conceptions that were (or were not) impacted over the course of the semester. Then, I present the findings regarding individual participants' conceptions at the beginning and end of the semester that do not fall under these broad themes. I do so in order to highlight the complexity of the individual participants' conceptions in response to the first research question as well as to illustrate other conceptions that may have been related to their performance in response to the second research question.

In response to the second part of the first research question, I present the findings regarding the progress each participant made towards revising a high-level mathematics task to be more culturally relevant for one student. I do this at the level of individual participant in order to highlight each stage of the progress in detail and to show how each stage built upon the previous ones based on the student they shadowed, culminating in their ability to revise a high-level mathematics task to be culturally relevant for the student they shadowed as well as improve that task based on instructor feedback. Finally, in response to the second research question, I tie all of the previous findings together to present the potential relationship between the participants' conceptions and their performance getting to know their students, revising a high-level mathematics task to be more culturally relevant for one student, and how they proposed they would launch and implement this task in a classroom.

Progress in Conceptions for all Participants

This section is organized around the productive and unproductive conceptions the participants held at the beginning and end of the semester in relation to three themes: good teaching practices; the importance of getting to know students and taking that information into account during instruction; and low income students in urban, high-needs schools. The participants' pre- and post-interview responses suggest that their conceptions regarding good teaching practices and the importance of getting to know students became somewhat more specific and detailed whereas the more deeply ingrained deficit conceptions and stereotypes about low income students in urban, high-needs schools did not change over the course of the semester. It is important to note that the distinction between productive and unproductive (i.e., deficit and/or stereotypical) conceptions was made in the methods section and was determined based on the research literature regarding the potential for these conceptions to positively (or negatively) impact the teaching practices a teacher might use to provide students with opportunities to learn.

Conceptions at the Beginning of the Semester

Good Teaching Practices

When prompted to discuss their own and others' teaching, all of the participants expressed productive conceptions at the beginning of the semester regarding good teaching practices that are effective with all students. This included whole-class discussions, allowing students to struggle with mathematical concepts, and the use of group work. For example, when discussing the teaching practices she favored, Janet said:

> I think I'm a fan of discussion so having students…look at a problem maybe at first not know how to go about it and you can let them break off into groups and solve them together throwing different ideas out within their peers and then…you as a teacher circulating the room, listening in, just trying to find those different multiple entry points, bringing it back together, asking either students before or right then if they would be willing to share, going through that letting them…talk amongst each other and then maybe that day ending with the conclusion.

In other words, Janet expressed a number of good teaching practices that she would employ including having students struggle with conceptual tasks that have multiple entry points, having whole class and small group discussions, and having the teacher facilitate those discussions. Similarly, John supported allowing students to grapple with mathematics tasks. For example, John said "I think that if the students had more discovery to their learning and try to figure out the problems on their own, find their own way of doing it, it might stick with them more." He expressed these views multiple times throughout the pre-interview. Zane also favored having students do the mathematical thinking when expressing his disagreement with using practices related to direct instruction. He said, "There needs to be a lot more than just talking about the steps of a problem…maybe even allow the students to try and solve the problem without even going over steps and just see what they come up with."

Janet and Zane particularly emphasized having whole class discussions as a particular good teaching practice to employ. Janet said that she "really like[s] the discussion methods so definitely integrating that." Zane also suggested that the teacher should have “a lot of discussions” and “a lot of student-led conversations” instead of modeling for the students. Zane suggested having class discussions as a way to assess student thinking and to get students to participate. When asked about what he should do to help a struggling student, he said he would probably “have a lot more discussion-based math classes…try to maybe force discussion out of her and see what she’s actually thinking.”

In addition, all of the participants except Zane emphasized group work as an effective teaching practice. For example, in response to a scenario of a teacher who uses direct instruction, John said that the teacher “just shows it to them and then asks them to regurgitate it in practice problems and instead of working in groups she just wants them to stay on task.” He also states later that he would “make the students work in groups and collaborate.” Rick also mentioned group work as something that should be used when students are engaging with high-level mathematics. He said:

> I think a lot of challenging and high mathematics might have to do with group work and like students doing their own teaching…because in order to grasp a high-level task you're going to have to put more than one head together, and also, as you're learning math in a group, you might be able to teach or assist other students in your group which will also benefit your own learning.

Throughout the pre-interview it was apparent that Janet particularly viewed group work as an effective teaching strategy for all students. For example, she said “I think more often than not students learn better when they collaborate and have the opportunity to think about it on their own without being told right away.”

However, Rick was not as forthcoming regarding what he viewed to be good teaching practices in that he only hinted at the use of other good teaching practices by dismissing practices related to direct instruction. When responding to a scenario that described a teacher who mostly used direct instruction practices, Rick said "it can be good occasionally but…I don't think I could ever put an ideal situation for this as…this is the way we teach." Instead, Rick suggested "maybe making the classroom environment more interesting…getting the students more involved up and around and doing more active learning." However, it is not clear what he meant by "active learning" and whether that means students should do more of the thinking or if he literally means for students to get up out of their seats for an activity.

Overall, the participants' discussion of these good teaching practices at the beginning of the semester suggests that they saw the importance of good mathematics teaching practices and intended to use them. It is important for teachers to understand that using good teaching practices is an important tenant of culturally relevant mathematics pedagogy as these practices can support students' in learning mathematics for conceptual understanding. It is unclear, however, how the participants viewed these practices as being connected to culturally relevant pedagogy.

Importance of Getting to Know Students

The participants also expressed, at the beginning of the semester, the productive conception that it is important to get to know their students' interests and their home and community lives and that it is necessary to take that information into account in their mathematics instruction. Janet and Zane emphasized that getting to know students is an important source of information for teachers. When asked what she would do to help a struggling mathematics student, Alicia (who is a fictional student from the pre-post interview scenarios), be more successful in mathematics class, Janet said "the first step is definitely to have a conversation with Alicia and say what's going on, why do you think you're not doing well in math, how can I help you?" When asked what the most important things he could do as a mathematics teacher to ensure that students who are socio-culturally different from him are successful, Zane said "just be aware of your student body, be aware of where they come from."

All of the participants particularly emphasized the need to get to know their students so that they could take that information into account in their mathematics instruction. When given information about a struggling mathematics student's interests and home/community lives, John discussed how this information is important in that "she has a lot of interests that she does, does involve math so just got to relate it to that." In addition, John discussed that it is important for teachers to "make sure [the math is] real and relevant to them" often despite the fact that "a lot of times teachers get stressed with all the material that they need to cover." He stressed that "it just might be extra work for [a teacher] but it's going to mean a lot more and do a lot more for the kids." Also, when asked to describe the most important things he can do as a mathematics teacher to ensure students who are socio-culturally different from him are successful, Rick said "talking to students to make the way you're teaching easily relatable to them and understanding the differences they have in their upbringing." In addition, when asked how she would implement a challenging mathematics curriculum with students, Janet said "I would survey the class and see what they were interested in and how I could connect it to them after that." She repeated this statement multiple times throughout the pre-interview.

Janet and John stressed how important it is to get to know students' home and community lives in particular. When asked why he would take a job in an urban school, John said:

> there's going to be a lot of opportunities to learn from the students and…just get involved in the community because you're going to need to figure it out to relate to these students if you haven't already lived in an urban community.

In one scenario, Janet was given a lot of information about a student's interests and home and community activities, and when asked what she thought was important to know, she said "I think all of it is. The more you know about students, the more you can relate to them. You can draw from their previous experiences, things that they're interested in, and just connect to them." This is a productive conception to foster and develop in prospective teachers as it will support them in learning about and using culturally relevant teaching practices. However, it is unclear what Janet and John believe the benefits for doing so are. It is important for teachers to understand that connecting the mathematics to students' backgrounds can give students access to the mathematical ideas and concepts as well as develop their cultural competence and it is unclear whether these participants understood these purposes at the beginning of the semester.

Rick and Zane also expressed the productive conception that they should get to know their students with the specific purpose of motivating them. When asked to describe how he would support a struggling mathematics student, Rick said he would try "to talk to her and figure out how I can help her in the class, making math related to her and her learning and how I can help to improve her attitude about learning." When presented with information about Alicia's community practices, Rick said "you can make things more easily relatable to Alicia…maybe I'll change her ways about math now." In addition, Zane said "I would say it's important to know your student body, their culture, because that would be…great information to base what you want your lesson plans to be on…how you want to get their attention."

Finally, Janet, Rick, and Zane gave specific examples of how they would connect information about a student named Alicia's home and community experiences to the mathematics they would teach. Janet said that she would say to Alicia:

> "I heard you were building your garden and you had to figure out how much plastic you needed to cover it, how did you figure that out?" And having her explain it and then taking what she said and say "oh so you measured the length and the width and you multiplied those together to find the area? Like that's great! And you know how you did that? Well that's similar to what we're doing here today." Just bringing it back in for her to see those applications…and going grocery shopping…they have to quantify and budget for the food so they have to use subtraction and they have to figure out what they need and how much they can take of each thing, so that's algebra.

In addition, when provided with information about Alicia's activities outside of school, Rick said:

> you can relate almost all of her after school activities to something mathematical, about how many vegetables they need to plant…comes down to mathematics formulas and stuff like that. Also to find out how much plastic needs to cover a garden could do with area and perimeter…also keeping a budget within going to the grocery store is also like something you can relate to math.

Finally, when asked to give an example of how he could use the information about Alicia in his instruction, Zane said:

> For the music you can talk about how many notes are in a song or when to actually do a dance move during a song, and discuss those things. And the garden, I feel like it's pretty obvious. How many plants are here if you have this amount of space, how many, where would you put your, x amount of plants and stuff like that.

Therefore, at the beginning of the semester Janet, Rick, and Zane already had ideas about how they could go about using the information they would learn about their students to make connections to the mathematical practices their students engage in outside of the classroom.

In summary, at the beginning of the semester, all of the participants held the productive conception that it is important to get to know students' backgrounds to be used in mathematics instruction. However, none of the participants pointed out how drawing on students' backgrounds can and should be done with the purpose of providing students' access to mathematical concepts and ideas and for developing students' cultural competence. These are important conceptions for culturally relevant mathematics teachers to hold, particularly in this study, because it may relate to the revising of high-level mathematics tasks to be more culturally relevant. For instance, if it is not clear that drawing on students' backgrounds can provide them access to mathematical concepts, then a teacher may revise a task that draws superficially on the students' backgrounds rather than on the mathematical experiences of the students that would give them access to the mathematics.

Low Income Students in Urban, High-Needs Schools

The prospective teachers also expressed some potentially unproductive (e.g., deficit and/or stereotypical) conceptions at the beginning of the semester about low income students, particularly students in urban, high-needs schools, which shift the control of student achievement from the teacher to the environment outside of the school. This is potentially problematic as this can lead teachers to place the responsibility for student achievement onto out-of-school factors rather than on themselves (Rousseau & Tate, 2003). Specifically, all of the prospective teachers mentioned at the beginning of the semester the deficit conception that students from low income families typically have less support at home. For example, when asked why a school in an urban, high-needs area with students from many racial and ethnic backgrounds would be more likely to have a large proportion of White students in the advanced math class, Janet replied “you tend to associate the lower income students having…a harder time in school in general so perhaps they don’t have the home life or the support outside of school.” When responding to the same scenario, Zane said that the class with the majority White students “have maybe a better home life, or maybe they’re better off financially, and…they have the support at home.” This suggests that he thinks racial and ethnic minority students in low income urban neighborhoods are more likely to have these issues.

Another example of this deficit conception was articulated by Rick when he was asked to explain why the struggling student Alicia was misbehaving in class. Rick thought it could be due to a

> lack of parental involvement…because if both of her parents are working full time, she's using the free and reduced lunch program even though her parents are working full time, it seems that her parents probably have very little care for her. Incomplete homework and failing to turn it in might also be a symptom of a lack of parental involvement in the classroom.

John also repeated this conception numerous times during his pre-interview. For example, when given the same scenario about Alicia, John said “I think because she doesn’t get any help at home, her parents are working full time” and “if she doesn’t have the support at home it’s going to make her struggle.” This is an assumption the prospective teachers might not have evidence for as there is diversity within income groups (e.g., middle class students may also have two parents working full time) and it is possible for students of all income groups to either have support or not at home in various forms.

In addition to this particular deficit conception about parental support, John and Rick expressed a stereotypical assumption that urban neighborhoods are inherently more dangerous and they use that assumption as the basis to explain the lower achievement of low income urban students. For example, when asked why he would prefer to teach in the suburbs, John said “a lot of times in urban neighborhoods there is a lot of crime or…kids don’t always have a lot of parental support” and “generally at suburban areas…there’s not going to be as much crime or stuff like that.” In particular, Rick expressed a connection between this perceived violence in urban neighborhoods and students’ motivation. When asked why a low income urban school with a racially and ethnically diverse student population would have an advanced math class with mostly White students, Rick said “I think the majority of it might have to do with students’ own motivation to learn and also the outside distractions that might come along with an urban area.” The “outside distractions” that Rick is referring to is the perceived violence that is present in urban neighborhoods. Rick said “I’m thinking of my personal idea of a large low income area where there’s just a lot of gang violence…it’s just the not nice areas of living that might distract a student from their educational goals.” Therefore, John and Rick perceive that particular students’ lives outside of the classroom play a major role in their achievement at school.

Similar to the conception regarding motivation in students from low income urban neighborhoods that Rick expressed, Zane expressed a connection between students living in a low income urban neighborhood and whether or not they value education. When asked to reflect on why struggling student Alicia might be misbehaving in math class, Zane said “probably because she doesn’t value education…if she’s turning in incomplete homework and she’s doing poor on her assignments it’s probably because she just doesn’t care.” Then when asked to discuss why he thought this might be the case, Zane said:

> I would say living in a low income urban neighborhood that probably influences that. I'm sure living in that area, there's not a lot of success coming out, and there's not a lot of people that value education, there's probably some trouble going on where she's from.

In other words, Zane suggested that students living in a low income urban neighborhood may not be performing academically to the standards of suburban students, that they do not value education as much, and that there may be other issues she might have to deal with living in such an area. These assumptions are likely not correct and these conceptions can shift the perceived control of student achievement to the students' lives outside of school. For example, if John's students perform poorly on assessments, he can attribute low achievement to students' lack of support at home or simply living in an urban neighborhood rather than figuring out what he can do to improve his students' achievement.

Despite the unproductive conceptions expressed by all of the participants regarding low income students in urban, high-needs schools, Janet's response on the pre-conceptions survey suggests that she was more aware about how the potential issues facing low income students could be challenging for her as a teacher and did not shift the reason for low income students' struggles from her onto factors outside of the school. When asked about the challenges she might face teaching students from low income backgrounds, she wrote:

> I guess if students are less affluent they may not have education as their top priority. I say this because, if students are struggling to find food/heat/shelter, then worrying about how to find the missing side-length will not compare to their other struggles. Therefore, I foresee a challenge of helping students feel wanted and cherished as well as safe in the classroom.

In addition, while Janet felt that these issues might be the cause of low income urban students' lack of success, she is aware that other factors might also impact these students' success. When asked about the potential reasons for the student Alicia, described above, to be struggling in mathematics class, Janet also provided a number of different reasons other than those related to Alicia's income. Janet said:

> There could be tons of reasons why. It could be that she just doesn't understand it and so instead of actively engaging and trying harder she just shuts down and gives up. It could be as simple as she doesn't like the person she's sitting next to and doesn't want to focus on that because she's distracted by them.

This suggests that Janet may have realized that a student's income is not the only or most important factor related to their achievement; only that it is one she needs to consider as a potential issue. This is a slightly more productive conception as it suggests that Janet might not have automatically assumed these stereotypes about low income students in urban, high-needs schools.

Summary

All of the participants expressed productive conceptions regarding good teaching practices for all students and getting to know students' backgrounds for use in mathematics instruction. Overall, the participants' discussion of these good teaching practices suggests that they saw the importance of these teaching practices and intended to use them which may be productive for their future teaching. In addition, all of the participants expressed the importance of getting to know their students and taking that information into account in their mathematics instruction. Despite these productive conceptions, most of the participants expressed deficit or stereotypical conceptions about low income students in urban areas. These unproductive conceptions may lead the participants to shift the reason for low income students' struggles from the teacher onto factors outside of the school. Despite this, Janet thought about these issues in more productive ways by expressing more awareness about how the potential issues facing low income students could be challenging for her as a teacher and noting that there are many factors that contribute to students' success that need to be taken into consideration, rather than shifting the reason for the lack of success solely onto out-of-school factors.

Conceptions at the End of the Semester

The responses to the post-interview and post-conceptions survey indicate that some of the participants' productive conceptions progressed to become somewhat more specific and detailed. The deficit and stereotypical conceptions regarding low income urban students remained unchanged. However, John emphasized these conceptions less during the post-interview and Janet continued to express slightly more productive conceptions regarding low income students.

Good Teaching Practices

All of the participants reiterated their productive conceptions regarding good teaching practices that are effective with all students. For example, Zane said that he would "try to make the classroom more discussion based" and that he would "launch an idea about the problem then throw the problem at the class and see what they can come up with" rather than using a direct instruction approach. However, most of the participants shifted how they talked about these practices slightly. Janet reiterated her productive conceptions regarding good teaching practices and how they are appropriate for all students, but focused more on how to implement them to engage and motivate students. For example, Janet discussed how diversifying her instruction can keep the students interested and engaged. She said:

> just diversifying it…some days doing it in centers…other times just posing a question without giving any sort of detail and just let students go…get it involved with other classes…if you could make it school wide that's kind of cool too…that would be fun.

In addition, Janet said "I'm a big fan of not letting kids sit the entire time too so if you somehow could get them involved, standing up, doing some sort of activity...I think that's better than just sitting at a desk." This conception is productive in that it is important for teachers to engage and motivate their students. Furthermore, this emphasis on motivating, engaging, and making students interested seemed to also impact her rationale for connecting the mathematics to students' backgrounds, as will be discussed in the next section about the importance of getting to know students.

Zane also reiterated his productive conceptions regarding the use of good teaching practices, but focused more on using group work during the post-interview. When discussing the strategies he would use when teaching any class, he said "probably a lot of group work," specifically that he would "have them work on the problems in groups of three or four…then we would come back together and share as a whole group." Even when specifically referencing struggling students, Zane said he would "try to still keep the group work aspect of it there." This suggests that Zane's conceptions of good teaching changed slightly to put more emphasis on group work. This could be due to the fact that using group work, specifically the group work advocated by complex instruction, was a focus of the middle school mathematics methods course.

Finally, Rick, who was not very forthcoming about the specific good teaching practices he would use during the pre-interview, articulated more of the teaching practices he would use with students during the post-interview. Rick favored student-led discussions when he said he would let "students kind of lead the discussion…students could lead the [discussion]…where every day there's a student going up and directing the class or…having the class direct the answering and understanding of the problems they've done." Rick also expressed more strongly the need for students to work in groups. For example, when talking about his own preferred teaching practices, Rick said:

> I'd probably have them in groups or pairs…I feel like students benefit from working together…collaboration's good for building knowledge, students maybe want to learn from one another as well…they're more engaged in the task if they have to talk about it, not just sit silently and do their work.

Similar to Zach, Rick's increased focus on group work could be due to the fact that using group work, specifically the group work advocated by complex instruction, was a focus of the middle school mathematics methods course. It is unclear whether Zane or Rick is referring to the type of group work advocated by complex instruction.

However, despite these good teaching practices, Rick also hinted at practices related to direct instruction that could lead to the lowering of the cognitive demand of the tasks he would implement. When asked how he would implement high-level tasks in the classroom, Rick said:

> I feel there are tons and tons of different ways that you could activate kids' knowledge before just jumping into a high level task you might take steps up towards it, so you're activating kids' prior knowledge before and you're giving them a not as challenging problem set [so] they have the confidence in their own ability before going into this higher level task

In other words, during the launch of a high-level mathematics task, Rick would give students an easier problem set to activate their prior knowledge. Rick repeated this idea when he said:

> If you're doing anything that's extremely challenging…you might need to…help activate students' prior knowledge…to scaffold them through the beginning, kind of direct students in the way they're going and what they already know and that they have confidence they will be able to do it, might be beneficial.

Drawing on students' prior knowledge during the launch of the lesson can be an essential teaching practice for students to engage in challenging mathematics during a lesson (e.g., Jackson, Shahan, Gibbons, & Cobb, 2012). However, Rick's response suggests that he would do so by either giving an easier task to start that might give too much information away or scaffold students by directing them how to do it. These teaching strategies have the potential to lower the cognitive demand of a high-level task depending on how these practices are enacted (Stein et al., 1996). It is uncertain, though, the extent to which Rick meant that he would direct students towards particular solution methods during the launch of a lesson.

Importance of Getting to Know Students

All of the participants also reiterated their productive conceptions about the importance of getting to know their students' backgrounds and using that information in their mathematics instruction. Rick's and John's conceptions shifted even further during the semester as evidenced by their discussion of practical and specific strategies for getting to know their students' backgrounds. For example, John said "It could start off as something in the beginning of the year just filling out…a get to know you card just to kind of see where they're coming from." More specifically, John and Rick discussed a number of different strategies for which they could get to know students' home and community lives. For example, John said he would go to "visit the students and their parents at home just so you kind of know where they're living from or coming from and…also just knowing the area that you're going to before you actually go there."

Rick and John both specifically emphasized contacting students' parents to determine what students' home lives are like. Specifically, when discussing a particular low income student, John suggested trying to

> reach out to her parents and just kind of figure out- see what their work schedule is, if they both work at night and if she's at home, like who she might be with if it's an older sibling or grandparent or something like that or if her parents are home then maybe…reaching out and seeing if they are able to help with the work and then…giving them guidance how to help.

Also, Rick suggested contacting students' parents to see "if there's anything that they think their child could benefit from as well as…asking where they are, how they're participating in their student's learning." Finally, Rick even suggested asking other teachers to get information about the student. Responding to the information gained from Alicia's (a struggling mathematics student) English teacher, Rick said:

> You can also ask her social studies or science [teacher] and your other departments in school about…what she's learning and how she's benefitting in those classes and if they can fill you in with anything else that you can work off of.

This suggests that Rick and John intended to be proactive in getting to know their students by using the resources (the students, the broader community, other teachers, and parents) available to them. This also suggests that when discussing individual students, John and Rick thought it was important to get to know individual students and not to generalize, which was discussed in the course a lot during the semester. One potential issue with these responses is in the way they suggest contacting parents. John's and Rick's responses are very teacher directed statements in that they suggested that they would reach out to the parents to determine what her home life is like (potentially to confirm their assumptions) and then provide guidance to the parents. Instead, it may be more productive to assume that the parents would be an expert on their own child and would have an idea of what the child may need to be supported.

In addition, all of the participants shifted their thinking productively by particularly referencing the need to draw on students' cultures as the participants only discussed students' interests and lives outside of school at the beginning of the semester. For example, when responding to a teacher who feels that taking student backgrounds into account is unnecessary in a mathematics class, Janet said "I think the way [math is] applied to different students you do need to integrate their culture, you do need to integrate their interests…making it real and relevant for the students." When responding to the same scenario, Rick said "to say I don't see why you have to worry about students' cultures at all is…strange...how do you not want to relate to your students?" In response to this teacher, Rick said "I'd probably try to explain how learning about students' cultures can benefit your teaching…and it'll also benefit the students in the class…if you show effort towards the students, the students will show more effort in the class."

In addition, John said "it is important to refer to the students' culture because they're going to be able to understand something that relates to them rather than it just is something that was thrown into a math book." Finally, Zane specifically discussed taking students' cultures into account in his instruction numerous times throughout the post-interview. For instance, Zane said "you should worry about your students' culture because it could affect their learning. If you do know your students' cultures it could make it a lot healthier environment." Specifically mentioning students' cultures for the first time in the post-interview suggests that the participants might have developed a way to refer to what they thought of as student culture rather than just student interests.

Finally, three of the participants (Janet, Rick, and Zane) emphasized that taking students' backgrounds into account in their mathematics instruction was for motivational purposes. For Rick and Zane, this was something that they emphasized during the pre-interview as well, so their conceptions in this regard did not change. For example, during the post-interview, when discussing what he could do to help the struggling student, Alicia, be more successful in mathematics, Zane said "I can try and motivate her, try to find problems and align the curriculum with real and relevant things in her life." In addition, when asked how he could help Alicia be more successful, Rick said "I think that Alicia could excel if…you made the connection [of] why she's doing what she's doing because that seems to be her question…[I] can make things more relevant to her, therefore she'll be more interested in learning."

Janet, on the other hand, exhibited a shift in her responses in that a part of her rationale for making connections to student backgrounds was now conveyed as being for motivational purposes as opposed to generally stating the need to connect the mathematics to the students' interests or home lives. For example, Janet said you need to make the mathematics "real and relevant for the students…if they don't buy into what's happening then they're not going to participate in the learning so you need to adapt it to them." In addition, she said that she needed to connect the mathematics to students' lives, "making it important to them to make sure they want to understand and learn it."

These responses suggest that for these participants, part of making mathematics meaningful and relevant for students means to motivate and interest students. This can be a productive conception for teachers because it is certainly important to motivate and interest students to learn mathematics. It is also important to understand that connecting the mathematics to students' backgrounds affords an opportunity to draw upon the mathematical practices and experiences that students have to give them greater access to the mathematics they need to learn at school, which may reflect a desire to draw on students' intrinsic motivation. However, this result could imply, as Wlodkowski and Ginsberg (1995) point out, that these participants feel that students are somehow incapable of self-motivation and are in need of help from someone in power (i.e., the teacher). This can be problematic when this assumption is made about certain groups of students because "the 'at-risk' label acts to heighten our perception of students as motivationally dysfunctional, and increases our tendency not to trust their perspective. The fact that an inordinately high number of 'at-risk' students are poor and people of color should cause us to reflect on how well we understand motivation" (Wlodkowski & Ginsberg, 1995, p. 18). It is unclear what Rick, John, and Janet felt was the main purpose of motivating students through connecting mathematics to their backgrounds. However, the latter issue may come in to play with Rick's and Zane's conceptions about low income students as discussed in the next section.

Low Income Students in Urban, High-Needs Schools

Unfortunately, three of the participants' deficit conceptions regarding low income students in urban, high-needs schools remained unchanged. Rick and Zane reiterated that students from low income families might have lower levels of motivation than other students. For instance, when asked why low income students were not present in an advanced mathematics class, Zane said "motivation I think is a big one, they don't value math, they have bigger problems going on at home probably." In addition, when asked why the struggling student Alicia was misbehaving in class, Zane said it was because of "motivation, she probably…doesn't really care." Related to motivation, Zane also reiterated that low income students from urban neighborhoods may not value education. In addition to commenting on Alicia's motivation, Zane said that he would "put her in a group where there are kids that see there is value in doing this." In other words, Alicia may not value mathematics because she doesn't see how it is relevant to her life and so she needs to be shown that mathematics is valuable.

Rick also reiterated his conception from the beginning of the semester that low income students from urban neighborhoods have lower levels of motivation. However, Rick further expressed that it was the racial and ethnic minority students in those neighborhoods that have lower motivation. This conception was expressed when Rick explained why he thought a racially and ethnically diverse school in an urban area would have an advanced mathematics class that had a majority of White students in it. Rick said:

> In the school like that, even though there might be a lack of motivation from all students…generally you could say that White students might be...showing more effort, maybe? I don't know…I would hope that the students are trying but there might be other things they are encountering being from like a low income area, where the African American, Hispanic American, Asian American groups could be influenced by the society around them, and perhaps the White students don't have the same issue. So then, the White students in Lancaster middle school would be more likely to be in an advanced math class than the rest of the students.

While this statement may not be unproductive because being aware of the issues that students face outside of the classroom is important for teachers, Rick’s later statements as presented below about which groups of students face certain kinds of issues (e.g., more violence) in urban areas suggest that it is these issues that Rick referred to in his above statement. These conceptions can be unproductive for Rick to have, especially if he gets a job in a low income and/or urban school, as his assumptions about which students in a low income area may face problems may not be correct and they could cause Rick to have different expectations for students depending upon their membership in a racial or ethnic group. This can cause a stereotype threat to happen where the racial and ethnic minority students do not achieve at the level of their White peers because they are expected not to (Steele & Aronson, 1995).

Rick and John also reiterated their conception from the beginning of the semester that students from low income urban areas have a lack of support from their parents. When asked why the low income student, Alicia, was struggling in class, Rick said that it could be

> a lack of support from her parents being that they’re not around very frequently because they’re both working full time…when she gets home, her parents might not be there so she just does what she really wants to do instead of doing her homework or studying for class.

In addition, when responding to the same prompt, John said “it might be…since both her parents are working they might not be able to be home and help her with work so she's not getting any involvement at home.” However, while this was something John reiterated a number of times during the pre-interview, he only mentioned it once during the post-interview.

Rick and John also reiterated their conception that low income students from urban neighborhoods are subject to encountering more violence in their communities.

Again, Rick expressed that it was the racial and ethnic minority students in urban neighborhoods that may be more subject to that violence. When responding to the scenario where an advanced mathematics class in a racially and ethnically diverse school in an urban area had a majority of White students in it, Rick said:

> In low income areas, especially…low urban areas there might be…[a] high percentage of violence and gangs in the area and stuff like that, and I feel like it's less effective to White students than it is to African American, Hispanic and Asian Americans.

It is unclear as to why this particular conception was expressed during the post-interview but not the pre-interview. However, in the post-interview, Rick attributed this conception to the experiences he had growing up:

> probably because of the area I grew up in, right by [urban area]…we used to have wrestling meets there and…you could see in the area around the neighborhoods that there's gang presence, but I've never seen many or at all of these people being White in that area.

Therefore, it appears as though Rick's out of school experiences impacted his unproductive conceptions and they could not be changed over the course of one semester.

John also discussed the perceived amount of crime or violence in urban neighborhoods during the post-interview as he did at the beginning of the semester. When asked what he would do to ensure that students who are socio-culturally different from him are successful, John said, "if you're going to be in an urban area that might have a lot of crime or violence and figure that out and know that some of your students might be coming from that background" in order to find out about students' backgrounds. John only expressed this conception once during the post-interview. This, along with his increased awareness of getting to know individual students, suggests that he made some progress in that he seems more cautious in making general statements about low income students and urban areas and that he would spend time getting to know students to determine whether or not his assumptions were true. While John made some productive progress by the end of the semester, Rick's unproductive conceptions remained and he even expressed other deficit and stereotypical conceptions regarding students' racial backgrounds.

Janet still held somewhat more productive conceptions about low income students, but shifted her responses slightly to talk less about the specific issues low income students might face (e.g., struggling to find heat/shelter/food) to placing a more neutral role on income as a contributing factor to student behavior and success. Janet mentioned low income students once during the post-interview, but only to say that the fact that students are low income does not necessarily say anything about the students. Janet said:

> I don't think a demographic who participates in free and reduced lunch says really anything about the students at all…they could be super excited and awesome students that are totally one hundred percent invested in their education and just because they're on the free and reduced price lunch program doesn't necessarily reflect anything about them.

This comment suggests that, like at the beginning of the semester, Janet may be less likely to make stereotypical assumptions about low income students.

Aside from the above comment, Janet's conceptions shifted from focusing on low income students to focusing on urban, high-needs schools. When responding to the scenario regarding one school that had a majority White student population in the advanced math class and the other school had a much more racially and ethnically diverse population of students in the advanced math class, Janet assumed that the urban, high-needs school was the one that had the majority White students in the advanced math class. When asked why she felt that way, Janet said:

> Maybe it's because the other programs that are offered, it could be…they just haven't had the support previously up until this point in their schooling so they don't feel like they are ready to be in a higher level math course."

However, the lack of support Janet referred to in this case is not from the students' homes, but from the issues related to teaching in an urban, high-needs school. Janet said "I guess in urban areas they have a higher number of students in the classroom so they have less time to have the one-on-one or feel like they're excelling in a certain area in math." Therefore, Janet progressed in her conceptions in some sense in that she has shifted the reason for low achievement from the students' home lives to school characteristics (e.g., tracking, inequalities in opportunities to learn, etc.). While it may be true that urban, high-needs schools are typically characterized as having large class sizes and fewer resources and that it is important for teachers to be aware of those issues, it is possible for Janet to use those issues as a way to excuse those students who are underperforming by attributing this underperformance onto the school situation.

Summary

Over one semester, all of the participants had productive conceptions regarding the use of good teaching practices with all students and the importance of getting to know students' backgrounds for use in mathematics instruction. The participants made some progress in these conceptions in that they were more specific about the good teaching practices they would use, in terms of strategies for getting to know their students (Rick and John), and the specific importance of getting to know students' cultures. These results suggest that the participants developed their knowledge of these practices and placed some value on them. On the other hand, most of the participants held on to their unproductive conceptions regarding low income urban students. Despite John expressing these conceptions less at the end of the semester, these results align with prior research documenting that these deficit conceptions may be hard to change over the course of one semester for most participants (e.g., Causey et al., 2000). However, Janet was able to progress towards slightly more productive ways of viewing low income urban students by shifting the reason for low achievement from the students' home lives to the school.

Thus, the participants were able to make some progress in their productive conceptions and seemingly none in their unproductive conceptions over the course of one semester while, as discussed in the next section, they made progress towards developing the skills necessary to revise a high-level mathematics task to be more culturally relevant for one student. As will be demonstrated in a later section, there may be a relationship between the participants' conceptions and this performance. Before discussing the participants' progress in their performance, I turn to presenting the progress individual participants made in some of their conceptions outside of the broad themes discussed in the above sections. I do this to illustrate the complexity of the individual participants' conceptions and to illustrate other conceptions that may have been related to their performance.

Other Conceptions – Complexity of Individual Participants' Responses

The shared conceptions examined in the previous sections do not capture the complexity of each of the individual participants in terms of the conceptions they held at the beginning and end of the semester. While specific conceptions shared across all of the participants can be illuminating, the different conceptions the participants held may be related to their performance getting to know the students they shadowed and their performance revising a task to be more culturally relevant for that student. In this section, I will briefly discuss some of the other conceptions that individual participants held to illustrate that complexity.

Productive Conceptions

Two of the participants (Janet and Rick) held other productive conceptions at the beginning and end of the semester that may be related to the conceptions discussed in the previous sections. As presented in previous sections, Janet expressed conceptions at the beginning and end of the semester regarding the use of good teaching practices with all of her students as well as the importance of getting to know her students' backgrounds so she can use that information in her instruction. There is also some evidence that Janet held a growth mindset (Dweck, 2010) regarding students' mathematical ability during the pre- and post-interviews that may be related to her other conceptions. For example, Janet was presented with a scenario in which one teacher expressed a fixed mindset about an underachieving student's mathematics ability by saying "she is not a very strong math student and so I suspect much of her behavior has to do with her math ability." A fixed mindset suggests that a students' ability or intelligence is fixed in the sense that a low achieving student will always be a low achieving student (Dweck, 2010).

Janet immediately responded in the opposite way. She said:

> Instead of just leaving her there and saying "Oh she doesn't understand, it's fine." Going that extra mile and working with her…[saying] "Oh, do you understand? Does a peer want to help her out?" Clarify it. I think any of those strategies will help her.

When pressed further to comment on whether the teacher's characterization of the student told her anything about the student's mathematics ability, Janet said "I don't think so…she even says I suspect it's because she doesn't have a great math ability, not because she can't perform in math." In other words, Janet felt that it is not the case that a student cannot improve his/her performance in mathematics class which is indicative of a growth mindset. Having a growth mindset might serve as a foundation for her other productive conceptions regarding the need to use good teaching practices and to take students' backgrounds into account in that if she believed all of her students can be successful, it may be more likely that she would want to use these effective practices to provide opportunities for all of her students to learn high-level mathematics.

As presented in previous sections, Rick was not very forthcoming at the beginning of the semester about the good teaching practices he would use with students. One potential explanation for this is that Rick also expressed the productive conception that the same good pedagogy is not always appropriate for all students. In other words, Rick emphasized that the practices he would use in the classroom "is dependent on the students" and "saying that you can only teach in one way and one is the only way to teach it is…crazy." While Rick was more explicit at the end of the semester about the good teaching practices he would use, Rick emphasized even more that his instructional choices would depend on the students at the end of the semester. This suggests that he recognized that there are specific teaching practices that can be effective with all students, but the practices he would use in the classroom would largely depend on the students in the class. This may also be related to his conception that it is important to get to know his students because in order to base his instructional practices on who his students are, then he would need to get to know them well enough to do so.

Rick also expressed at the beginning and end of the semester a productive conception that the teacher should take a large part of the responsibility for students' achievement. When discussing the struggling student Alicia, Rick said, "as a teacher it's probably your job to get Alicia more involved in her academics." He also expressed shock when presented with information that Alicia's previous teacher blamed Alicia's achievement on her mathematics ability. He said "that might be true that Alicia's not a strong math student, but I feel like the teachers' lack of support is also a symptom of her poor performance the entire year." Therefore, rather than attribute Alicia's achievement to her ability, Rick thinks that he should shoulder some of that responsibility as a teacher. This conception can be productive for Rick because it suggests that he feels it is the teacher's job to ensure the success of all of his students. This conception may also be related to his conceptions regarding the use of good teaching practices in that Rick was aware of that.

Therefore, some of the participants expressed other productive conceptions at the beginning and end of the semester that may align with or complement some of the productive conceptions they expressed regarding good teaching practices and getting to know students as discussed in the previous sections. The potential relationships between different productive conceptions illustrate how different conceptions can influence each other and align with or bolster their views of good mathematics teaching and reinforce the usefulness of good teaching practices and the importance of getting to know their students.

Unproductive Conceptions

Most of the participants also expressed other potentially unproductive conceptions that may be related to the conceptions discussed in the previous sections and also may be related to the progress they made in their performance towards revising a high-level mathematics task to be culturally relevant for one student. For instance, at the beginning and end of the semester, John characterized “lower level” students as having the potential to learn and improve, but may not have the potential to become “higher level” students. He said “higher level students…should be able to explain a higher level of thinking or…more difficult processes while the lower level students should be able to explain a simpler process.” In addition, John discussed his choice to use high-level mathematics tasks as a way for every student to progress, but assumed that lower level students might not be able to progress as much. John said that lower level students “might not have had the same answer as their friend or the best answer, [but] they did figure it out and they are progressing through their math.” This suggests that lower level students can make progress, but will likely not become higher level students. This thinking shifts control away from the teacher in that it attributes ability onto the student rather than being seen as a capability that can be changed by support from the teacher as well as effort from the student. This conception played a role in how John said he would use group work to implement the task he revised for the student he shadowed, which I discuss in a later section.

As discussed in previous sections, Zane and Rick expressed productive conceptions at the beginning and end of the semester regarding the use of good teaching practices. However, at the beginning and end of the semester, both Rick and Zane also expressed missionary conceptions regarding wanting to teach in an urban school that may be in conflict with their productive conceptions. For example, when asked why he would want to teach in an urban, high-needs school, Rick said "in an urban area I feel like I'm making more of an impact." Zane also expressed similar things when discussing his intent to teach in an urban, high-needs school. Generally, this conception may be unproductive because it could lead to a focus on mastering the material through direct instruction rather than on the learning of high-level content (Martin, 2007). This conception may be in conflict with their productive conceptions regarding the use of good teaching practices depending on which conception would take precedence over the other when teaching. This is a specific concern for Rick given that he hinted at using direct instruction practices during the post-interview, as will be discussed below.

Rick was a particularly complex case in that he expressed a number of potentially unproductive conceptions both at the beginning and end of the semester. Despite mentioning specific good teaching practices in his post-interview, Rick also hinted at practices related to direct instruction that could lead to the lowering of the cognitive demand of the tasks he would implement. Specifically, when asked how he would implement high-level tasks in the classroom, Rick said that he would give students "a not as challenging problem set" and that he would "direct students in the way they're going" so that they would be more confident in solving a high-level mathematics task. These teaching strategies are in conflict with the productive conceptions Rick expressed regarding good teaching practices in that they have the potential to lower the cognitive demand of a high-level task depending on how he would enact these practices.

As discussed in previous sections, Rick expressed some unproductive conceptions at the beginning and end of the semester regarding low income students in urban areas, particularly that students in these areas may have lower levels of motivation due to the perceived crime and violence they face. Related to this conception about low income students in urban areas, during the pre-interview Rick expressed that there might be different goals for students depending on the school setting. In particular, the goal for students in an urban school is to motivate and interest students whereas in a suburban school the focus is more on student achievement. He said that when teaching in a low income school, the idea "is more about motivating a student to just be excited about learning than actually getting the A plus in the class." He also expressed that if the students are not motivated to learn mathematics, your focus as a teacher should be to motivate and interest your students and if the students do value mathematics, your focus is more on the learning of the content. Given Rick's deficit conceptions about low income students having low motivation (due to the lack of parental support at home), this is an unproductive conception for Rick to have because focusing on student motivation and interest, while important, could lead to de-emphasizing the learning of high-level mathematics. However, this particular conception was not expressed during the post-interview, though his deficit conceptions regarding low income urban students were as discussed in previous sections.

Summary

The participants all had some other productive and unproductive conceptions that illustrate how complex the conceptions of the individual participants were. These results suggest that some productive and unproductive conceptions can align with or bolster others, but that unproductive conceptions can also be in conflict with some productive conceptions (e.g., Rousseau, 2004). Thus, learning about a few isolated conceptions that the participants' held does not tell the whole story. These other conceptions and their relation to each other need to be kept in mind as some of the participants' conceptions may be related to their progress towards revising a high-level mathematics task to be culturally relevant for one student, which I discuss in a later section.

I now turn to exploring the findings related to the progress the participants made towards being able to revise a high-level mathematics task to be more culturally relevant for one student. These findings relate to the first research question. It is important to look at both participants' conceptions and their performance because of the potential impact that their conceptions can have on their performance on the course projects for this study.

Progress towards Revising a Task to be Culturally Relevant

Despite the minimal change in conceptions, the participants were all able to make progress towards revising a task to be culturally relevant for one student. In this section, I present the findings regarding this claim. Because all of the participants shadowed a different student, I present the results for each individual participant to highlight each stage of the progress in detail and to show how each stage built upon the previous ones based on the student they shadowed, culminating in their ability to revise a high-level mathematics task to be culturally relevant for the student they shadowed as well as improve that task based on instructor feedback. The sections below will provide evidence for the following claims for all four participants in terms of this progress. First, the participants were able to get to know their students' interests, cultures, home and community lives and the mathematical practices that occur in these settings and were all able to use the information they learned about their students to develop general ideas for mathematics instruction for those students with varying degrees of specificity. Then, all of the participants were able to take something they learned that was personally meaningful for their student to revise a task to be more relevant for that student with varying degrees of success. The success the participants had was related to what and how much they were able to get to know the students they shadowed. Finally, most of the participants were able to make more progress on their task revisions during the post-interview with the guidance of the instructor's feedback on their *task revision* projects and during the post-interview.

John

The student that John got to know during his field placement (Molly) is a White, middle class female in eighth grade. John learned a detailed amount of information about Molly's behavior at school as well as about her home life and was able to use that information to develop some specific ideas for mathematics instruction. John also learned even more information in subsequent weeks and used that information to revise a high-level mathematics task to be more culturally relevant for Molly in a more surface level way. The following sections will discuss these claims in more detail.

Getting to Know Molly

During the first week in his field placement, John learned a detailed amount of information about Molly's behavior at school, her home life, her interests, and some of the mathematical practices that go on in some of these areas and used much of this information in his initial ideas for mathematics instruction for Molly. In terms of Molly's behavior at school, John found that she is "friendly with everyone and everyone was the same with her" and she works well with her peers in all of her classes. John also wrote that "she told me that she was a visual learner and I noticed throughout the day that she was." John did notice that Molly was very artistic and "had drawings in a notebook that she showed me." John connected this piece of information with how she acted in her classes. John found that Molly acted differently depending on the class she was in. For example, in Social Studies class, it appeared to John that Molly did not comprehend the content that was being read aloud,

> …but when they went over notes on a power-point the teacher had pictures to go along with notes and she understood them much better for the class activity even though both the reading and the power-point contained the same information.

Also, in English class "Molly was very eager to participate and knew nearly every answer" because in English "everything they did was hands on and had pictures or was a movie." Whereas in mathematics class, Molly was "still very friendly and social, but would never participate and was always behind on her work." John decided to ask her about math class and "she said that it was her least favorite subject and could only understand it when she drew pictures."

John also gleaned a lot of information regarding Molly's home life and the mathematical practices that go on there from Molly that influenced John's initial ideas for mathematics instruction as well as the task revision. John determined that Molly has a mother, father, and younger brother. John also determined that "Molly comes from a culture of a family that travels a lot. Both her parents traveled when they were younger and she used to take trips to other countries when she was younger." In particular, Molly has friends in England and Scotland that she wants to visit, but is not able to afford it. In fact, John found that Molly "has looked up flights but has never committed because the price just keeps adding up."

John also found from listening in on the conversation between Molly and her friends at lunch that Molly went shopping with her mom and brother and discussed how “it was unfair because since he was younger he got 100 dollars spent on school supplies while she only got 75 dollars.” John noted that “this was one way she used math outside of school.” John also asked Molly directly about the math she does outside of school and she told John that she used measuring cups with her mom, “but she could not figure out the fractions so she left the cooking to her mom.” So, it appeared as though John learned that Molly had at least some experiences with math outside of school with both cooking and shopping.

Initial Ideas for Mathematics Instruction

John was able to use what he learned about Molly’s learning preferences and interests to develop some specific ideas about mathematics instruction. Because Molly described herself as a visual learner and his observations of her behavior in class seemed to confirm this, John thought that “problems that have a context that is either a graph or picture would be great to help Molly learn, or a problem that she can develop a picture for as one strategy.” Despite providing other examples of tasks to use with Molly, John didn’t give a specific example of a problem he thought would be appropriate that would require using pictures for the *shadow a student* paper. However, John did write in his *problem solving interview* paper that for Molly’s difficulty with solving division of fractions problems,

> I would give Molly problems that start with easy whole numbers being divided into a whole number and ask her to first write the division statement since this is her strength, and second draw a picture using the information from the story and the division problem that she wrote.

In this example, John wanted to give Molly an opportunity to use pictures to understand division so that she can move on to using those ideas with division of fractions.

John also gave one specific example of a mathematics task that draws on Molly's interest in travel in his *shadow a student* project paper:

> One problem that could be used would be having the students do research as to which flight would be cheapest for them to fly on. I could let them pick their destination and give them a one week period when they can depart and a one week period where they could fly back. They will have to personally take into account how many people are flying, the price of different airlines, airports, taxes, baggage fees, taxi and transportation fees, etc.

John argued that this would make Molly "more involved" in math class as it will be "more hands on and visual," but he didn't describe in detail why he believed this particular task draws on Molly's visual learning preference. John also argued that this is something that is relevant to her because "if she was able to find something to fit her budget she might really be able to take this trip to visit all of her friends." John learned more about Molly's interest in travel over the next two weeks in the field. Subsequently, this problem context happens to be what John used for his task revision.

John's Task Revision

John successfully revised a high-level mathematics task using the information about Molly that he learned in subsequent weeks in the field. However, John made beginning, surface-level changes to the original task as opposed to more meaningful ones for Molly. John drew on Molly's interest and family practice of travel and her interest in art that he learned about during the first week in the field. However, it is unclear whether this interest/family practice is related to Molly's culture. John wrote:

"I came to find out that over the summer she attended a camp where she did a lot of sailing and boat safety and she loved being out on the water." John used these particular interests to revise a high-level mathematics task to be more relevant for Molly.

John chose to revise the task whose context was about budgeting travel options to a basketball camp (See Appendix B). His revised task can be found in Appendix C. All of the changes made to the task were based on things that Molly was interested in. However, the changes can be described as beginning level changes. If you compare the original task to John's revised task, you can see that he replaced the name to be Molly, replaced "train" with "boat" as a travel option, changed the basketball scholarship to an art scholarship, and changed the location of the travel to be Scotland. John also changed the amount of money Molly would have to spend because "1500 is a harder number to work with than an even 1000, but also because for this example it would not have been realistic to fly to Scotland and take art lessons for a week and still be under $1000." None of the other text of the problem was altered. I interpreted these changes as beginning level changes because the only things that were changed were the nouns (names, places, transportation options, etc.) rather than changes that drew more authentically on the mathematical practices of the student.

However, these changes are based on careful consideration of the things John learned about Molly. John gave valid reasons for the choices that he made for this revision and suggested that he thought carefully about the revisions he made. He wrote that generally, "budgeting is definitely a topic that Molly showed…interest in learning about and would be excited to learn." He also wrote that he chose Glasgow, Scotland because Molly said she has friends who live there and "by doing this type of task on budgeting she might be able to apply it to a future trip for herself." John also wrote that he included an option to travel by boat because "it was cheaper and an experience she would like to take." Therefore, John did appropriately draw on many of Molly's interests and the task appears to be one that Molly could engage in successfully.

Despite this, John's revised task may not be as mathematically meaningful or authentic of a problem for Molly in terms of the experiences that Molly had. There are two ways in which the revised task could be improved. First, the art context could have drawn more meaningfully on the mathematics. In particular, John did say that he changed basketball to art "[because] it was more fitting to her" which suggests that John used the art scholarship context as a way to gain Molly's initial interest in solving the problem, but does not draw meaningfully on the mathematics related to art. Second, the travel context could have treated the trip in a more authentic manner. The choice of budgeting for a trip is something that John found Molly has some experience in (i.e. looking up plane ticket fares). Therefore, the choice to keep the focus of the problem on budgeting for travel was appropriate. However, the problem does not necessarily do this in an authentic way as there are other expenses that Molly would have to consider for a trip to Scotland (e.g., travel to and from the airport, hotel costs, etc.). Interestingly, the problem John proposed for the *shadow a student* paper seemed to take these more authentic constraints into account.

Post-Interview Edits to Task Revision

During the post-interview, John recognized after reading comments from the instructor that his task revision included more beginning level changes and was able to make edits to the task that would make it more authentic for Molly. The instructor directly addressed how the student's revision was at a beginning level and gave suggestions for making the revision more authentic for Molly. Specifically, the instructor wrote: "if you had just made it about budgeting (the art seems secondary and not what is meaningful here) with more constraints (such as hotel costs, etc.) it might be more realistically meaningful." These comments were reiterated during the post-interview and John was asked to reflect on them, specifically discussing how he would improve his revision. John gave many ideas for how to edit his revised task to take other travel expenses into account:

> I could have…a couple hotels and…one hotel could be cheaper but farther away so if she's going to visit her friend it will cost more for gas or like bus or like train or however she's going to get there and then one that's a little bit more expensive um but is closer so she won't spend as much on like transportation so she has to…give like three examples and find one that balances the best and what she prefers...and then it could also be like find out like a couple different activities in Scotland that they could do…go to like Edinburgh Castle or go to like Loch Lomond and- and figure out the price for that and how much it would cost for her and her friend to go and figure out that cost and see what she would prefer to do and then she can balance like between…by boat or by air or the hotels with the gas cost and then uh also like the places that she wanted to go.

Therefore, John was able to give more specific, real-world budgeting constraints that a person traveling would have to consider. John also recognized the difference between beginning level changes and more meaningful or authentic changes and could articulate the differences. He said:

> mine were more [beginning] level because…even though I changed the numbers to higher or more difficult numbers it was still the same kind of thing…by having more possibilities and more factors like the gas factor when she's at the hotel it's going to be like more realistic.

Thus, John could articulate that the changes he originally made did not make the task as realistic as the changes he suggested during the interview. Therefore, when given feedback within his zone of proximal development (Vygotsky, 1987), John was able to successfully suggest amendments to his task revision that may be more authentic for Molly.

Summary

John made significant progress throughout the semester towards developing the necessary skills to be able to revise a high-level mathematics task to be more culturally relevant for one student. John was able to learn how to get to know a student's background interests and home life in detail. He was also able to use that information to develop some specific ideas about mathematics instruction that would benefit a particular student and then successfully revise a mathematics task to be more relevant for that student. John was also able to make a high-level mathematics task more authentic and meaningful for his student with support from the instructor.

Zane

The student that Zane got to know during his field placement (Ben) is an African American male in sixth grade. Zane learned some things about Ben's behavior at school and his interests and was able to use that information to develop some initial ideas for mathematics instruction for Ben that were not specific or detailed, but included justification for general instructional practices based on Ben's behavior in school. Zane revised a high level mathematics task based on a meaningful interest of Ben's, but ultimately changed the mathematics content that was being addressed in the original task. The following sections will discuss these claims in more detail.

Getting to Know Ben

During the first week in his field placement, Zane learned some information about Ben's behavior at school and his interests, but not a lot about his out of school activities due to Ben's unwillingness to speak at length about his home life. In terms of Ben's behavior at school, Zane found that Ben struggled in his honors math class and Zane observed that he often became bored and "would see him twirling his pencil and staring around the room. Ben would never raise his hand or volunteer to show his work." In Language Arts, Ben also showed his disinterest. Zane wrote that "during the class reading Ben was slouched over and did not really look into his book." Zane found out that Ben was put on some medication that might have been affecting his behavior, but he also suspected that it might be a lack of interest. Zane wrote: "I am sure the medicine he is taking is affecting him in some way, but I also think he loses interest." Zane thought that this lack of interest might be the case because he had observed Ben performing well in math class before. Zane wrote: "I have seen Ben do challenging math problems before. I think he has the potential to become a very effective math student."

Zane also gathered evidence that led him to believe that Ben was disinterested in math because of Ben's interest and behavior in his favorite classes. When Zane asked what his favorite classes were, Ben said "I really like computers." Zane wrote that Ben "really showed his love for video games and computers throughout the day." Zane learned that Ben looked at YouTube videos online, particularly reporting that Ben had told him about a man on YouTube that "makes funny videos about video games and stuff." Zane also noted that Ben had considerable skills on the computer and that "other students were coming up to him and asking him to help [them] throughout the whole class." However, it is unclear from what Zane reported the extent to which Ben likes computers beyond his interest in video games and YouTube videos.

Zane also found out that Ben had a strong interest in science and he seemed to participate more in class as a result. Ben told Zane that he really likes science. Ben said “science is just cool. You get to see all them animals and mess with stuff, you know?” In addition, when asked what his favorite animal was, Ben said “I guess a cheetah, you know? They’re like quick and think fast. They’re like super cool too.” Zane also found that when asked to complete activities related to science, his interest in the class increased. At one point during his language arts class, Ben became very interested when they had to read an article about spiders and their webs in their groups and answer questions about it. Zane observed that Ben and another student “talked on and on about all the spiders they saw on television.” Ben also expressed his interest in his assignments for science class at the beginning of the day. Zane observed Ben talking to his friends in the hallway before homeroom about their assignment for science class. Ben said “Yeah I did that. I think mine is really cool. It took me a long time, but I kinda like that stuff.” Therefore, it is clear that Ben had a strong interest in science, at least from the specific standpoint that he really likes animals.

However, Zane was unable to determine much about Ben’s home life, despite making efforts to ask Ben about it. This is not particularly surprising given the limited amount of time Zane spent with Ben and so he may not have felt like opening up to someone he didn’t know very well. When Zane asked who he lives with, Ben said “my mom is always around.” When Zane asked if he had any brothers or sisters, “he shook his head yes, but that was all he would give me.” Most of the discussion Zane had with Ben about what happens outside of school surrounded Ben’s interest in video games, particularly World of Warcraft that he played after school and on weekends. In addition, Zane was not able to find out much about the mathematical practices Ben engages in outside of school. When asked if he ever used math outside of the classroom, Ben said "I guess so…I sometimes have to run to the store and buy stuff with the money my mom gives me, does that count?" However, Zane did not report finding out anything more about his out of school activities. This lack of information may have contributed to Zane's limited success when determining the initial ideas he had for mathematics instruction and had an impact on his success revising a high-level mathematics task for Ben.

Initial Ideas for Mathematics Instruction

Zane's initial ideas regarding mathematics instruction for Ben in the *shadow a student* project paper were not specific or detailed, but included justification for general instructional practices based on Ben's behavior in school. Zane's initial ideas for mathematics instruction focused on broad ideas related to Ben's interests in computers and in science. Related to Ben's interest in science, Zane suggests that he could have students "measure different parts of an animal and compare the lengths. With a cool visual I am sure Ben would take an interest to it." As this was all that Zane wrote in his project paper, it is unclear what Zane means when he says that they could compare the different measurements. He could be referring to a proportional reasoning problem or simply comparing the difference in lengths or something else entirely. However, if he is referring to comparing the difference in lengths, it would not be an appropriate task for a sixth grade student.

Zane also provided some broad examples of how he could incorporate Ben's interest in computers. Zane wrote: "Ben really likes computers so I could see if there was a way for me to use the computer lab for a lesson. We could use software geared towards math activities." However, Zane did not elaborate beyond this to discuss what software he would use, how he would use it, or any mathematics content or topics that would be appropriate to use in the computer lab. Zane also wrote: “I am sure he has an interest for the SmartBoard, but I am not sure of how comfortable he is getting up in front of a class and solving a problem.” Here Zane is inferring interest for the SmartBoard based on Ben’s interest in computers that he really had no evidence for. Zane made more inferences like this when revising his task, as will be discussed below. Also, he does not give any examples of activities that he would do using the SmartBoard or how he would address the perceived comfort level of Ben to use it in front of the class.

Finally, Zane also provided ideas for general instructional practices he would have used with Ben in the mathematics classroom that address his disinterest and behavior in class, but did not do so in any meaningful way for Ben. Zane suggested “a lot of hands-on activities, have constant cool visuals with the math problems, and promote discussion that forces every student to talk.” This suggests that Zane assumed that because he perceived that Ben “understands what is going on in the classroom” and is just disinterested, that simply using these practices will make a difference. These are all good teaching practices that can be engaging and motivating for students in a general sense. However, Zane was instructed to go beyond this to create more meaningful activities for Ben based on his interests.

This lack of specific examples and detail could be a result of not learning as much about Ben as Zane would have liked. However, because there was plenty of information for Zane to draw on to at least develop some slightly more specific examples, these results suggest that Zane struggled at this point in the semester to apply his knowledge of a student in his mathematics instruction.

Zane's Task Revision

Zane revised a high-level mathematics task based on a meaningful interest of Ben's, but speculated about the amount of knowledge Ben had surrounding the mathematics related to this interest. Overall, Zane's task revision was a good one in that he drew upon a meaningful interest of Ben's, maintained a high-level of cognitive demand, and went beyond surface level changes to the original task. However, Zane's task revision had room for improvement as a result of not getting Ben to open up to him and of the mathematics content addressed in the revised task not matching that of the original. Zane expressed in his *task revision* project that "it was difficult to get a clear understanding of his actual culture and life outside of school" because Ben was so quiet. As a result of not getting to know Ben's culture or home and community experiences, Zane chose to draw on Ben's personal interest in science, particularly on his interest in cheetahs. Zane chose to revise the task whose context was about interpreting a graph and writing a story based on the context of the speed of a student walking to his grandmother's house (See Appendix B). His revised task can be found in Appendix C. Zane specifically focused his revision on the speed of a cheetah chasing a rabbit. However, Zane speculated about how much knowledge Ben had about how a cheetah's speed changes while doing this. Specifically, Zane said:

> If I had to guess, I bet Ben likes to watch a lot of the Discovery channel. I say this because he would tell me that a cheetah can catch a rabbit so quickly unless the rabbit knows to turn a lot, but the cheetah will always catch it.

Zane also further speculates that because Ben liked to watch a lot of YouTube videos on the internet, "he may watch videos of cheetahs every day after school." Based on Ben's previously expressed interest in watching videos on YouTube, it may not be an incorrect assumption on Zane's part. However, Zane does not really know whether or not either of these options is true. Also, it is unclear how meaningful of an interest cheetah's are to Ben based on the limited amount of information Zane was able to gather from Ben. That said, given the information he was able to collect, this could be a fairly meaningful task for Ben to engage with.

When revising the task, Zane altered the mathematical content that was being assessed in the original task. Zane changed the task from writing a story based on a given graph to drawing a graph based on a story. Zane did provide a rationale for doing so based on what he learned about Ben's interest and behavior in math class. He wrote that because Ben showed a disinterest in math, "I feel like if he was given another sheet of paper with a graph on it he would be turned off." Zane expanded upon this rationale during the post interview when he said:

> the whole idea of there being a graph on the sheet of paper that I'm giving him, I feel like that would be "oh here we go we're doing a graph, what do I have to do." Even though it says write a story which he might be in to, it's just [that] there's still a graph there that he has to look at. So my idea was just take the graph away and give him the story to read…obviously I think it would be interesting to him…and like even though he knows in the back of his mind he has to draw a graph, he's still reading this story.

Therefore, Zane had a reason for altering the mathematics content addressed by the task, but there are a number of reasons why the project required the prospective teachers not to do this. From a teacher's standpoint, changing the content that was addressed in the original task changes the learning goal of the lesson. If he were to do this with their curriculum materials based on the school or district pacing guide, then changing the learning goal might not be possible for any given day. Also, changing the mathematics content also changes the knowledge and understanding that was assessed by the original task. Therefore, it is important for prospective teachers to learn how to revise a task so that they could use it for the lesson it was originally intended for.

Post-Interview Edits to Task Revision

During the post-interview, Zane was able to propose another revision to the task that did not alter the mathematics content addressed in the original task without the assistance of the instructor. However, Zane exhibited confusion as to whether the new revision was at a more surface level. He said:

> I mean I would still relate it to him being a scientist observing cheetahs, but I guess if I have to give them the graph, I would ask the class to explain in terms of what the cheetah's day was like, what happened there. I just think that was too surface level…I think this is a good task and I think that it's a challenging task but, I don't know.

In other words, Zane would revise the context to having the students write a story about what the cheetah was doing at different times based on the graph of his speed. This is a more ideal task revision in that it draws on an interest of Ben's, it draws on the mathematics in relation to a cheetah's changing speed in a potentially authentic way, and it draws on the knowledge that Zane speculated that Ben might have of the mathematics underlying a cheetah's speed. This suggests that Zane was capable of revising the task to assess the mathematics content of the original task, but that he might have some confusion as to what constitutes a surface or beginning level revision to a task.

Summary

Zane made progress throughout the semester towards developing the necessary skills to be able to revise a high-level mathematics task to be more culturally relevant for one student. Zane had difficulty getting Ben to talk about his life outside of school, which limited the amount of information he was able to get, which in turn related to what he was able to do on his task revision. While Zane did struggle to provide ideas for how to use what he learned about Ben in his mathematics instruction, Zane was able to revise a task that was given to him based on Ben's interest. On the other hand, as a result of not being able to get Ben to open up, Zane was unable to draw upon Ben's culture and he was unable to determine whether Ben actually had experience watching videos of cheetahs and therefore, access to the mathematical idea of changing speed. Finally, despite altering the mathematics content addressed by the original task, Zane was able to justify the choice based on what he did learn about Ben's behavior. Zane also exhibited evidence during the post-interview that he was able to revise a task that addressed the same mathematics content as the original task despite not doing so initially.

Rick

The student that Rick got to know during his field placement (Aaron) is an African American and Hispanic, middle class male in eighth grade. Rick learned a detailed amount of information about Aaron's interests and home life and was able to use that information to develop broad ideas for mathematics instruction. Rick then learned more about Aaron in subsequent weeks and used that information to successfully revise a high-level mathematics task to be more culturally relevant for that student. The following sections will discuss these claims in more detail.

Getting to Know Aaron

During the first week in his field placement, Rick learned a lot about his student's home life and his interests without describing it in much detail. Rick did learn a lot about Aaron's family, including that his biological father is incarcerated and he lives with his mother and stepfather. Rick found out that Aaron's mother and stepfather met at a bank, but they now work at different banks. Rick wrote that "Aaron thinks that both of his parents' new jobs are better than their previous ones." Rick also reported that Aaron "calls himself an only child" although he "does have an 11 year old brother" that "he does not live or speak with." Rick also listed a number of things that Aaron is involved in outside of school, but it is unclear the extent to which he does these things. Rick lists that Aaron goes grocery and back-to-school shopping and cooks with his mother, eats at McDonalds with his mother, attends church, plays at the park, goes to the bank with parents, and attends an after school program for additional educational help. While it appears as though Rick got to know a great deal about Aaron's family and what he does outside of school, Rick does not talk about any of Aaron's out of school activities with any detail.

Rick reported somewhat more detail about Aaron's interests, particularly his interest in various sports. Rick wrote that "Aaron loves to play basketball with his friends after school…if he has any down time he will usually be shooting the ball around." Rick also wrote that "Aaron used to play football as a defensive tackle and kick return specialist" but that he did not sign up to play on the team again. However, Rick did not report that he found out why this was the case and so it is unclear how much of an interest Aaron had in playing football at the time Rick shadowed him. Rick also reported that he observed Aaron playing Yu-gi-oh cards every day with his friends during lunch. Again, with the lack of detail that Rick provided, it is unclear how meaningful these interests are to Aaron.

Rick did report briefly about the mathematical practices Aaron participates in outside of school by referencing that his student knew about the mathematical practices he used and providing only one example of when Aaron does so. When Rick asked Aaron to relate what he does outside of school to mathematics "Aaron started spewing different answers…it is clear that Aaron understands how important it is to know math outside of school." Despite the fact that Rick stated that Aaron was able to make these connections, Rick only provided one specific example. Rick discussed how Aaron saw mathematics a lot when they went to McDonalds, including watching what the cashier did behind the counter. When Rick pressed Aaron to discuss the mathematics that he does when he goes to McDonalds, "Aaron said that he can spend $10, so he picks out items off the menu, adding them together in his head to make sure he doesn't overspend."

The lack of detail that Rick reported learning about Aaron is apparent. In addition to not being very detailed about the things he did write about Aaron, Rick also did not report any of Aaron's behavior during the classes he observed. This could suggest that Rick had issues shadowing Aaron, but given what Rick did write in his project paper and through informal conversations with Rick, it did not appear that this was the case. Therefore, this omission could be due to the fact that Rick did not find Aaron's behavior to be important to report or he simply forgot to include it in his project write-up. This lack of detail also impacted the initial ideas Rick provided for mathematics instruction that would benefit Aaron.

Initial Ideas for Mathematics Instruction

Rick's initial ideas regarding mathematics instruction for Aaron included incorporating his general interest in athletics and information about his parents' careers into mathematics instruction, but were not specific or detailed in terms of their relation to Aaron's specific interests and home life. Specifically, Rick gave a general sense of how one might use sports in math class, but doesn't talk about Aaron's interests in basketball or football directly. Rick wrote:

> A teacher could start with simple math operations seen in a game, such as: distance traveled or adding scores. More advanced operations seen in a game could be the trajectory of a ball or the acceleration and deceleration of a player.

The scenarios Rick proposed could be related to basketball or football and could become high-level tasks that Aaron might be able to engage in, but Rick does not go beyond these scenarios to illustrate how these general ideas could be applied specifically to what Aaron has experience with and an interest in.

In addition, Rick wrote "Another math activity I could use to extend on Aaron's thinking is developing a stronger understanding of his parents' occupations or just jobs in general." Rick's idea for instruction related to this was to provide a link to a website that helps students explore how math is used in different careers. Rick justified the use of this website by saying that "Students frequently ask the question "When are we going to use this? This site gives the answer. Students are able to explore different businesses in an online activity to identify how mathematics is used in that specific job." When discussing this website, Rick focused on how it could be used to show students where mathematics is used in the "real world." However, Aaron's parents' occupation of banker is not one of the careers students can explore on the website. Rick also does not suggest any specific activities or problem contexts he would specifically use from this website related to being a banker or to any other career. In particular, Rick provided no discussion of which of the activities on the website would be appropriate or meaningful for Aaron and why. This suggests that

Rick focused on the usefulness of this website in a whole-class setting, rather than what would be personally meaningful or interesting for Aaron.

Rick did try to make this suggestion more meaningful for Aaron by stating:

> In addition to using the site, a teacher could ask students to interview their parents to draw a connection to what their family members do [with] mathematics. For Aaron, this could help him understand what his parents are doing at the bank, rather than just knowing that he gets a lollipop every time he is there.

While this might be personally meaningful for Aaron in the sense that he might want to know more about his parents' occupation, Rick did not mention whether Aaron was interested in learning about careers that use math, banking as a career specifically, or whether Aaron has experience or knowledge of what his parents do. The above quote suggests that Aaron might not have this knowledge, experience, or interest and Rick did not provide any supporting evidence to be led to think otherwise. Therefore, Rick's initial ideas for mathematics instruction 1) focus broadly on Aaron's interest in sports; and 2) focus on learning about his parent's occupation rather than drawing on the mathematical knowledge Aaron might have from his activities outside of school.

Rick's Task Revision

Rick continued his relationship with Aaron and found out a more meaningful activity that Aaron engaged in, supporting him in successfully revising a high-level mathematics task to be more relevant for Aaron. Rick learned about this activity in the remaining two weeks in the field. Rick reported in his *task revision* project that "my relationship with Aaron did not stop once I completed the *shadow a student* project. Aaron and I speak frequently at the beginning and end of his class period with me." It was during these informal interactions that Rick discovered an activity that was personally meaningful for Aaron in which he had access to the mathematical practices that occur during this activity. Rick wrote in his *task revision* project:

> Aaron has informed me that at a recent doctors visit, his doctor has suggested that he begin to exercise more as he is considered to be obese. Aaron along with his mother have begun to take walks after school together. Each day they have been extending the distance they are traveling and the speed in which they are traveling. Aaron is keeping a log of the mileage and time of his walking so that he can report back to his doctor on his progress.

It is this activity that Aaron engages in with his mother that Rick chose to draw on for his task revision. Rick wrote: "I chose to draw upon this aspect of Aaron's life because of the sheer excitement I have seen from him in explaining to me his walking progression." Therefore, it made sense to Rick that this was something that should be used for his task revision because of how meaningful it was for Aaron.

Rick chose to revise the task whose context was about interpreting a graph and writing a story based on the context of the speed of a student walking to his grandmother's house (See Appendix B). His revised task can be found in Appendix C. Rick revised this task to "focus on the trend Aaron might see as he progresses through his walking overtime." This task is something that Aaron had access to as he was keeping track of how far and how fast he walked. The revised task is at a more advanced stage of revising a high-level task as Rick drew upon activity that was personally meaningful for Aaron that he did at home with his mother. However, the revised task did not draw upon Aaron's culture, but a personal home experience. Also, the revised task remained at a high level of cognitive demand (doing mathematics) and addressed the same mathematical content as the original task. The revision also drew realistically on the mathematics content present in the context, which in this case was the speed at which he walked over time.

Finally, the task also specifically drew upon the mathematical practices related to what Aaron had access to; namely that he was tracking his own speed as he walked. Rick discussed how Aaron had access to the mathematics in that he understood how increasing his speed would allow him to reach his goal distance faster. Rick wrote:

> Aaron came to class telling me about the drastic improvements he made over the weekend. Aaron was pretty excited that each day over the weekend he walked 2 miles with his mother and was excited to continue to walk with her throughout the week…Aaron intends on trying to increase the speed of his traveling rather than the distance he travels as he continues to try to lose weight. So the focus of Aaron's progression going forward will be to jog rather than walk in hopes that he can finish his 2 miles at a quicker pace.

Therefore, Aaron had access to the mathematical ideas and concepts required to engage in the revised task. Overall, Rick's determination to continue to build a relationship with Aaron allowed him to find a meaningful activity that Aaron could engage within the context of a mathematics task.

However, there is one potential issue worth mentioning about Rick's revised task. In the direction for his revised task, Rick added in parentheses "using clue words" to describe what Aaron is doing at different times on the graph. This does not change the task itself drastically in terms of cognitive demand, but it may hint at the way Rick would teach this math content to a class. The use of "clue words" may imply having students memorize specific tricks or phrases to be used but it could also imply that the students need to use proper mathematical vocabulary. Rick wrote in his *task revision* project write-up that

> students should say "at a steady pace" in the word problem if the graph shows a horizontal line. Students should state that a graph is "steadily increasing" or "steadily decreasing" if the graph shows a diagonal line. If the graph shows a sloped line the student should describe this as getting "faster and faster" or "slower and slower."

This suggests Rick emphasized the use of proper mathematical vocabulary rather than memorizing clue words.

Post-Interview Edits to Task Revision

During the post-interview, Rick discussed some revisions that he would suggest for his revised task because he felt it was unrealistic and potentially inappropriate for use with a whole class. Interestingly, Rick was not prompted to discuss such revisions to his task but felt that he should address them during the post-interview. When reacting to the project itself, Rick discussed the problems he had with implementing this particular task with a whole class:

> When we made the revision, I was stunned by the assignment, when it says we're making revisions to one specific student and I make this revision so specific, so that it connects with a student and they understand it…then to teach this specific task to an entire class of students with this student in it…this kid is walking with his mother, it's 8th grade. To say that Aaron's walking with his mother…in an 8th grade class…puts him on the spot and people are going to be looking at him, and what's going on there? I think that I would revise the task more though. Maybe I wouldn't say Aaron and his mother. I would change the names so that it's not a student in the class.

This response suggests that Rick is concerned with embarrassing his student because of the personal nature of the revised context, Aaron's age, and how Aaron's peers will view the task and Aaron. This also suggests that Rick is cognizant that a task tailored to one student can be used in the class, but that he might have to alter the revisions slightly for use with the entire class.

In terms of the realistic nature of the task, Rick felt that walking speed over three hours might not be very realistic, but it would be hard to compress the time interval. Rick said "I don't want the student [to] travel for six miles per hour for a minute, and then now they're changing direction. That graph's too hard to read so you have to expand the time." To counteract this issue, Rick suggested that perhaps tracking a car's speed over time might be more realistic. Rick said that the walking context is

> kind of unrealistic…they were walking slow and then just sped up and now we're going really fast…at 8 miles per hour…and two miles is so slow. So the problem could change from walking to being…the movement of a car. I feel like…a walking pace isn't going to change so drastically, and to come to a stop light and then steadily increases.

In other words, the graph that he drew for this task might make more sense if it were a car's speed because walking speed might not be realistic, depending on the speed. While it is good that Rick tried to make the task more realistic and while the students may still have access to the task, changing the task like this might no longer be meaningful for Aaron. If Rick was worried about having realistic speeds for walking, he could have changed the scale of the graph or had the function itself be at more realistic speeds. This is something that teachers will have to wrestle with when attempting to revise high-level mathematics tasks to be more culturally relevant for entire classrooms full of students.

Summary

Rick made progress throughout the semester towards developing the necessary skills to be able to revise a high-level mathematics task to be more culturally relevant for one student. Rick learned how to get to know a student's interests and home life in some detail. Rick used that information to develop some broad ideas for mathematics instruction that would benefit Aaron, although they were not very specific and drew on the mathematics that his parents do in their jobs rather than the mathematical practices that Aaron used in his life outside of school. However, Rick continued to get to know Aaron in the weeks beyond completing the *shadow a student* project and was able to find out about a meaningful activity (Aaron walking with his mother to get in shape) that he could use to successfully revise a high-level mathematics task to be more meaningful for Aaron. During the post interview, however, Rick expressed awareness of how a task revised for one student may not be appropriate for a classroom full of students and thus suggested possible revisions he would make to the task to make it more appropriate in the whole class context.

Janet

The student that Janet got to know during her field placement (Kelly) is an Indian, middle class female in sixth grade. Janet learned a detailed amount of information about Kelly's behavior at school, visible and invisible culture, her home and community practices, her interests, and the mathematics that occurs in these categories. Janet was able to use that information to develop specific ideas for mathematics instruction for Kelly that included ideas about incorporating her student's interests and culture into various mathematics tasks as well as ideas for how to implement such tasks based on her student's behavior in school. Finally, Janet successfully revised a high-level mathematics task based on something meaningful from her student's culture and home life and the mathematical practices the student engages in at home. The following sections will discuss these claims in more detail.

Getting to Know Kelly

Janet learned a detailed amount of information about Kelly's behavior at school, visible and invisible culture, her home and community practices, her interests, and the mathematics that occurs in these categories. In terms of Kelly's behavior at school, Janet found that “In all of her classes, Kelly was attentive and stayed on task completing her work.” In general, Kelly was a reserved and quiet student and, while was willing to participate in her classes, “Kelly exhibited several times throughout the day that she was not as confident in her answers.” Janet found that “Kelly was visibly nervous” when asked to show her work at the document camera in math class. Janet also saw Kelly “squirming in her seat” in English class because the teacher calls on students randomly throughout class. “Not wanting to give a wrong answer, Kelly was nervous for not being able to plan a response.” It should be noted that Janet is inferring that Kelly doesn’t want to give a wrong answer and may not have direct evidence of this. Janet also noticed that “Kelly especially doesn’t like to respond to open-ended questions or that have an opinion base.”

Janet also provided evidence of Kelly’s concern over having to explain her thinking in her *problem solving interview* paper. When solving a problem on proportional reasoning, Kelly stated that the answer was “8” (which was incorrect) and when Janet asked her how she arrived at that answer, Kelly was “visibly worried about the answer” and said that she didn’t know. When pressed again by Janet to explain why her answer was eight, Kelly said “It just is. Can we move on now?” Janet used this information when providing ideas for mathematics instruction that would benefit Kelly. Also, Janet probed deeper into the reasons for Kelly’s introverted behavior at school by asking about her home life and culture.

Janet was able to get to know about Kelly’s visible culture in the time that she shadowed her. In terms of Kelly’s visible culture, Janet found that Kelly’s family is from India, is Hindu, and she speaks a dialect of Hindi (Gujarati) at home and that she started learning English when she was in Kindergarten. She found that Kelly and her family travel to India every other summer to visit the relatives she has there. Janet wrote "Kelly lit up when she talked about her experiences in India, saying how much fun it was to see her MuMum and cousins."

Janet also reported that a very important part of Kelly's visible culture is Indian food. Specifically, that Kelly often cooks traditional Indian food with her mother. Janet wrote that Kelly shared "her enjoyment of cooking with her mother and explaining her Indian cuisine lunches to me on several occasions." Janet also wrote that Kelly "even disclaimed to me that she shops and works with different pricing." Janet elaborated on this piece of information during the post-interview when she said Kelly "goes grocery shopping with her mom always." Kelly's experiences cooking and grocery shopping with her mother became the inspiration for Janet's task revision as it became clear to Janet in weeks beyond the *shadow a student* project how important this was to Kelly.

Janet also found out a lot about Kelly's home and community life and her invisible culture that could explain Kelly's hesitancy to participate at school. Janet found that Kelly spends most of her time playing outside with her neighbor and younger brother. Kelly is friends with the neighbor "because both her mom and the neighbor's mom speak a different Hindi dialect with one another." Kelly told Janet that she could understand what they talked about, but "she doesn't know how to respond in that specific language, so she usually doesn't talk much." However, Janet also wrote that "Kelly was always better at speaking [another dialect of] Hindi and relating her experiences with her Hindu neighbor." Janet inferred that part of Kelly's struggle to be more vocal in school is related to her limited experiences at home to interact with other children in English. Having learned that Kelly started learning

English in Kindergarten, Janet noted that “when her peers started to learn how to make friends and build those relationships, Kelly was learning how to communicate with her peers.”

In terms of Kelly’s invisible culture, Janet also found out through conversations with Kelly “that in her culture it is better to be seen and not heard, as well as to speak only when you know you have something valuable and important to contribute.” Janet concluded that the reason that Kelly doesn’t like to respond to open-ended questions is “because at home she is supposed to keep her opinions to herself.” However, Janet also noted that Kelly is aware that she is expected to participate and that this is the reason “Kelly feels more comfortable in writing answers or offering answers that she knows are correct and can be backed up with support.” Thus, Janet took the extra step to not only notice Kelly’s behavior in school, but to find out the home and cultural influences that could be contributing to that. Janet also takes this into account when discussing her ideas for mathematics instruction that would benefit Kelly, which will be discussed in the next section.

Janet was also able to learn about Kelly’s interests. When visiting her cousins in India, Kelly stated that “their favorite activity is to play dolls together.” However, this is not something that Kelly does often when she is at home. Janet also wrote: “art was deemed her favorite subject although she said she isn’t in any classes at school.” These interests appeared secondary to Kelly’s interest in cooking, which is part of the reason Janet selected cooking for her task revision. When discussing her initial ideas for mathematics instruction, Janet did draw on Kelly’s interest in art which will be discussed in the next section.

Finally, Janet found that Kelly was also aware of the mathematics that she had experience with outside of school. When asked if she thought math was used in her everyday life, Kelly said "Numbers are everything. You need to multiply, divide, add, and subtract maybe." When Janet pushed her to give more examples, Kelly told Janet that she also uses math when cooking with her mother. Janet wrote that Kelly "has to change the measurements from metric to the cups and ounces" and that she "was excited to share…that she is capable of finding the price of an ingredient she needs two of." These mathematical practices influenced Janet's initial ideas for mathematics instruction as well as her task revision.

Initial Ideas for Mathematics Instruction

Janet was able to use what she learned about Kelly's interests and culture to develop various mathematics tasks and activities as well as ideas for how to implement such tasks based on her student's behavior in school. Janet wrote that because Kelly was quiet and did not like to speak up in class, that she would create "more individually based lessons [that] will yield less nerves and more learning for Kelly." Therefore, Janet suggested teaching practices throughout her discussion of mathematical tasks or activities she would use that take this into account. Because Kelly expressed an interest in art, Janet tried to integrate mathematics into art topics that might be of interest to Kelly. One suggestion that Janet made was to have students explore tessellations. Janet suggested that she would explain the properties required for a shape to tessellate and from there "students can have the opportunity to explore (either in groups or on their own- whichever Kelly chooses) which regular shapes will yield proper tessellations and which shapes will not work." This activity was designed to draw on an interest of Kelly's but also to be cognizant of how Kelly might prefer to learn.

Another way that Janet suggested connecting mathematics with art is through the investigation of the Fibonacci sequence. Janet suggested that "Kelly can research Fibonacci as a mathematician as well as the patterns that have been discovered in nature and art. From this exciting sequence, Kelly can create her own art that shows and reflects what she's learned." Janet noted that Kelly "liked seeing evidence and being able to support her answer" which provided a rationale for doing this type of activity with Kelly. However, it is unclear how relevant these art topics are for Kelly as Janet only found out that Kelly likes art generally.

Janet was also able to provide a mathematical task that drew on Kelly's love of cooking and grocery shopping with her mother. Janet wrote that she would have

> …let Kelly go to the store with a recipe that included an ingredients list along with the amount of batches I needed to make. By telling Kelly a specific recipe will create 5 servings and I wanted to cook for 20 I would be extending her thinking in a practical way. Needing to scale up to make sure there is enough food for everybody is something that people do on a daily basis… Modifications to this idea could also include scaling down a recipe or needing to scale the recipe by an improper fraction.

In this example, Janet wanted to give Kelly an opportunity to explore this type of task in the classroom so that she "can take it back home and utilize the skill." It should be noted that this statement implies a one-way direction in that Kelly can use the skill at home rather than being able to use her knowledge of this practice to solve the task at school. Janet further discussed this goal by providing another example of implementing a lesson on conversions as this is something that Kelly said she struggled with when cooking. Janet wrote that she would start with easy numbers so

Kelly could learn “about how to read in one measurement and multiply to get a second number that is of equal value just labeled with a different unit.” Janet wrote that this would be beneficial to Kelly because she often has to convert from metric to US units to use the “cooking tools that are in her home kitchen.” Therefore, Janet focused on things that were meaningful for Kelly, but also focused on how she could help Kelly develop the knowledge and skills that she struggled with that are important for Kelly to be able to engage more fully when cooking with her mother. Janet recognized how meaningful cooking with her mother (both in terms of enjoyment and interest and in terms of mathematics) was for Kelly and therefore, chose to make her task revision about this.

Janet’s Task Revision

Janet successfully revised a high-level mathematics task based on something meaningful from her student’s culture and home life and the mathematical practices the student engages in at home. Janet focused her task revision on shopping for ingredients to cook a traditional Indian dish. Based on what she learned about Kelly during the *shadow a student* project and in subsequent weeks, this seemed to be the most meaningful for Kelly. Janet discussed how Kelly explained “her Indian cuisine lunches to me on several occasions.” During the post-interview, Janet elaborated on how she knew that this was particularly meaningful for Kelly and why she chose to focus on it for her task revision:

> She’s a very quiet student in general and when I got to interview her, this is where she really opened up and you could see it in her eyes. She was so excited to talk about it…it kind of just seemed like nobody had asked her before so the fact that someone cared and wanted to know more made her really excited.

Therefore, it made sense to Janet that this was something that should be used for her task revision.

Janet chose to revise the task whose context was on unit pricing and budgeting of patio blocks (see Appendix B). Her revised task can be found in Appendix C. Janet's revised task can be considered an ideal task revision in that her revision drew on something that was meaningful for the student culturally, drew on the mathematical practices of Kelly, maintained the cognitive demand of the task, and addressed the same mathematics content (unit pricing, converting measurements, and budgeting) as the original task. All of the changes made to the task were based on Kelly's cultural and home practice of cooking traditional Indian food, converting measurements, and her experiences going grocery shopping. These are all mathematical practices that Kelly has at least some experience engaging in. In addition, despite the fact that Janet completely changed the task from what it was, the task was still at a high level of cognitive demand and it still addressed the same mathematics content.

Further, all of the changes, no matter how small, were done purposefully based on the details she learned about how Kelly engaged in this practice. The revised task states that Kelly will be cooking with her mother, who is "making a favorite Indian dish of [Kelly's], tandoori chicken." Janet also wrote: "I wanted it to be as authentic as possible, so I recalled some of the types of rice Kelly shared with me (peanut rice and mango rice)" and so she included these types of rice. In addition, Janet made the decision to use rice as the focal point rather than a main dish because "Kelly helps her mom cook, but doesn't make the entire meal by herself." This suggests that Janet learned a very detailed amount of information about Kelly surrounding this cultural practice and used that information to revise a task that would be meaningful and culturally relevant for Kelly.

One concerning part about Janet's task revision is related to whether or not it draws on the mathematics used in the actual context. Janet's task requires the student to find the "smallest quantity price" of each ingredient and asks the student to find which recipe would be the cheapest based on the "smallest quantity price." This is unrealistic for a grocery shopping context because you typically cannot purchase, for example, a single teaspoon of turmeric powder at the grocery store. To address this concern, an extension question that was not part of the original task stated: Would the cheapest rice dish be different if you bought the whole sale quantities at the whole sale price? Explain your answer with words and numbers to prove your reasoning." This suggests that Janet was cognizant of how realistic her task was prior to getting feedback from the instructor. Janet was also asked to address this issue during the post-interview, as discussed in the next section.

Post-Interview Edits to Task Revision

During the post-interview, Janet discussed the issue of the potentially un-realistic nature of buying unit prices of various grocery items and what she did to address this issue. When asked to comment on the extent to which her task revision was realistic, Janet said:

> It is realistic in the sense that you will have to convert, you will have to unit price, you will have to [say] which is the cheaper value so the context is a little off realistically but I think the application of it is definitely something that she can continue with.

Janet recognized that many of the things the task requires Kelly to do are realistic in the sense that converting measurements, unit pricing, and determining the cheapest option are things that Kelly has access to in various settings, but that it may be somewhat unrealistic in the grocery store setting. Janet elaborated on this when discussing why she added the extension question to her task revision. Janet said:

> I think she'll definitely like be able to look at the idea, make the connections...it's a little unrealistic in the smallest quantity pricings. Are you really going to buy half a teaspoon of something? Probably not, but that's why I tried to make the whole sale price more realistic in that sense.

Also, Janet thought “you’re not always going to have that perfect scenario where you get all the exact amount of ingredients you'll need” so she added the extension question to ask which recipe would be cheaper if they purchased ingredients at the whole sale price because she “thought that was more realistic.” This suggests that Janet was aware from the beginning that her task might not realistically draw on the mathematics that one does while at the grocery store but she was able to provide an extension to the task to address it.

Summary

Janet made progress throughout the semester towards developing the necessary skills to be able to revise a high-level mathematics task to be more culturally relevant for one student. Janet was able to learn how to get to know a student’s visible culture, interests, and home and community life in great detail. Janet was even able to probe deeper into her student’s background to get to know her invisible culture to explain her quiet and reserved behavior at school. Janet used that information to develop some specific ideas about mathematics instruction that would benefit her student and then was able to successfully revise a high level mathematics task to be more culturally relevant for that student.

Conclusions

Over the course of one semester, all of the participants were able to make progress towards revising a high-level mathematics task to be more relevant for the students that they shadowed (*shadow a student* project) and interviewed (*problem solving interview* project) with varying degrees of success. Specifically, all of the participants were able to learn about the students that they shadowed and interviewed, were able to come up with initial ideas for mathematics instruction, and successfully revise a high-level mathematics task to be more relevant for their students. In addition, most of the participants were able to make more progress on their task revision during the post-interview with the support of instructor feedback.

However, with the exception of Janet, the participants did not draw upon something that was culturally meaningful for their students in their task revisions. Instead, the other three participants drew upon their students' interests and/or family practices. This may have been due to the fact that they did not learn specific information about their students' culture or did not spend enough time with their students to determine whether what they learned was influenced by the students' cultures. Despite learning about Kelly's visible and invisible culture, Janet drew upon something from Kelly's visible culture for her task revision: Kelly's love of cooking traditional Indian food with her mother. Thus, most of the participants' revised tasks were much more personally relevant for their students despite not drawing on the students' cultures. In the next section, I discuss how the participants' conceptions might be related to their performance throughout the course.

Relationship between Conceptions and Performance

In this section, I illustrate the ways in which the participants' conceptions at the beginning and/or end of the semester may be related to their performance making progress towards revising a high-level mathematics task to be culturally relevant for one student. Specifically, I will present how the participants' conceptions regarding good mathematics teaching practices, the importance of getting to know their students' backgrounds for use in their mathematics instruction, and regarding low income urban students may be related to the participants' performance on their *shadow a student* and *task revision* projects. In particular, the participants' productive conceptions may be related to how they described they would use good teaching practices to implement their revised tasks and how successful they were getting to know the students that they shadowed, despite only being tangentially related to the success they had revising tasks to be culturally relevant. Also, it is unlikely that the participants' unproductive conceptions regarding low income urban students are related to their performance given the demographic information of the students they shadowed and the location of their field placement schools.

Good Teaching Practices – Collaborative Work

The participants' productive conceptions at the end of the semester regarding the use of good mathematics teaching practices with all students, particularly around collaborative work, may be related to how they described they would implement their revised tasks with a classroom of students in their *task revision* projects. Specifically, John and Rick's productive conception regarding the use of collaborative instruction may be related to how they described how they would implement their revised tasks. For example, during the post-interview Rick said:

> I would want to have students working together on this because then they can discuss the one student that comes up with the [idea that] they're looking at a dog for 15 minutes, or they're stopping and going into a restaurant for 15 minutes. They can discuss if they're right and what the differences are…they could have multiple responses of what happened.

In other words, Rick suggested that using collaborative work for this task would allow students to come up with a number of different ideas for what is happening on each time interval and to discuss each person's ideas.

John also indicated that he would use collaborative work when implementing his revised task in the classroom. He wrote in his *task revision* project:

> I would have students pair up with a partner…some students might get stuck on how to approach this task if they are working by themselves. Having a partner will also give them a chance to possibly come up with different strategies within their group before moving on to the class discussion.

These results suggest that this productive conception could impact the revising and implementation of tasks in that Rick and John might ensure that the tasks are at level appropriate for use in collaborative work.

It should be noted that John's unproductive conceptions regarding students who are perceived to have low mathematics ability might have played a role in this instructional choice. John discussed how he would have students work in partners as this was a high level task, specifically pairing Molly with a high level student. However, John reiterated his conception that the purpose of this is so that the higher level student can show the lower level student more complex strategies they would not otherwise discover. He wrote "since she struggles with math it would be nice to have her with a high level student so that she could see some strategies and how she could implement those strategies in real life" because "this task might be difficult for her to accomplish on her own." Therefore, rather than recognizing this task revision as one that Molly would have access to based on her home experiences and be successful with, John assumed that Molly would struggle and need the help of a higher level student to be successful. This suggests that the conception that John held regarding low ability students may not impact the writing of tasks, but that it might not be productive in terms of how he would implement such tasks.

Finally, Janet's and Zane's productive conceptions regarding the use of group work may be related to how they would implement their revised task. In the *task revision* project, they both took what they learned about the behavior of the students they shadowed into account. Janet discussed that she would use group work when implementing her task, but she also said she would first "ask the students to begin working on their own" to accommodate for Kelly's shy tendencies and then she would ask the students to work in pairs. She wrote "I know that sometimes she is uncomfortable with speaking out to the class and sharing her ideas in fear that it may be wrong," however, having students work on the task in this way "helps Kelly feel more confident and comfortable with her rationale of the task." In other words, because Kelly is shy, Janet wanted to give Kelly more time to gather her own thoughts before working with other students. This choice of instructional practice does align with Janet's conceptions regarding good teaching practices in that, while she did highlight group work as being an effective practice at the end of the semester, she also described how she would use different teaching practices to accommodate for her students.

Zane similarly accounted for Ben's behavior in how he stated he would implement the revised task which created some tension with his previously expressed conceptions. During the post-interview, Zane said that Ben "doesn't work well in partners" but that he didn't think it would be appropriate for the entire class to work individually on the task. Therefore, Zane said that he would have students "work with a partner if you want to and if you're having trouble ask your partner and that way the only person that would ask him would be his partner…but he wouldn't be forced to help him with anything if he didn't want to." This suggests that while Janet and Zane did favor using group work, they will take the individual needs of their students into account when planning how to enact a mathematical task in the classroom.

Importance of Getting to Know Students

The participants' incoming productive conceptions regarding the importance of getting to know their students may be related to the success they had in getting to know their students. It is clear from the discussion of what she learned about Kelly that Janet took the time to get to know Kelly beyond surface level information to learn detailed and meaningful information about her interests, home life, and visible and invisible culture. In addition, it was also clear that Rick took the time to get to know Aaron based on the detailed information he learned about Aaron and especially because Rick took the time to keep talking to Aaron in later field experience weeks to find out more personally meaningful things about him to draw on for his task revision. John was also successful in getting to know a detailed amount of information about Molly.

Also, Zane did learn about Ben's interests and, as discussed above, made it clear that he tried to learn about Ben's home life and culture but was unsuccessful. In his reflection on the *shadow a student* project, Zane wrote:

> He was a hard student to shadow because he was so closed and quiet. He would talk to me about superficial things like what video games he

> played or his interest in music, but never anything that happened outside of school.

This suggests that while Zane had good intentions to get to know Ben and conceptions that showed Zane thought that this was worthwhile, it is not always easy to enact your conceptions. Different school situations may impact how well a prospective teacher can implement practices they feel are important.

Relatedly, the participants' experiences shadowing their students were positive ones and may have reinforced the conceptions they expressed about getting to know students and using that information in their mathematics instruction. For instance, when reflecting on her experience shadowing Kelly, Janet wrote "I can say with conviction that getting to know your students and taking that time to learn about their interests will help you tenfold in teaching…I can't wait to try it out in my own classroom." Also, Zane reflected in his *shadow a student* project that even though Ben was hard to get to know he "did like doing this assignment and I think Ben liked me doing it too…I still got a better understanding of who he is and how to make math material more relatable to him." In addition, when John reflected on his experiences getting to know Molly, he wrote "I learned that I am a better observer than I thought. I was able to figure out a lot about Molly in just a few hours. This is what I will be doing the whole year while I am a teacher."

Also, Rick reflected in his *shadow a student* project that "This shadowing project is extremely beneficial. There is so much to be learned about each and every student in the classroom. This project also helps to identify connections you can make between a student's personal life and teaching." This statement and the success Rick had during the *shadow a student* project led Rick to continue that relationship with Aaron beyond what was required of him in the class to find out more meaningful things about him to base the task revision on. The fact that the participants' conceptions about getting to know students were reinforced by this project is a positive outcome as it suggests that their conceptions may productively impact their practice as a future teacher.

In addition, the participants' conceptions about getting to know their students and the need to use that information in their instruction suggest that they may have been open to learning how to revise a task to be more culturally relevant for their students in that they were mostly successful in doing so. The revisions the participants made were all chosen based on information that they deemed to be meaningful for their students and they were able to give evidence, as discussed above, for why they thought that these were meaningful changes. For instance, John wrote in his task revision project that he chose to focus on budgeting and traveling "because it was something that seemed particularly important." Also, for her task revision project, Janet focused on cooking Indian cuisine because "Kelly brings Indian food for lunch every day to school and has explained to me on several occasions the cooking that occurs at home as well…it visibly brightened her day to share a bit of her culture with me." This suggests that the participants' productive conceptions may have supported them in that they were willing to engage in the *shadow a student* project to the extent that they did which allowed them to successfully complete the *task revision* project.

It is important to note that it is possible that the participants' productive conceptions may have influenced their willingness to learn how to revise a task to be culturally relevant which, in turn, may have supported them in successfully engaging in that process. However, there is little evidence to suggest that the participants' unproductive conceptions were directly related to their performance revising the task itself. This apparent lack of relationship and the implications of that will be discussed in greater detail in the discussion chapter.

Low Income Students in Urban, High-Needs Schools

Given the demographic information about the students the participants shadowed, it is not likely that their unproductive conceptions about low income urban students were related to what they were able to get to know about their students or how they revised the high-level mathematics tasks to be culturally relevant for their students. In other words, there is no evidence to suggest that there is a relationship between the participants' unproductive conceptions and their performance revising the task. None of the schools where the participants completed their field experiences were located in low income urban areas.

However, Zane was placed in a rural middle school where about half (51%) of the students were from low income families. Despite this, Zane wrote in his shadow a student project that Ben "did not mention a good or bad home life, I get the impression that it is ok." Therefore, Zane's deficit conceptions about low income students (e.g., lacking a supportive home life) may not have played a role in what he was able to get to know about Ben or his task revision. In summary, because none of the participants were teaching in low income, urban areas, means it is unclear how their deficit conceptions about students living in such areas would have impacted their success on the *shadow a student* project or the *task revision* project.

Conclusion

This concludes the presentation of the findings related to the progress the participants made in their conceptions and performance as well as how their conceptions were related to their performance on their course projects. Overall, the participants made some progress in their productive conceptions, but the more deeply ingrained deficit conceptions remained constant. In addition, all of the participants made progress towards revising a high-level mathematics task to be more relevant for the student that they shadowed in that they were all relatively successful. Finally, the participants' conceptions may be related to their performance on the *shadow a student* project and *task revision* project, despite only being tangentially related to the success they had revising tasks to be culturally relevant. In the next chapter, I discuss these findings and I will draw conclusions based on the relative success of the middle school mathematics methods course in each of these areas.

Chapter 5

DISCUSSION

The purpose of this study was to determine (1) the progress prospective teachers' can make in their conceptions of mathematics teaching and learning and of socio-culturally diverse students and students in urban, high-needs schools; (2) the progress prospective teachers can make in their performance revising a high-level mathematics task to be culturally relevant for one socio-culturally different middle school student; and (3) the relationship between their conceptions and their performance. In this chapter, I will discuss the major findings and conclusions related to each of the research questions. Next, implications for mathematics teacher educators will be discussed. Finally, limitations to the study and proposed future research will be presented.

Progress in Prospective Teachers' Conceptions

The prospective teachers in this study entered the middle school mathematics methods course already having productive conceptions about mathematics teaching and learning, particularly regarding the use of good teaching practices and the importance of getting to know students and using that information in their mathematics instruction. This stands in contrast to research that has shown that prospective teachers' conceptions regarding mathematics teaching and learning may "originate from previous traditional learning experiences mainly during schooling" and "are eventually reproduced in classroom instruction" (Handal, 2003, p. 47). In other words, prospective teachers often experience direct instructional practices as students and reproduce them when they get into the classroom as teachers. Based on their pre-post interview responses and informal conversations with them, the participants in this study reported experiencing these direct instructional practices as K-12 students. One reason for the prevalence of productive conceptions with these participants at the beginning of the semester may be that good teaching practices were emphasized consistently in the mathematics education courses in their teacher education program. For example, as mentioned in the methods chapter, the participants had also conducted a project for the elementary mathematics methods course similar to the *shadow a student* and *problem solving interview* projects and so already had an opportunity prior to the middle school mathematics methods course to develop their productive conceptions about the importance of getting to know students.

It is promising, then, that with respect to changes or progress in these conceptions, the participants' initially productive conceptions were reiterated and, for most of the participants, became somewhat more specific and detailed as the semester progressed. From a culturally relevant standpoint, the productive conceptions regarding good teaching practices are important to have because one of the components of culturally relevant mathematics pedagogy is to ensure that students experience academic success through learning mathematics for conceptual understanding and these practices can support students' learning (Boaler, 2006a; Rubel & Chu, 2011). Also, getting to know students' culture, interests, and home and community lives and using that in mathematics instruction can help build students' motivation and engagement (Philipp & Thanheiser, 2010), maintain and develop a students' cultural competence (Boutte & Hill, 2006; Ladson-Billings, 2009), and provide opportunities for students to learn mathematics for conceptual understanding (Ensign, 2003; Gutstein et al., 1997; Tate, 1995). Thus, the participants' conceptions may productively impact their future teaching.

The middle school mathematics methods course, as one of the last courses prospective teachers in this program take before student teaching, served as a means to further refine the participants' already developing productive conceptions. Based on the results and the situated, sociocultural theory of learning that guided this study (J. S. Brown et al., 1989; Putnam & Borko, 2000; Vygotsky, 1987), some conjectures can be made about particular mechanisms that supported the participants in reinforcing and developing their productive conceptions. A large contributing factor that I hypothesize supported the participants' progress that they did was the amount of time spent addressing the particular productive conceptions that were prevalent in their interview responses. Specifically, providing prospective teachers not only with opportunities to read about certain ideas/practices, but also providing them with multiple opportunities to have small and whole group discussions throughout the semester around those ideas and practices, may have supported the participants in developing more specific and nuanced ideas surrounding their productive conceptions. For instance, a major focus of the course was to develop (1) strategies for getting to know students who were socio-culturally different from the participants and (2) specific teaching practices for how to use that information in mathematics instruction, particularly through mathematics tasks. During class time, the prospective teachers read articles providing specific examples of how teachers have taken their students' experiences into account in mathematics tasks so that the prospective teachers could have group discussions in class that focused on what the teachers knew about their students, how the teachers used that information in the tasks, the participants' opinions of how well that was accomplished, and what the benefits and constraints of doing that were. This specific focus may be related to the participants' continued expression during the post-interview that it is important to get to know students and to Rick and John shifting their conceptions to describe specific strategies for doing so.

Additionally, I conjecture that having authentic opportunities during field placements to implement good mathematics teaching practices and get to know students' interests, home/community experiences, and culture (as opposed to simply reading and talking about these ideas) may have supported prospective teachers in reinforcing and further developing their productive conceptions. For example, the *shadow a student* project may have been a contributing factor in the sustained expression of the importance of getting to know students and taking that information into account in mathematics instruction. The results of this study suggest that the participants' positive experiences shadowing and interviewing their students may have reinforced and supported the further development of their conceptions regarding getting to know students. This result is supported by other research on the impact of shadowing students on prospective teachers' conceptions (e.g., Ukpokodu, 2004).

It is important to consider in this example what kinds of opportunities prospective teachers should have in getting to know their students in order to support their developing conceptions. Shadowing a student allowed the participants to get to know surface level information about their student. Beyond that, I hypothesize that it was the experience of actually spending time talking to the student and asking specific questions about their background that allowed them to also learn the specifics about the student's background that cannot simply be observed. For example, Janet could have determined that her student liked Indian cuisine by noticing the lunch Kelly brought to school every day, but it was through talking to her that Janet determined that Kelly actually helped her mother cook that food and that it was something she was passionate about. Additionally, I conjecture that shadowing a student who was socio-culturally different from them was an essential part of this experience. Research suggests that it is easier to get to know and understand a student who comes from a similar background (e.g., Spindler & Spindler, 1982) and may ultimately be easier for a teacher to take a certain experience into account in their instruction when they share that experience with their students. For this reason, it is important to support prospective teachers in developing an understanding of how students whose backgrounds differ from their own might impact the students' learning as well as to provide opportunity for prospective teachers to potentially confront assumptions they may have about students from diverse backgrounds. Therefore, extended periods of time to read and discuss (in small and whole groups) as well as targeted experiences in the field may be important mechanisms in developing prospective teachers' more specific and nuanced productive conceptions.

Unfortunately, the participants (with the exception of Janet) also held some unproductive conceptions regarding low income students in urban, high-needs areas that persisted throughout the entire semester. Particularly, at the beginning and end of the semester, Rick and Zane emphasized that low income students in urban, high-needs areas may have lower levels of motivation. This aligns with research conducted by Wlodkowski and Ginsberg (1995) that states that many teachers have this view of student motivation. Also, at the beginning of the semester, (1) Rick, Zane, and John felt that these students do not have parental support at home; and (2) Rick and John emphasized that low income students from urban neighborhoods are subject to encountering more violence in their communities. All of these conceptions may be unproductive for their future teaching because it could lead the participants to shift the blame for students' achievement onto factors outside of the school rather than asking what they can do to support their students' learning. These conceptions may also lead to a lowering of expectations for these students and ultimately, to more direct instructional practices because they may not feel their students can handle more challenging mathematics (Boaler, 2002; Sztajn, 2003).

In terms of prospective teachers' unproductive conceptions, their experiences prior to their teacher education programs may have developed their conceptions about socio-culturally diverse students. These unproductive conceptions may have been learned and internalized from the media or their parents (Milner, 2005). For example, Rick specifically drew on his aunt's experiences teaching in an urban, high-needs school to justify that there might be different goals for students depending on the school setting. In particular, the goal for students in an urban school is to motivate and interest them whereas in a suburban school the focus is more on promoting student achievement. It should be noted that in both of these cases, group work may be a productive teaching practice to support these goals. Thus, while prospective teachers' can hold productive conceptions about good teaching practices, they may still hold some unproductive ones about their students that, for this example, may impact how they implement and facilitate group work. Also, their unproductive conceptions may be so deeply held that one course that addressed multicultural education in the context of mathematics was not enough to change these conceptions substantially.

Despite the fact that the participants' prior experiences may have developed and maintained their unproductive conceptions, there are some conjectures that can be made regarding mechanisms that may support prospective teachers in confronting and addressing their unproductive conceptions, which were absent or unsuccessful in this study. One factor that was absent from the participants' experiences during the middle school mathematics methods course was being in a field placement school/classroom that aligned with the contexts about which they held unproductive conceptions. Specifically, most of the participants (with the exception of Zane) were not placed in low income areas and none of the participants were placed in schools located in urban areas. Thus, the field placements they did have may not have been the authentic experiences they needed to support their learning and confrontation of unproductive conceptions. Thus, one mechanism that research has shown can have an impact on prospective teachers' unproductive conceptions, namely, field placements in low income urban schools (e.g., Causey, Thomas, & Armento, 2000) was absent in the case of this study. This may have contributed to the lack of progress the participants made over the course of the semester.

Similar to developing the participants' productive conceptions, opportunities to read about and discuss ideas surrounding their unproductive conceptions were provided. Also, one particular activity (Mythtakes activity as described in the methods chapter) was implemented at times throughout the semester to provide the participants a space in which to grapple with their ideas about a particular issue (e.g., whether or not a teacher should be color- or culture-blind) individually and in small groups. Then, they were provided with opportunities to share their ideas with others (and critique or comment on their classmates' ideas) during a whole class discussion. Based on the conversations had during the course, I suspect that this, or a similar activity where prospective teachers have to grapple with their conceptions and ideas with their classmates, can be beneficial in supporting prospective teachers to begin to confront and address their unproductive conceptions. However, the time spent confronting and addressing their unproductive conceptions with this activity was less as compared to the amount of time spent developing the participants' productive conceptions. Discussions surrounding the prospective teachers' unproductive conceptions were sometimes cut short due to the time constraints of the course. Thus, one mechanism that seemed to have a positive impact on the participants' productive conceptions (time to grapple with their ideas/conceptions) was at times absent during the middle school mathematics methods course. Therefore, it may be unsurprising that the participants' did not make similar progress in their unproductive conceptions.

Because prospective teachers' conceptions can have an impact on their teaching practices, sustained emphasis on both maintaining and developing productive conceptions, particularly those related to culturally relevant pedagogy, and on confronting and addressing unproductive conceptions, is warranted if we want to prepare prospective teachers to not only develop good and culturally relevant mathematics teaching practices, but to have the conceptions that will support their use in every school setting. The results of this study suggest that while there was not enough time during one semester to develop all of the conceptions of a culturally relevant mathematics teacher, small changes in some productive conceptions can occur. It makes sense, therefore, that multiple courses should address prospective teachers' conceptions if this were to be a goal for a teacher education program. In particular, certain mechanisms as discussed above may need to be present to support prospective teacher progress in their conceptions. It is promising nonetheless that one course can positively impact prospective teachers' conceptions, even if slightly.

However, it is concerning that the participants held onto their unproductive conceptions at the end of the semester. This result suggests that much more emphasis on confronting and addressing prospective teachers' unproductive conceptions may be warranted. More research is needed to determine if sustained focus on impacting prospective teachers' unproductive conceptions regarding the teaching and learning of mathematics to socio-culturally diverse students throughout teacher education programs through the use of certain instructional mechanisms (e.g. field placements in low income urban schools) can create significant positive change in their unproductive conceptions.

Progress towards Revising a High-Level Task to be Culturally Relevant

All of the participants in this study made progress towards being able to revise a high-level mathematics task to be more culturally relevant for one student in that they all learned about the students that they shadowed and interviewed and took something that they learned to make at least beginning level revisions to the original tasks. Based on these results and on the situated, sociocultural perspective of learning that guided this study (J. S. Brown et al., 1989; Putnam & Borko, 2000; Vygotsky, 1987), some conjectures can be made about particular mechanisms that supported the participants in learning to revise high-level mathematics tasks to be culturally relevant for one student.

In order to do so successfully, a teacher first needs to get to know students (or one student) on a meaningful level. This means getting to know the student's mathematical knowledge/thinking, interests, home/community lives, and culture.

Prospective teachers may need structured opportunities in class and in the field within their zone of proximal development (Vygotsky, 1987) to explore strategies for getting to know their students and thinking about what information they should gather from students. I conjecture that the opportunities provided to the participants during the middle school mathematics methods course supported them in being largely successful in learning a detailed amount of information about their students that was useful for them to be able to revise a high-level mathematics task to be culturally relevant for their students. Specifically, the participants were provided with opportunities to complete readings and participate in small and whole group discussions in order to support them in examining how and why getting to know students is important for their teaching and for student learning. In addition, I conjecture that small and whole group discussions surrounding their thinking about strategies for getting to know their students may have supported the participants in being able to approach and get to know their chosen students in ways that would support them when revising a high-level mathematics task. This targeted support during class time may have led to most of the participants' talking with their students more than what was required of them during their field placements. This is important because that extra time led most of the participants to determine more detailed information about the interests and home experiences of their students.

Further, the authentic opportunity to get to know a student during their field placement may be an essential mechanism in prospective teachers' eventual success in revising a high-level task to be culturally relevant for their student. Specifically for this study, what the participants were able to get to know about their students in the field was important in that the specific and detailed information learned about their students allowed them to draw meaningfully upon their students' personal and/or family interests for their task revisions. On the other hand, while Zane was able to determine some detailed information about Ben's interests and behavior at school, Zane struggled to get Ben to talk to him about his home life and it is not clear from his project write-ups whether he continued to speak with Ben or not in subsequent weeks like the other participants did. It could be the case that Ben was wary of a teacher trying to get to know his personal life and so simply did not want to open up to Zane, a teacher he barely knew. Perhaps if Zane had the opportunity to spend more time in the classroom with Ben and develop a relationship with him over time then Ben would have been more forthcoming.

Thus, within this mechanism of needing to get to know their students, it is particularly important for prospective teachers to spend an extended period of time with their student observing as well as interviewing their student as described in the previous section. For mathematics teacher educators who try to incorporate this shadowing activity in their courses in the future, I conjecture that having a requirement that the prospective teachers talk to and get to know the student they chose for more than the five hours required for the project would greatly improve their success in getting to know that student well to the extent required to create culturally relevant mathematics tasks. I would require that after the specified five hours, prospective teachers should continue to observe and talk to their chosen student whenever they can over the course of their entire field placement as the participants in this study who did so were more successful at getting to know their students. It is essential for prospective teachers to have the best opportunity to learn from this experience so it is important that they gather detailed and meaningful information about their students to support their success in taking that information into account in their mathematics instruction; namely, by creating culturally relevant mathematics tasks.

Also, the participants were successful in getting to know their students in that they gathered specific and detailed information about their students' personal and/or family interests required to draw meaningfully upon these interests for their task revisions. I classified the information the participants learned about their students mostly as interests (e.g. Ben likes science) or family practices (e.g. Molly's family travels a lot) rather than cultural practices because they are things that are visible and are not necessarily practices that extend beyond the individual students or their immediate families. On the other hand, a cultural practice is something that is shared by a particular group of people (e.g. ethnic groups, particular communities, etc.) that can include common visible things like food, traditions, and holidays, but also include the shared ways in which a group of people interact (e.g. cooperation over competition) and how they view the world (Ascher, 1994).

It is possible for a student's interest or family practices to be related to or influenced by their culture. This is evidenced by Janet who drew upon her student's interest in cooking traditional Indian cuisine with her mother, which may have been influenced at least partially by her Indian heritage. However, it is difficult to tease out what aspects of an individual student's life are culturally influenced and which are just their interests. Thus, it is not clear whether the participants drew upon their students' actual cultural experiences, with the exception of Janet whose student's cultural practices were visible. The level of performance of the participants then, lies in how much they were able to learn about their students. Given the limited time in the field to get to know their students, all of the participants were mostly successful in finding out meaningful information about their students, even if it was not to the level of determining whether and how what they learned was related to their students' culture.

Culturally relevant teachers develop relationships with their students and communities with sustained interaction over long periods of time (Ladson-Billings, 1995a, 2009). Therefore, I conjecture that more time may be required for teachers to develop the kind of relationship with their students to find out more about their students' home and community experiences and particularly their larger, invisible cultural experiences so that teachers can help maintain and develop students' cultural competence as well as provide them with opportunities to learn mathematics for conceptual understanding. For culturally relevant tasks, teachers must go beyond student interests to make connections to what students know, understand, and experience which is largely connected to students' culture. Therefore, drawing on student interests and family practices as most of the participants in this study did is a beginning level of revision.

Revising a high-level mathematics task to be culturally relevant for one student was a new teaching practice that was developed by the participants in this study. Therefore, one overarching instructional mechanism that I conjecture may have an impact on the progress prospective teachers can make is to design specific lessons that are purposefully structured to scaffold prospective teachers' learning from what they know to what they don't know within their zone of proximal development (Vygotsky, 1987). Specifically, the prospective teachers in this study first needed to know what a high-level mathematics task is and so one lesson was devoted to classifying tasks by level of cognitive demand so that they would be able to recognize a high-level mathematics task. The prospective teachers then needed to understand what it looked like to take students' backgrounds into account in mathematics tasks and to recognize culturally relevant mathematics tasks. Specifically, I conjecture that providing prospective teachers with readings that contained examples of culturally relevant mathematics tasks and examining the task properties in small and whole group discussions may support them in developing an initial understanding of what a culturally relevant mathematics task is.

More importantly, I conjecture that the theoretical framework for revising tasks to be culturally relevant that I developed (see Table 1) and the activities surrounding learning how to use it can be instrumental in supporting prospective teachers' learning to recognize a culturally relevant mathematics task and eventually to revise a task to be culturally relevant themselves. In particular, providing the prospective teachers in this study an opportunity to classify "good" and "bad" culturally relevant mathematics tasks based on a fake student profile (see Appendix A) using this framework as a guide was an important activity to support the prospective teachers in being able to recognize and evaluate the extent to which a mathematics task is culturally relevant. Specifically, using the framework focused the prospective teachers' attention to each of the important parts of the tasks and allowed the prospective teachers to ask themselves questions about the task to evaluate it. For instance, they had to ask themselves whether the task drew upon something meaningful about the student and what that was (component 1). Then the prospective teachers were able to have productive small and whole group discussions about each example task and could justify their assertions based on the components of the framework.

I also conjecture that providing guided practice to prospective teachers prior to revising a task themselves may be an essential mechanism for success. Specifically, the prospective teachers in this study had an opportunity to revise a high-level mathematics task for the fake student in small groups during class time. This was important step in the scaffolding because it was likely not enough to simply see and classify examples to be able to revise a task themselves. The prospective teachers needed an opportunity to grapple with actually revising a task during class time so that small and whole group discussions could be had around the tasks they revised as small groups (similar to the discussions had around the classifying “good” and “bad” tasks activity) before making an attempt on their own. I hypothesize that providing prospective teachers an opportunity within their zone of proximal development (Vygotsky, 1987) to revise a task with each other before asking them to do it alone may be an important step to support their eventual success revising a task to be culturally relevant for their students.

Additionally, I conjecture that the theoretical framework for revising tasks (Table 1) may be an important mechanism for prospective teachers’ success in revising a high-level mathematics task to be culturally relevant for their students. Specifically, the participants were able to apply each of the components of the framework (with varying degrees of success) in order to revise a high-level mathematics task to be culturally relevant for their students. All of the participants were particularly successful drawing on a meaningful interest that they learned about their student (component 1), drawing on the mathematical practices that their student actually does in relation to this meaningful interest (component 3), and maintaining the cognitive demand of the original task (component 4). While John initially had difficulty making changes beyond a surface level (component 2) and Zane struggled with addressing the same mathematics content as the original task (component 5), they both were able to make their revised tasks better with respect to these components in response to instructor feedback. Thus, the additional opportunity during the post interview served as a final mechanism to support the participants' learning. Because revising a task to be culturally relevant was something that the participants had never learned to do before, the results of this study suggest that the theoretical framework I developed and the purposefully scaffolded course activities I used in the middle school mathematics methods course did support the participants' initial learning to revise a high-level mathematics task to be more culturally relevant.

Thus, there are a number of instructional mechanisms based around a situated, sociocultural perspective of learning that were used to support the participants' learning to revise a high-level mathematics task to be culturally relevant for one student that may be beneficial for other mathematics teacher educators who have the same goals. These included having prospective teachers participate in a targeted field placement assignment designed to provide them with multiple opportunities to get to know their students and providing prospective teachers with supports (e.g. the task revision framework) and activities designed to scaffold their learning to revise tasks and provide them with opportunities to grapple with new concepts and ideas with their classmates prior to revising a task on their own. More research is needed to determine whether these mechanisms support prospective teachers' learning as I conjecture they would.

Relationship Between Conceptions and Performance

The relationships that can be discerned from the evidence are largely how the participants' expressed conceptions are aligned with the practices they state they would use in the classroom rather than any alignment with their performance revising a task to be culturally relevant. This can have both good and bad implications depending on the conceptions that were held and how they might interact. Specifically, the results suggest that the participants' conceptions about good teaching practices (particularly group work) at the end of the semester may have influenced their description of how they would implement their revised tasks with a classroom full of students, as all of the participants stated that they would use group work in some form. While it is not surprising that their proposed plans for implementing their revised tasks may have been influenced by their conceptions about good teaching practices, it is important to consider how these conceptions may impact their enacted teaching practices. These productive conceptions could ultimately influence what teaching practices they use when they become full-time classroom teachers because at this point, they at least recognize the potential positive impact of using such practices on student learning (e.g., Boaler, 2006b). However, it is unclear whether they would actually use the teaching practices they claimed they would in their future teaching. Whether or not the participants would use good teaching practices in their teaching would likely depend upon their experiences once they become in-service teachers as well as the other unproductive conceptions they might have about students.

Teachers' unproductive conceptions can negatively impact the opportunities they provide students to learn because (1) their unproductive conceptions can interfere with how teachers interpret the purpose and use of particular good teaching practices or (2) their unproductive conceptions can overshadow their productive ones. For instance, John's unproductive conceptions regarding students who are perceived to have low mathematics ability might have played a role in his choice to use group work to implement his revised task. Rather than recognizing his task revision as one Molly (who was perceived as a struggling learner) would have access to and be successful with (as it drew upon her home experiences), John assumed that Molly would struggle and need the help of a higher level student to be successful. This suggests that unproductive conceptions can impact how certain good mathematics teaching practices are utilized in the classroom (e.g., Sztajn, 2003). In other words, prospective teachers' unproductive conceptions may conflict with their productive conceptions on the use of good teaching practices and, as evidenced by John, may directly impact how those practices get enacted in the classroom and ultimately the opportunities he provides his students to learn.

The implication of this is that mathematics teacher educators cannot just support prospective teachers in learning how to implement good teaching practices, but they also need to confront and address the unproductive conceptions that may keep these practices from being used effectively in the classroom. Further, this implies that mathematics teacher educators need to get to know their prospective teachers in terms of their productive and unproductive conceptions as well as have an understanding of how these conceptions may interact with each other to impact the prospective teachers' learning and eventual teaching practices. This needs to be done in order for mathematics teacher educators to provide their prospective teachers with the best possible opportunities to learn how to be effective teachers of mathematics for all students. Suggestions for how mathematics teacher educators can address and confront prospective teachers' conceptions will be discussed in the implications section.

Also, the participants' incoming productive conceptions regarding the importance of getting to know their students and taking that into account in their mathematics instruction may be related to the success they had in getting to know the students they shadowed. The participants' productive conceptions about getting to know their students may have supported them in the sense that they were willing to engage in the *shadow a student* project to the extent that they did (and in most cases, they went beyond what was required of them to continue their relationships with their students). On the other hand, given the demographic information about the participants' students (middle class suburban or rural), it is not likely that their unproductive conceptions about low income urban students are related to what they were able to get to know about their students. There is no evidence to suggest either way that if the participants had shadowed low income urban students that this would have impacted their performance. Also, the participants did not really discuss their conceptions regarding racially diverse students (despite there being opportunities to in the interviews) and so there is no evidence to suggest whether the race of the students they shadowed impacted the participants' willingness to get to know their students as it did not appear to.

Thus, I speculate that it might be the case that because the students were more like the participants, at least in terms of socioeconomic status and the type of neighborhood where they attended school, that the participants may have been more comfortable and more willing to get to know their students. The implications of this might be that if the participants had been placed outside of their comfort zone with students who had characteristics directly related to the prospective teachers' unproductive conceptions (i.e., low income, urban), then they may have had a more difficult time getting to know those students because they may have had preconceived notions of what the students might be like or simply may have been less comfortable doing so. While there is research that shows that getting to know a student who is socio-culturally different from you through various means (shadowing and interviews) can positively impact prospective teachers' unproductive conceptions (Bartell, Foote, McDuffie, Turner, & Aguirre, 2013; Ukpokodu, 2004), this research also suggests that prospective teachers may still have some other unproductive conceptions after such an experience. These remaining unproductive conceptions could ultimately have a negative impact on revising a task to be culturally relevant for a student because this practice relied heavily on what the participants were able to get to know about their students.

The participants' experiences shadowing their students were positive ones and engaged their already established productive conceptions without disrupting them. Therefore, this experience may have reinforced the productive conceptions they expressed at the beginning of the semester regarding getting to know students and using that information in their mathematics instruction. This result aligns with that of the TEACH MATH project which found that most of the prospective teachers in their study found shadowing experiences and problem solving interviews with African American students to be positive ones (Bartell et al., 2013). This is important because it is critical for prospective teachers to see the value in learning about students and their culture if they are to provide the best opportunities for students to learn mathematics for conceptual understanding (Leonard, 2008). Also, the prospective teachers may be more likely to continue to practice these ideas in the future with students who are socio-culturally different from them.

Given their mostly positive experiences shadowing students who are socio-culturally different from them (at least along lines of race or ethnicity) and thus outside of their comfort zones, it is possible that the prospective teachers may be more willing to get to know such students in their future classrooms. These results also align with the discussion in a previous section in that the participants' productive conceptions overall were reinforced by the middle school mathematics methods course activities. However, it is important to note that given that the participants viewed their students as racially different but not disadvantaged along lines of socioeconomic status, a focus only across lines of race may not account for their conceptions about students from low income backgrounds. In other words, the participants' conceptions about income are not necessarily tied to their conceptions about race. This is important because, while it is promising that their productive conceptions were reinforced, it may be the case that the participants were not placed in a situation (i.e., shadowing low income urban students) where they may have had to confront their unproductive conceptions in a way that may have impacted their productive conception about getting to know students. In other words, it is unclear whether, if the participants had shadowed low income urban students, their productive conceptions would have been reinforced or challenged based on their unproductive conceptions.

In addition, the productive conception regarding taking what they learned about their students into account in their mathematics instruction suggests that the participants may have been open to learning how to revise a high-level mathematics task to be more culturally relevant for their students in that they saw the value of doing so and were mostly successful at it, despite not getting to know and/or drawing on their students' cultural practices. The lack of attention to their students' culture is possibly a reflection of the participants' conceptions about and/or more limited experiences thinking about culture and mathematics teaching and learning prior to the middle school mathematics methods course. While getting to know their students was a prevalent conception expressed throughout the pre-interview, the participants did not discuss the importance of getting to know students' cultures specifically (although they did during the post-interview). This suggests that at the beginning of the semester when they shadowed their student, getting to know their students' culture may not have been a focus and/or they may not have known what that would entail. It could also be a result of the limited time they spent in the field getting to know their students as a much longer amount of time may be required to get to know a student's cultural practices. These results suggest that prospective teachers' conceptions may play a role in what course assignments they find valuable and how they engage in these assignments, which in turn can impact what they end up getting out of completing projects like these. Thus, it is important to take into account prospective teachers' conceptions and knowledge when designing course projects so that the prospective teachers experience and learn what the instructor intends for them to learn.

It is important to note that the participants were able to successfully engage in revising a high-level mathematics task to be culturally relevant for one student, seemingly independent of the unproductive conceptions that they expressed. It is possible that the participants' productive conceptions about the importance of taking their students' backgrounds into account in their mathematics instruction may have influenced their willingness to learn how to revise a task to be culturally relevant which, in turn, may have supported them in successfully engaging in that process. However, there is no evidence to suggest that the participants' unproductive conceptions were related to their performance revising a task. It is not the case, for instance, that the participants who held more unproductive conceptions overall were the ones who struggled with their task revisions. As described previously, the participants did not shadow low income students and/or students in urban schools and so it may be unlikely for their unproductive conceptions about low income students to have an impact on their success shadowing their students or on revising the task itself. Prior research has shown that unproductive conceptions about low income students can lead to a move towards more traditional teaching practices, including using low-level mathematics tasks (e.g., Sztajn, 2003). Thus, it is possible that if the participants had shadowed low income students, they may have either been forced to confront their unproductive conceptions to be successful or relied on their unproductive conceptions which may have led them to not be successful (e.g., lowering the cognitive demand of the original task because their student would not be able to handle high-level mathematics).

The fact that the students the participants shadowed were similar to them along lines of socioeconomic status and the neighborhoods where they attended school implies that the participants may have had an easier time revising their tasks to be culturally relevant for their students because if the participants were familiar with the student's interest/cultural experience and/or placed personal value upon that experience, it may not have been as challenging to revise the task as compared to if they did not have knowledge of the interest beforehand. This has implications for the participants' future use of culturally relevant mathematics tasks in that if they are unfamiliar with a particular student's interest or cultural practice, then it may be more difficult to revise a task based on that practice. Further, if prospective teachers' unproductive conceptions influence the value placed upon certain cultures and experiences, then that might impact the quality of culturally relevant tasks the prospective teachers create and ultimately the opportunities they provide their students to learn.

During the course, it was emphasized repeatedly that it is important to get to know students as individuals and not to stereotype or make assumptions about students based on demographic characteristics (race, gender, SES, etc.). However, the nuance with which the participants appeared to understand and embrace this issue during the methods course seemed to be missing when asked to comment on groups of students as a whole during the interviews. In other words, the participants appeared to understand that individual students might not fit the stereotypes, but still resorted to expressing those stereotypes when asked about groups of students. Specifically, the participants expressed unproductive conceptions about low income urban students when responding to the interview scenarios that described groups of students (as opposed to individual students) as being from low income urban areas. Therefore, it is possible that the participants were able to be successful revising a task for only one student because they did not have to directly confront the unproductive conceptions they held about certain groups of students. If the participants had to revise a task for an entire classroom full of students, particularly those from low income and/or urban neighborhoods, it is possible that their unproductive conceptions could have played a bigger role in their success revising a high-level task to be culturally relevant. However, it is unclear whether or not this would be the case.

An important consideration to take into account is that the participants in this study were required to revise a high-level mathematics task to be culturally relevant in the way that I had taught them to during the class. Their desire for a good grade on the *task revision* project could have trumped any influence their conceptions might have had on their task revision. For example, John's task revision remained at a high level of cognitive demand (which was a requirement) despite his perception that the student he revised the task for would not be able to handle the challenging task on her own. The implication of the *task revision* project being a requirement is that revising a task to be culturally relevant for one student may be a skill that can be developed independently of teachers' conceptions.

This is not to say that the participants' productive conceptions about taking students' interests, home/community experiences, and cultures into account didn't have any impact on their success. The prospective teachers' productive conceptions about taking students' backgrounds into account may have led them to realize that this sort of activity is a worthwhile endeavor, which in turn may have supported them in attaining the success that they did. Thus, it is important to think about the consequences of prospective teachers having this skill with some productive conceptions that support implementing it, but still holding unproductive conceptions when they leave the methods course and start teaching. First, prospective teachers would have to choose to use culturally relevant mathematics tasks with their future students, which their unproductive conceptions may not support depending on which of their conceptions would take precedence. If teachers do choose to use culturally relevant mathematics tasks in their classrooms, there may be some implications of holding unproductive conceptions. For example, if a teacher's goal for her students is to engage and motivate them rather than to support their learning of high-level content (similar to what Rick stated in his post-interview about students in urban schools), that teacher may revise low-level tasks based on her students' backgrounds to motivate her students, but not challenge them.

A possible implication of holding productive conceptions (specifically the importance of taking student backgrounds into account in their instruction) coupled with the unproductive conceptions about low income urban students is that the participants' success in revising a task may be missionary in nature (Martin, 2007). In other words, revising a task to be culturally relevant for students may be perceived by prospective teachers as being a means to ensure the success of their students in the traditional sense (i.e., on standardized tests) so that they can "save" the students from the lives they currently live (to be more like the teachers' lives). For example, if a prospective teacher holds conceptions that taking student backgrounds into account can be motivating for students and that she needs to motivate certain students (e.g., low income and/or urban students) in order to support their success, the prospective teacher may view that the purpose of implementing culturally relevant tasks is to achieve this goal. However, the purpose of revising mathematics tasks to be culturally relevant should not be seen from a deficit view of students who need to be saved, but should instead be seen from an empowerment view of students (Gutstein et al., 1997) whose experiences are valued and seen as strengths in the classroom.

However, prospective teachers' success being reflective of a missionary stance at this point in their development may be an acceptable stage for them to be at. It is important that they see the value in using culturally relevant mathematics tasks so that they make the choice to use them in their teaching. For this study, the participants' productive conception that it is important to take students' backgrounds into account suggests that the participants may have started to develop an understanding that they need to value students' out-of-school experiences and that this can be done through revising tasks to be culturally relevant. At this point, it is a question of how the participants' viewed the purpose of such revisions. Based on the results, it is not clear that the participants had developed an empowerment view that using students' backgrounds can give students access to the mathematical ideas and concepts as well as develop their cultural competence, despite having discussions around this idea during the course. I conjecture that with time, it is possible for the prospective teachers to develop this view if they choose to implement culturally relevant mathematics tasks in their future classrooms and are supported beyond their teacher preparation program in developing conceptions that support the use of these tasks.

Based on the results of this study, the consequences of having unproductive conceptions may not impact the task revision itself as much as what the teacher does with that task once they have it. The example of John's unproductive conception about low ability students that may have influenced his choice to use group work to implement his task with his student illustrates that it wasn't necessarily the task itself, but how he intended to use the task in the classroom, that was potentially problematic. Similarly, the productive conceptions that the participants held also appeared to align with what they said they would do to implement the task with their students as discussed at the beginning of this section. Thus, it is necessary to consider the importance of teachers implementing other culturally relevant practices that will support the use of culturally relevant tasks as well as to consider the role that teachers' conceptions play in their instructional choices. These issues will be taken up in the next section.

Is Good Mathematics Teaching Enough? A Case for Culturally Relevant Pedagogy and Developing Productive Conceptions

One question related to the entire study is whether what we consider to traditionally be good mathematics teaching (and the conceptions that may support the use of such practices) is enough to provide all students with sufficient opportunities to learn mathematics. I would argue that it is not. We can look to the research in complex instruction that shows that even with good teaching, status issues come into play that limit the opportunities of some students to learn high-level mathematics (Cohen & Lotan, 1995; Horn, 2010). We can also turn to the research that illustrates how a "cultural mismatch" between students' culture and the school culture, particularly in mathematics tasks, can impact the opportunities students have to learn mathematics (Gutstein, 2003, 2006; Lubienski, 2000; Murrell, 1994).

Importantly, the results of this study also shed some light into why good teaching practices (or holding the productive conceptions related to good teaching practices) are not enough. The participants of this study began the middle school mathematics methods course with both productive and unproductive conceptions and ended the semester making some positive progress in their productive conceptions regarding good teaching practices (including getting to know their students) while their unproductive conceptions remained. While it is an important finding that the participants made some progress in their productive conceptions, continuing to hold unproductive conceptions impacted how John wrote that he would implement his revised task in a classroom and may impact some of the participants in their future teaching of low income urban students. In other words, good mathematics teaching skills may not be enough if teachers hold unproductive conceptions that conflict with their use.

Therefore, while it is important that this teacher education program (including the middle school mathematics methods course) emphasized supporting prospective teachers in learning how to implement good mathematics teaching practices and has been largely successful (at least in terms of their conceptions regarding these practices), more emphasis should be placed on supporting prospective teachers to be good mathematics teachers for all of their students, particularly students whose culture may not match that of the school (Joseph, 1987; Romberg, 1992). This includes having the conceptions that will support the use of effective teaching practices. I have argued that culturally relevant pedagogy is one way to provide opportunities for all students to learn (Ladson-Billings, 2009; Rubel & Chu, 2011; Tate, 1995) and have focused on supporting the participants in developing *some* of the practices and conceptions that culturally relevant teachers employ in this study. An extended experience where prospective teachers can actually implement culturally relevant mathematics tasks and teach students who are socio-culturally different from them may take prospective teachers further towards becoming culturally relevant mathematics teachers.

All of the participants started to develop some of the practices of culturally relevant teachers and some productive conceptions that would support the use of such practices. Getting to know students and being able to use that information to create a culturally relevant mathematics task are important practices of culturally relevant teachers (e.g., Rubel & Chu, 2011). Therefore, the success that the participants had in doing both practices and the productive conceptions they held that support the use of these practices is promising in that it suggests that mathematics teacher educators can support prospective teachers in learning the practices of culturally relevant teachers.

However, this begs the question of whether a mathematics task can be culturally relevant by itself or make a teacher who uses such tasks a culturally relevant mathematics teacher. As I have stated elsewhere, I do not intend to make this assertion as culturally relevant mathematics teachers do more than just use tasks such as these. Culturally relevant mathematics teachers hold high expectations for all of their students; get to know their students' interests, home lives, communities, and cultures over time through building relationships with the students, their families and communities (Ladson-Billings, 1997, 2009); and "empower students to critique society and seek changes based on their reflective analysis" (Tate, 1995, p. 169). The results of this study, particularly those regarding the participants' unproductive conceptions, support this argument that mathematics tasks are not in and of themselves culturally relevant.

As discussed previously, prospective teachers' unproductive conceptions may impact the opportunities they provide their students to learn (Milner, 2005). Therefore, prospective teachers' unproductive conceptions are just as important to consider when helping prospective teachers become culturally relevant mathematics teachers. Most of the participants in this study had some unproductive conceptions that may conflict with the use of culturally relevant teaching practices. As discussed in the previous section, these unproductive conceptions did not seem to directly surface in the task revision process (as all of the participants did have some success in revising a task), but in their description of how they would implement their revised tasks. One potential reason for this was that the participants did not shadow low income students and/or students from urban areas and so it may have been a non-issue to revise a task for the students they shadowed. Also, a large portion of the course was focused on getting to know students as individuals and to not put labels on students. Therefore, the participants may have had an open mind when shadowing one student and so could revise a task without issue, but could not transfer that idea to address their unproductive conceptions regarding low income urban students as a group.

The example of how John's unproductive conception about low ability mathematics learners as discussed above exemplifies how unproductive conceptions can impact how one views the purpose of some teaching practices and therefore, how they say they would implement such practices. In John's case, it was not the task itself, but his description of how he would implement the task that was particularly problematic. This suggests that a mathematics task may not necessarily be culturally relevant by itself because it is the sum total of all of a teachers' practices that makes one a successful culturally relevant mathematics teacher. However, getting to know students and using that to create such tasks and developing the conceptions that may support the use of these tasks is one step towards supporting prospective teachers in becoming culturally relevant mathematics teachers.

Implications for Practice

Based on the discussion in the previous sections, there are a few implications for mathematics teacher educators as well as K-12 teachers. These implications are related to developing prospective teachers' conceptions, culturally relevant teaching practices, the relationship between conceptions and practice, and the framework developed for this study.

Developing Conceptions

There are some specific implications based on the results of this study on how mathematics teacher educators can foster and develop productive conceptions and confront and address unproductive conceptions. In the context of a single course, carefully designed assignments related to field experiences can be effective in providing prospective teachers opportunities to develop productive conceptions. Providing prospective teachers with time to get to know one student (or multiple students) can be beneficial in terms of helping prospective teachers see the value in getting to know their students (which all of the participants in this study claimed). Having to complete the *task revision* project may also have been beneficial in developing the participants' productive conceptions because it provided them a way that they can use the information they learned about their students to directly benefit their students' opportunities to learn, which may have placed further value on the importance of getting to know students. Thus, projects like the *shadow a student, problem solving interview,* and *task revision* projects can be beneficial for mathematics teacher educators to implement with prospective teachers in order to develop their productive conceptions about the teaching and learning of mathematics for all of their students.

Also, providing multiple opportunities for prospective teachers to engage with issues of mathematics teaching and learning and/or students who are socio-culturally different from them through the use of course readings, discussions, and activities can help prospective teachers maintain and develop productive conceptions. Specifically, during the middle school mathematics methods course, multiple class sessions were focused on readings, small and whole group discussions, and activities (e.g., readings jigsaw, concept maps, etc.) related to (1) group work as defined by complex instruction; (2) the importance of getting to know students and using that information in their mathematics instruction; and (3) on culture and culturally relevant pedagogy. The importance of all of these issues was emphasized heavily by the participants during their post interviews.

Based on the results of this study, I would also argue that mathematics teacher educators need to give the same, if not more, attention to prospective teachers' unproductive conceptions about students who are socio-culturally different from them as they do regarding prospective teachers' productive conceptions. The course activities that were employed throughout the semester (e.g., the Mythtakes activity discussed in the methods chapter) resulted in whole group discussions where the participants' conceptions and ideas were challenged. However, the results suggest that such activities did not do enough to create positive changes in their unproductive conceptions. The fact that there were fewer class sessions that directly confronted and addressed the participants' unproductive conceptions as compared to those related to their productive conceptions about good mathematics teaching practices suggests that providing prospective teachers with multiple opportunities throughout one semester to confront their unproductive conceptions through course readings, discussions, and activities is warranted.

Specifically, mathematics teacher educators should incorporate readings and class discussions throughout the semester that focus on issues of race, culture, and income specifically so that prospective teachers have multiple opportunities to confront and address their unproductive conceptions. Also, given that the participants in this study did not have their unproductive conceptions regarding low income students challenged by their field placement experiences and prior research suggests that carefully designed shadowing/interviewing experiences can be important in confronting such conceptions (e.g., Bartell et al., 2013), mathematics teacher educators should strongly consider providing these kinds of experiences for their prospective teachers in addition to the work done in the class meetings.

Ideally, these kinds of course and field experiences would be implemented throughout teacher education programs because the results of this study and prior research suggest that a one semester course may not be enough to substantially change prospective teachers unproductive conceptions (e.g., Pope & Wilder, 2005). The results of this study further this argument to suggest that this should be done specifically in the context of mathematics teaching and learning because the participants' unproductive conceptions about students can come into conflict with their productive conceptions about effective mathematics teaching practices and impact whether and how they intend to use culturally relevant mathematics teaching practices. Thus, course projects, readings, discussions, activities, and field placements should be designed and implemented throughout mathematics education coursework to provide prospective teachers with the best opportunities to maintain and develop productive conceptions and confront and address their unproductive conceptions.

Culturally Relevant Teaching Practices

I would also extend this argument to consider developing prospective teachers' culturally relevant teaching practices throughout their teacher education programs. Previous research has shown that it is challenging for teachers to understand and learn how to implement culturally relevant teaching practices (e.g., Young, 2010), but it is possible to support prospective teachers in learning how to be culturally relevant when a major goal of their teacher education program is to ensure all students are provided with the best possible opportunities to learn through culturally relevant pedagogy (Ladson-Billings, 2001). The results of this study, which provided the participants with their only experience with culturally relevant mathematics pedagogy in their teacher education program to this point, further suggest that a one course introduction to culturally relevant mathematics pedagogy, while it can help prospective teachers make progress towards becoming a culturally relevant mathematics teacher, is not enough. Therefore, one implication would be to start supporting prospective teachers to develop culturally relevant teaching practices early during their teacher education programs and continue that support throughout.

However, it may not be possible to restructure entire teacher education programs to focus more on culturally relevant teaching practices. Therefore, it is important to consider the implications from the results of this study for methods instructors who may only have one semester in which to support prospective teacher learning. The success of the participants to revise a high-level mathematics task to be culturally relevant for one student suggests that this is a worthwhile introduction to culturally relevant pedagogy in that the participants were able to engage with the ideas of culturally relevant pedagogy throughout the semester and finished the course with a concrete practice that they can implement in their future teaching. While this in no way guarantees that prospective teachers will continue to develop their skills as culturally relevant mathematics teachers, the activities and projects in the middle school mathematics methods course provided the participants with a foundation upon which they can further develop the knowledge, skills, and practices of culturally relevant mathematics teachers, whether through the support of professional development or through their own curiosity to continue to read about and try to implement other culturally relevant mathematics teaching practices.

Considering Conceptions and Culturally Relevant Practices Together

While the results regarding the participants' productive conceptions and their ability to revise a high-level mathematics task to be culturally relevant for one student are promising, the results regarding the participants unproductive conceptions are concerning and have other important implications for mathematics teacher educators. Specifically, the implications come when looking at prospective teachers' conceptions and their practice together. The results of this study suggest that the participants were mostly successful in revising a high-level mathematics task to be culturally relevant for one student. However, if I did not consider the participants unproductive conceptions, I may not have determined that those conceptions may have impacted their less than ideal choices about how to implement those tasks. In other words, the participants' success in creating culturally relevant mathematics tasks may not be a beneficial skill to have if their unproductive conceptions conflict with this practice to the extent that students are not provided with the best opportunities to learn.

As I have argued in a previous section, while the results on the participants' performance are promising and warrant further focus and research, it is equally important for mathematics teacher educators to confront and address prospective teachers' unproductive conceptions. I have given specific suggestions for how to do so in a previous section. Whether this happens during a single methods course or throughout mathematics education coursework, it is not enough to simply develop prospective teachers' culturally relevant teaching practices if they do not have the conceptions that support the use of such practices that will benefit all students.

Culturally Relevant Task Framework

The theoretical framework for revising a high-level mathematics task to be more culturally relevant (see Table 1) contributes to the research on culturally relevant mathematics pedagogy and on prospective teacher education. Very few studies have examined what culturally relevant mathematics tasks are (e.g., Ensign, 2003; Leonard & Guha, 2002) and fewer have developed a framework for supporting teachers to learn how to revise high-level mathematics tasks to be more culturally relevant for students (Herron & Barta, 2009) and no known published research studies have done so at the middle school level.

Herron and Barta’s (2009) framework, as discussed in the literature review, is a list of things that the teachers were supposed to get to know about their students (i.e. interests, family members, pets, places familiar to students, etc.). Then the teachers were to use the information they gathered in relation to the framework to replace names, places, and objects in second grade mathematics word problems. This aligns with component 1 of my framework (draws on something meaningful learned about students) and promotes more surface level changes to tasks (lowest level of component 2). While the revisions Herron and Barta (2009) suggest may be beneficial for student learning, my theoretical framework was developed with the intent to go beyond these beginning, surface level revisions to take into account the out-of-school mathematical practices students engage in that would give them a greater opportunity to access the mathematical concepts and ideas in the task. Specifically, my framework expands upon Herron and Barta’s (2009) framework to account for the cognitive demand of the task, realistically drawing on the mathematics in the context, and incorporating the mathematical practices students may participate in or have access to in relation to the context. All of the components of the framework served to provide more structure and support for the participants in that the framework could be used as a check list of sorts to ensure that they took each of the components into account in their revisions. Given that this study was the first time this framework was used, it is open to being refined by future research studies should the need arise.

This framework contributes to the culturally relevant mathematics pedagogy research by providing some evidence of what a culturally relevant middle school mathematics task is (as there are no known published studies that address middle school tasks) and giving an idea of how one can create a culturally relevant mathematics task from existing mathematics curriculum. The revised tasks that the participants created (see Appendix C) provide examples of the kinds of tasks that can be created by applying the framework to high-level mathematics tasks found in middle school mathematics curricula. Because John and Zane struggled some with revising their tasks the first time, but were able to create better revisions during the post-interview with the support of the instructor, it may be beneficial for mathematics teacher educators who want to support prospective teachers in creating these kinds of tasks to provide them with multiple opportunities to revise tasks individually rather than only giving them one opportunity as I did on the *task revision* project. In this way, the prospective teachers can have multiple opportunities to get feedback from the instructor on their revised tasks so that they can develop a better understanding of the different components of the framework.

In addition, no published studies have specifically examined how mathematics teacher educators can support prospective middle school mathematics teachers' learning to revise high-level mathematics tasks to be more culturally relevant for students. The theoretical framework (see Table 1) developed for this study as well as the related course projects can be implemented by mathematics teacher educators with prospective teachers as a model of a particular culturally relevant teaching practice. This can be done in much the same way that I implemented the framework in the middle school mathematics methods course through activities where the participants use the framework to analyze revised tasks to determine whether they are “good” or “bad” revisions and then use that framework to revise a high-level mathematics task for a particular student first as a class and then, as suggested above, multiple times independently with feedback provided by the instructor. In addition, mathematics teacher educators can use the framework to revise high-level tasks themselves for use as “good” and “bad” examples for their prospective teachers to examine.

Importantly, the framework can even be used as it is with elementary and high school mathematics prospective teachers as there is nothing about the framework to suggest that it is specifically for middle school mathematics tasks. In addition, the course activities and projects used to support the prospective teachers in making progress towards revising a task to be culturally relevant (i.e., the *task revision activity*, *problem solving interview* and *shadow a student* project) can also be used with slight modifications. For instance, the *task revision activity* and *problem solving interview* tasks would have to be altered to address mathematical topics appropriate for elementary or high school students. The *shadow a student* project interview questions can also be used with any student. However, in-class discussions of strategies for approaching the student selected to shadow and how to shadow a student may differ depending on whether they are shadowing an elementary or middle/high school student. For instance, it may be more difficult to get to know an elementary student who spends most of the day in one classroom because students may more readily or obviously exhibit different strengths and competencies with different teachers in different class settings.

In addition, the framework for revising a high-level mathematics task to be more culturally relevant is one that K-12 teachers can use as part of their instructional planning as one way to incorporate students' cultures and home and community lives into instruction in a way that motivates and engages students as well as providing students access to important mathematical ideas and concepts. Specifically, this framework can be applied to the high-level mathematics tasks found in the mathematics curriculum that K-12 teachers use with their students to create culturally relevant mathematics tasks in much the same way that the prospective teachers in this study did. I envision that teachers would use this framework after taking the time to get to know their students' interests, home/community practices, and cultures. In particular, this framework should be used to guide teachers in how to take information they learn about their students to revise existing high-level mathematics tasks that they find in their curriculum or other materials. First, teachers should be introduced to the framework and culturally relevant mathematics tasks, perhaps through professional development, so that they understand the specific components of the framework. It should be noted again that the framework is set up so that both ideal and not ideal revisions for each component are listed (they are listed in the framework from not ideal to more ideal). This is so that teachers can not only see what the ideal characteristics would be, but those that are not ideal so that they can be cognizant not to do those things. It is important for teachers to be trained in how to read the framework so that it is clear that, for example, they do not want their revised task to be at a lower level of cognitive demand than the original task. Once teachers have learned about their students and found a high-level task to revise, they should use the components of the framework as a check list to guide their thinking about the characteristics their revised task should have.

Another implication to consider in relation to the framework is the fact that the participants in this study only had to revise a high-level mathematics task for one student. As argued in the methods chapter, Grossman et al.'s (2009) framework suggests that having the participants revise a task for only one student is an appropriate decomposition and approximation of practice to support prospective teacher learning. However, this has implications for current and future K-12 teachers who may have to consider the needs, interests, cultures, and home/community lives of all of their students at once. I hypothesize that it may be more challenging to revise a high-level mathematics task for an entire classroom of students as it may be difficult to get to know and analyze all of the different experiences that students in a classroom have to find a common context among all or most of the students in a classroom. Thus, while the framework is not specifically written for use with only one student, some modifications may need to be made and studied to determine how teachers can be supported in learning to revise a high-level mathematics task to be culturally relevant for an entire classroom. I propose potential minor modifications to the framework and a research study in the future research section below.

Limitations

There are several limitations to this study. First, the findings from the four participants cannot be generalized to all prospective teachers or even to the other eight prospective teachers enrolled in the middle school mathematics methods course. The only data collected from the eight other prospective teachers enrolled in the course was the pre- and post-conceptions survey. There was not enough data from this survey to make strong claims about whether these four participants were "cases of" different types of prospective teachers found in the methods course.

In addition, all of the evidence collected on prospective teachers' conceptions came from self-reports. While it was necessary to collect such self-reports to understand a person's conceptions, there are some concerns about these data. In this particular study, the sensitive nature of some of the topics I asked the participants to provide their thinking on (issues of race, income, ELLs, etc.) may have impacted how the participants responded to the pre-post conceptions survey and the pre-post interviews. Specifically, the concern was that the participants would have assumed they knew what the researcher wanted them to say (i.e., the "politically correct," "right" answer) and simply said that whether they believed it or not. This was addressed in several ways as discussed in the methods chapter. First, the pre-interview was conducted by someone other than the researcher/instructor of the methods course (who did not listen to the interviews until after grades were submitted) so that the participants didn't have to worry that their responses would affect their grade or how they were treated throughout the course. Also, the interview protocol was made up of different teaching scenarios (see Appendix E) so that it would be more difficult for the participants to determine the "correct" response to the interview questions. Finally, the post-interviews and all data analyses were conducted after grades were submitted so that the participants did not have to worry about their responses influencing their grades. Despite these precautions, it is possible that the participants were not completely forthcoming about their conceptions.

Another limitation to this study is that the prospective teachers, with the exception of Zane, completed their field placements in majority White, middle class suburban schools which closely resembled the demographics of the schools they attended as K-12 students. Zane's field placement school was in a middle school in a rural area outside of a suburban neighborhood and had a majority of racial and ethnic minority students (mostly African American) with a large proportion (51%) of students coming from low income households. Because none of the participants were teaching in low income urban, high-needs schools and the fact that there were few course activities where the participants had to confront their conceptions about poverty, it is not clear how their conceptions regarding low income students in urban areas would have been related to their performance on the course projects. More research is needed to determine how their performance would have differed had they experienced shadowing a low income student from an urban area.

Finally, while the results illustrate that there is some connection between the participants conceptions and the practices they state they would use in the classroom, it is unclear how their conceptions will impact their actual teaching practices. As discussed in the literature review, there is evidence that teachers' conceptions can impact their mathematics instruction (e.g., Sztajn, 2003). However, it was outside the scope of this study to observe the participants as they taught during their field placements. More research is needed to determine how prospective teachers' productive and unproductive conceptions may impact their current and future teaching practices, particularly practices such as getting to know students and using that information in their mathematics instruction and group work as defined by complex instruction.

Future Research

This study analyzed four different prospective teachers' conceptions regarding mathematics teaching and learning and socio-culturally diverse students and their performance learning to revise a high-level mathematics task to be culturally relevant for one student. While these four prospective teachers did share many conceptions, they did differ from one another in many ways (e.g., Rick and Zane held missionary conceptions while John had unproductive conceptions about students' perceived mathematics ability). Future studies could analyze the conceptions of many more prospective teachers so that different profiles or "cases of" different prospective teachers could be determined. This may be important because if we can define profiles of prospective teacher conceptions, we can track those prospective teachers over time throughout their teacher education programs so that we can potentially determine an evolutionary path for teachers' conceptions. Further, while there are many studies on teachers' beliefs and conceptions, the mixed results found in the research literature illustrate that we don't have a clear idea of what specific experiences can positively impact prospective teachers' conceptions. Therefore, future research can also address what coursework, field experiences, and other supports can result in progress in prospective teachers' conceptions, particularly their unproductive conceptions about particular groups of students, to become more productive on the anticipated evolution paths.

Future research could refine the theoretical framework (see Table 1) for use with entire classrooms of students to determine the progress teachers can make towards being able to revise a high-level mathematics task to be more culturally relevant for an entire classroom. I do not anticipate that the framework would need to change drastically, but in subtle ways. For example, in relation to component 1 (draws on something meaningful learned about students), it may be harder to find a meaningful interest that is common across an entire classroom full of students and so teachers may have to think about an interest *most* of the class shares or they may have to focus more on the home, community, and/or cultural experiences that all (or at least most) of the students might share and/or have access to. Also, in relation to component 3 (draw on mathematical practices of the students), it may be difficult to find a particular context that all students are aware of and/or find interesting where they would have engaged similarly in the mathematics related to that practice. Variability in student experiences is to be expected and different students can (and should) bring different ideas to the table for how to engage with a particular task. Thus, the framework may need to be refined to take this into account in that the teacher may have to focus more on the mathematical practices of the people in the larger community rather than on individual student practices, for example.

As I argued in the methods chapter and the previous section, while there may be instances where an in-service teacher would revise a task for one specific student, it is also important for teachers to learn how to do this by taking into account the needs and backgrounds of an entire classroom of students. One example of where a teacher may want to revise a task for one student is if she had one student (or a few students) who may have been struggling to understand a particular mathematical concept. Thus, the teacher could decide to draw on some meaningful out-of-school practice that would provide that student with access to the mathematics. Another example is if a teacher decided to revise a task for each of her students in turn so that she could help students see that their race, culture, interests, etc. are valued in the classroom. Despite the fact that it is useful for the participants' future teaching to have learned to revise a task for one student, it can also be beneficial to learn to revise a task to be culturally relevant for the whole class so that everyone can have greater access to the mathematics.

For a proposed study in which I would determine the progress teachers can make towards revising high-level mathematics tasks for an entire classroom of students, I would have either student teachers or in-service teachers as participants, as the constraints of a methods course field experience may limit the amount of information a prospective teacher can learn about an entire classroom of students, which may ultimately impact the quality of their revised tasks, as evidenced by this study. Therefore, student teaching or in-service teaching may be a more appropriate setting to conduct a study like this as these teachers would have more time to get to know their students well enough to revise a task that meets all (or most) of their students' needs. For this study, the teacher would have to spend time getting to know her students as a class by interviewing them and/or spending time in the community and taking that information into account to revise a high-level mathematics task to be culturally relevant for her class.

There is little published research that has looked at the effects of culturally relevant mathematics tasks (e.g., Ensign, 2003). Thus, a logical next step to take from this study would be to determine whether the culturally relevant mathematics tasks as I have defined them would be effective with students in terms of providing them opportunities to learn the mathematics. Future research studies could have prospective teachers in their methods course revise a high-level mathematics task for one student as was done in this study and use that task to teach a lesson in their field placement classrooms. This would be similar to how they discussed how they would implement the task in their field placement classroom for the *task revision* project in this study except they would have to actually implement their proposed lesson. The researcher could observe the prospective teacher implementing a different lesson that did not use a culturally relevant mathematics task first to get an idea of student motivation, engagement, problem-solving strategies, etc. in the classroom before culturally relevant mathematics tasks are used. Then the researcher could observe the students working on a culturally relevant task as the prospective teacher implements the task and compare qualitatively the student's motivation, engagement with the task, problem solving strategies, etc. on this task from what they had observed of their student's behavior in mathematics class during the first lesson. Note that this comparison does not necessarily focus on the learning of mathematics in terms of students' individual achievement as they would likely be working in small groups to complete the task. Coupled with the previous idea for future research of student teachers or in-service teachers revising tasks for an entire classroom, this line of research could be scaled-up to determine over the course of a unit whether students' performance on different assessments is better after using culturally relevant mathematics tasks during instruction as compared to a control group classroom.

Finally, based on the results regarding the effects of a one semester course on prospective teachers' conceptions and practice, a longitudinal study can be an appropriate way to determine the progress prospective teachers' can make in (1) their conceptions and (2) their learning about and implementing culturally relevant mathematics practices throughout their teacher education programs. This could be on a large scale with multiple mathematics teacher educators agreeing to implement lessons, activities, and assignments in a variety of courses designed to support prospective teachers making progress. While difficult to conduct, a study such as this could give great insight into whether a targeted teacher education program can make a positive impact on prospective teachers' conceptions and practices to better prepare them to teach mathematics to socio-culturally diverse students.

Conclusions

This study revealed that while it is difficult to change prospective teachers' deeply ingrained unproductive conceptions, the participants did make some progress in their productive conceptions to make them more specific and detailed. Also, the prospective teachers' were successful in getting to know one student who was socio-culturally different from them and taking that information to revise a high-level mathematics task to be more culturally relevant for that student. The results of this study have implications for mathematics teacher educators in that it is important for them to provide targeted course readings, small and whole group discussions, course activities (readings jigsaws, class concept maps, etc.), and field experience assignments (e.g., *shadow a student* projects) to address prospective teachers' productive and unproductive conceptions as well as develop culturally relevant teaching practices throughout their teacher education programs in order to better prepare prospective teachers to teach students socio-culturally different from them. Also, an important contribution of this study is the culturally relevant mathematics task theoretical framework which can be used by mathematics teacher educators to support their prospective teachers in learning a specific practice of culturally relevant teachers. Finally, future research is warranted in order to get a better idea of how to support prospective teachers' development in (1) their conceptions about mathematics teaching and learning and socio-culturally different students and (2) in learning to implement culturally relevant teaching practices throughout their teacher education programs.

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Appendix A

FAKE STUDENT PROFILE

You shadowed a sixth-grade student named Brianna in a school that resides in New Castle County in Delaware. She is African American, lives in a low income urban neighborhood, and participates in the free and reduced-price lunch program. Her parents both work full time jobs so Brianna often gets home from school without anyone being there.

In school, Brianna seems well-liked by her peers. They often say hello to her when they pass in the hallway and she seemed to work well with others in her class. Her favorite classes are English and Social Studies. She seems to participate a lot in each of these classes by raising her hand to answer most of the questions asked by the teacher. In English class, Brianna enthusiastically participated in the discussion they were having around the book they were reading. This book is part of a unit on fairy tales. It was a sort of Cinderella story but from the African American culture. Brianna seemed very engaged with this class and readily gave her opinion about what was happening in the story. She was exceptionally adept at making claims about what happened in the story and giving evidence for them by drawing on parts of the story and pictures in the book.

In mathematics class, Brianna seemed uninterested. When asked questions directly she answered, but she didn't volunteer answers. She claimed that math is her worst subject and that sometimes she has trouble understanding what to do. The teacher uses Connected Mathematics Project 2 (CMP2), but Brianna rarely finds the real-world contexts very interesting. However, she does work well with her classmates when they work in small groups in that she tries to contribute when she can, but does not do so often.

You also found out that Brianna spends much of her time at the local church community center. While there, she participates in a number of different activities including getting homework help, playing games with other children, and helping tend to the community garden. She can almost always be found either playing soccer with her friends (her favorite sport), dancing, or working in the community garden. For example, Brianna and some of her friends helped the adults figure out how much of each vegetable they needed to plant based on the needs of the church and community. She also helped them determine how much plastic they needed to cover the garden when they saw that frost was coming that could damage the plants. Brianna also gets very excited for the annual church community center pot luck dinner. She and other students from the community often help set everything up and help clean up after the pot luck is over. She also likes to help her mother and grandmother cook dishes to share.

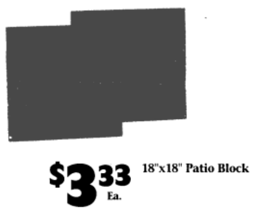
Brianna also really loves music and especially likes to dance. She spends time with her friends creating music and dance moves that go along with it. They focus on different beats and come up with many different patterns with the music and with their dance moves. When creating dance moves, they not only need to be aware of what looks good, but how to place their legs, arms, etc. so that they can balance properly.

Brianna also likes to go grocery shopping with her mother. She often helps her mother figure out how much they should buy of each item on the shopping list for her family while staying within their budget for food. Every once in awhile, Brianna's mother gives Brianna some money to go down the street to the corner store to buy a needed item (milk, bread, etc.) and has Brianna bring back the change. Brianna also likes to help her mother cook using traditional African recipes.

Appendix B

ORIGINAL TASKS FOR TASK REVISION PROJECT

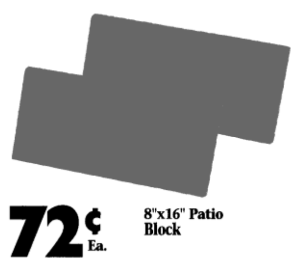
1. **Unit price and budgeting:** You have just been given the job of providing the measurement specifications for an advertising circular that the HandyHome Company is going to produce. It is very important that your specifications be accurate. Fill in the missing data on the following sketch of one of the ads:



1 patio block covers _______ sq. ft.

_____ stepping stones cover 12 sq. ft.

_______ round patio blocks cover 100 sq. ft.



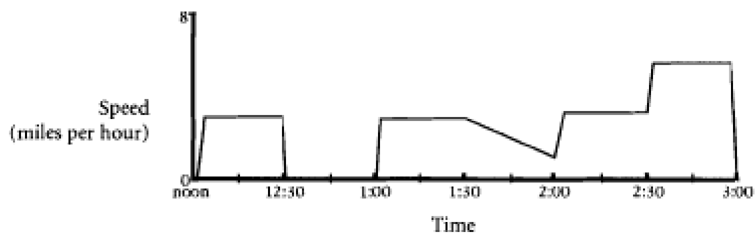
_______ patio blocks cover 100 sq. ft.

A customer calls your HandyHotLine and wants to know what is the most economical block to use to pave a 12 ft. x 15 ft. patio. What would you advise? Be sure to justify your answer clearly.

Source: Balanced Assessment – Harvard Group, 2000b, http://balancedassessment.concord.org/docs/m001tr.pdf

2. Interpreting Graphs: Use the following information and the graph to write a story about Mike's walk:

At noon, Mike stated walking from home to his grandmother's house. He arrived at her house at 3pm. The graph below shows Mike's speed in miles per hour throughout his walk.



Write a story about Mike's walk. In your story, describe what Mike might have been doing at different times. **Source:** Smith, Stein, Arbaugh, Brown, & Mossgrove, 2004, p. 66

3. Budgeting: Treena won a 7-day scholarship worth $1,000 to the Pro Shot Basketball Camp. Round-trip travel expenses to the camp are $335 by air or $125 by train. At the camp she must choose between a week of individual instruction at $60 a day or a week of group instruction at $40 A day. Treena's food and other expenses are fixed at $45 a day. If she does not plan to spend any money other than the scholarship, what are *all* choices of travel and instruction plans she could afford to make? Explain which option you think Treena should select and why. **Source:** Smith, Stein, Arbaugh, Brown, & Mossgrove, 2004, p. 66

4. Growth Patterns: Suppose Tyler is growing a plant and wants to track how fast it grows over 15 days. The table below shows the height of the plant on the first four days.

Day	Height (in.)
0	1
1	3
2	5
3	7
4	9

Tyler wants to determine how many inches the plant will grow by day 15 but doesn't want to wait until that day or write out the pattern for all 15 days. Explain how he could do this and give the answer Tyler should get for the height.

5. Comparing Functions: Sam needs to rent a car for his upcoming trip. CheapWheels charges $20.25 per day plus $.14 a mile. Easy Rider charges $18.25 a day plus $.22 a mile. Rent-a-Car charges a flat rate of $24 a day. Sam plans to do a lot of driving on his 3-day trip. Which company should Sam go with? Explain your choice. Does the difference in cost go up or down as mileage increases? Support your answer.
Source: The Franklin Institute n.d., http://learn.fi.edu/school/math2/dec.html

Appendix C

PARTICIPANTS' TASK REVISIONS

John's Task Revision

3. **Budgeting:** Molly won a 7-day art scholarship worth $1500 to the Center for Young Artists in Glasgow, Scotland. Round trip travel expenses to the camp are $875 by air or $640 by boat. At the camp she must choose between a week of individual instruction at $60 a day or a week of group instruction for $40 a day. Molly's food and other expenses are fixed at $45 a day. If she does not plan to spend any money other than the scholarship, what are all choices of travel and instruction plans she could afford to make? Explain which option you think Molly should select and why?

Zane's Task Revision

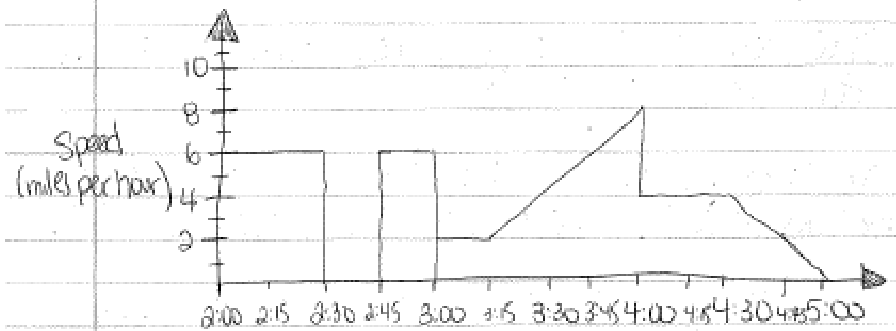
2. Revised Task for Ben: Ben is a scientist studying cheetahs. He spends his days watching their every move. One day he takes note of a cheetah's activity in a valley for THREE HOURS!!! He sets up his observation post at noon. He notices a cheetah walking very slowly around the grassland. He stops completely and looks around for a minute or two. Suddenly the cheetah sees a rabbit and bolts for it. The cheetah chases the rabbit for fifteen minutes until he finally catches him. The cheetah then jogged to his cub where he allowed him to feed off the rabbit. The cheetah then walked back to the grassland to look for a rabbit himself to eat. He laid in the grassland for a whole hour waiting to see a rabbit! Finally he saw one and got up and sprinted for in instantly. The cheetah was running so fast and the rabbit too. He lost track of the rabbit after a long chase, but still ran around the grassland looking for it. He finally saw it again and ran even faster for it. The rabbit cut one way and the cheetah was right on his tail. Finally the cheetah was able to catch the rabbit. The cheetah then spent a half hour sleeping.

Draw a graph showing the different speeds of the cheetah throughout the three hours Ben observed him.

Rick's Task Revision

2. Interpretting Graphs

At 2:00, Aaron began his daily walk with his mother. Aaron walked from his house to the park and back. Aaron got back home at 5:00. The graph below shows Aaron's speed in miles per hour throughout his walk.



Write a story about Aaron's ~~story~~ walk. In your story, describe (using clue words) what Aaron might have been doing at different times.

Janet's Task Revision

1. You are making an authentic Indian dinner with your mom tonight for your family. Your mom is making the Tandoori Chicken and chickpea curry. She left you in charge of making the rice. There are four rice recipes you know and can choose from: peanut, dill, mango and carrot. The recipes are below:

<u>PEANUT RICE</u>
1 cup of rice
2 ¼ cups of water
½ teaspoon of salt
1 teaspoon of turmeric powder
½ cup of peas
½ cup of peanuts

<u>DILL RICE</u>
1 cup of rice
½ cup of chopped dill leaves
1 green chili
1 teaspoon of oil
1 teaspoon of mustard seed
1 teaspoon of urad dul

<u>MANGO RICE</u>
1 cup of rice
1 whole mango
1 teaspoon of mustard seed
1 teaspoon of urad dul
2 green chilies
1 teaspoon of turmeric powder

<u>CARROT RICE</u>
1 cup of rice
1 cup of carrots
1 small chopped onion
2 green chilies
2 teaspoons of turmeric powder
½ teaspoon of salt

Not sure what to make, you decide to look at what ingredients you have and what you would need from the store. After raiding through your cabinets and refrigerator you realize you don't have turmeric powder, peanuts, green chilies, mustard seed or mango.

Looking through the Indian Grocery Flyer, you see all the ingredients you are missing. However, your little brother was drawing and scribbled over some of the information. Fill in the missing data below:

INGREDIENT	Turmeric Powder	Peanuts
WHOLE SALE PRICE	$5.76 for 1 cup	$18.08 for 2 quarts
SMALLEST QUANTITY PRICE	or $.12 for ______ teaspoons	or $______ for ¼ cup

Green Chilies	Mustard Seed	Mangos
$9.85 for ______ chilies	$1.08 for 2 tablespoons	$ ______ for 3 mangos
or $1.97 per chili	or $ ______ for ½ teaspoon	or $1.49 per mango

Based on your recipes and pricing of the missing ingredients, what will be the cheapest rice to make for dinner if you bought the <u>EXACT</u> amount of what you needed? How do you know? Justify your answer clearly.

Extension: Would the cheapest rice dish be different if you bought the whole sale quantities at the whole sale price? Explain your answer with words and numbers to prove your reasoning.

Appendix D

CONCEPTIONS SURVEY

This survey is about your views of teaching mathematics to **students in urban, high-needs schools**. There are no correct answers to this survey. We are interested in learning about your beliefs on these issues so please answer the questions based on your own opinions.

Demographic Information
Please answer the following survey items to the best of your ability about your demographic information and your program here at the University of Delaware.

1. Please write your first name and last initial: _______________

   This information will only be used to keep track of who responded and who did not. After you submit this survey, you will be assigned a number and your name will be removed from your responses.

2. Gender:
   a. Male
   b. Female

3. Age: ____________

4. How would you best describe yourself? Select all that apply.
   a. White
   b. African American
   c. Hispanic
   d. American Indian
   e. Asian American
   f. Other:_____________________

5. Year in your UD program:

a. Freshman
b. Sophomore
c. Junior
d. Senior
e. Graduate student
f. Other:____________________

6. In what grade level(s) would you prefer to obtain a teaching job?

7. Which courses have you taken prior to this semester? Check all that apply.
    a. MATH 217 – Algebra for Middle School Teachers
    b. MATH 240 - Geometry and Measurement for Middle School Teachers
    c. EDUC 258 - Cultural Diversity, Schooling & the Teacher
    d. EDUC 259 - Cultural Diversity in Community Contexts
    e. EDUC 335 - Elementary Curriculum: Mathematics

8. Which course(s) are you currently enrolled in?
    a. MATH 217 – Algebra for Middle School Teachers
    b. MATH 240 – Geometry and Measurement for Middle School Teachers
    c. EDUC 258 - Cultural Diversity, Schooling & the Teacher
    d. EDUC 259 - Cultural Diversity in Community Contexts

Personal and Professional Experiences
Please answer the following questions about your personal and professional experiences with diversity to the best of your ability.

1. Please identify the primary racial/ethnic composition of the neighborhood(s) in which you grew up.

2. Please identify the primary racial/ethnic composition of the high school(s) you attended.

3. What experiences do you have working with children different from you **outside of** experiences required at UD?

4. What experiences do you have working with children different from you **through** experiences required at UD?

Beliefs
Please answer all of the following questions to the best of your ability.

1. What challenges do you think you will face teaching mathematics to students with different cultural or racial backgrounds from you?

2. What challenges do you think you will face teaching mathematics to economically disadvantaged students?

3. What challenges do you think you will face teaching mathematics in an urban, high-needs school?

For each of the following statements, select the answer that best represents your beliefs:

	Strongly Disagree		Uncertain		Strongly Agree
1. It is the responsibility of the teacher to be aware of his/her students' racial and cultural backgrounds when teaching mathematics.	1	2	3	4	5
2. Students' success in mathematics depends on the support they receive at home.	1	2	3	4	5
3. A challenging and intellectually rigorous mathematics curriculum is not always appropriate for all students.	1	2	3	4	5

4. Students of color in urban, high needs schools perform worse than their suburban counterparts in mathematics because they are typically less motivated.	1	2	3	4	5
5. I do not need to take my students' cultural backgrounds into account when teaching mathematics.	1	2	3	4	5
6. Differences in mathematics achievement between different races can be completely explained by differences in family income levels.	1	2	3	4	5
7. Students in urban, high needs schools perform worse than their suburban counterparts in mathematics because they typically have more behavior issues.	1	2	3	4	5
8. Every student has the ability to learn and excel in mathematics.	1	2	3	4	5
9. A very important factor in promoting high mathematics achievement for all students is the teachers' belief that all students can learn and be successful.	1	2	3	4	5
10. A student who excels in mathematics has a natural ability.	1	2	3	4	5
11. Issues of diversity and equity do not matter in the teaching of	1	2	3	4	5

mathematics.					
12. Students who attend urban, high-needs schools typically struggle more with mathematics than students who attend suburban or rural schools.	1	2	3	4	5
13. It is necessary to incorporate the diverse cultures of students into mathematics curriculum.	1	2	3	4	5
14. Multicultural training for teachers in mathematics instruction is unnecessary.	1	2	3	4	5
15. Students from poor and low income families struggle more than higher income students.	1	2	3	4	5
16. Grouping urban students of color by ability level is necessary in mathematics instruction for student learning.	1	2	3	4	5
17. Students in urban, high needs schools perform worse than their suburban counterparts in mathematics because of less effective teachers in those schools.	1	2	3	4	5
18. Students in urban, high needs schools perform worse than their suburban counterparts in mathematics because they typically have low levels of parental support.	1	2	3	4	5

19. Traditional mathematics instruction, or direct instruction, (e.g. students working independently on tasks posed by the teacher) is more appropriate for students in urban, high-needs schools.	1	2	3	4	5
20. A good mathematics classroom in an urban, high-needs school is one in which the students are well-behaved and working quietly and efficiently.	1	2	3	4	5
21. Students of color in urban, high-needs schools should be taught using challenging and intellectually rigorous mathematics curriculum.	1	2	3	4	5
22. Students do not have to be proficient in English to learn high-level mathematics in an English language classroom.	1	2	3	4	5
23. Grouping students by mathematics ability is an effective way to teach mathematics.	1	2	3	4	5
24. Students who lack basic mathematics skills need to master these before they can do higher level mathematics.	1	2	3	4	5
25. Students from poor and low income families are less likely to have the capacity to learn challenging mathematics material.	1	2	3	4	5

26. I will treat all of my students the same, regardless of race or ethnicity.	1	2	3	4	5

Intentions to Teach

For each of the following statements, select the answer that best represents your beliefs:

	Strongly Disagree		Uncertain		Strongly Agree
1. I intend to obtain a job in a school with a majority of students of color upon my graduation.	1	2	3	4	5
2. I would take a job in a school with a majority of students of color only if no other jobs were offered to me.	1	2	3	4	5
3. At this time, I would feel uncomfortable teaching in a school with a majority of students of color.	1	2	3	4	5

1. Why (or why not) would you choose to teach in a school with a majority of students of color?

	Strongly Disagree		Uncertain		Strongly Agree
1. I intend to obtain a job in an urban, high-needs school.	1	2	3	4	5
2. I would take a job in an urban, high-needs school only if no other jobs were offered to me.	1	2	3	4	5
3. At this time, I would feel uncomfortable teaching in an urban, high-needs school.	1	2	3	4	5

1. Why (or why not) would you choose to teach in an urban, high-needs school?

Please answer the following questions.

1. How would you define mathematics?
   a. What sets mathematics apart from other subjects?

2. Describe a successful mathematics student.
   a. What knowledge, skills, and abilities do they have?
   b. What makes a student successful in mathematics?

3. Describe a successful mathematics teacher.
   c. What qualities do they have?
   d. What knowledge, skills, and abilities do they have?

4. Describe your most recent field placement in a mathematics classroom.
   a. What were the students like?
   b. What was the teacher like? Describe some practices you observed him/her using on a regular basis.
   c. What surprised you about the students, teacher, classroom environment, etc.? Why do you think that was surprising?
   d. What did you find interesting about the way the class is run, how the teacher teaches, how the students behave and interact with each other and the teacher, etc.?

Appendix E

PRE-POST INTERVIEW PROTOCOL

Introduction

Thank you for coming to this interview and participating. My name is __________ and I am math education graduate student who is conducting this interview on behalf of your instructor, Heather Gallivan for her dissertation study about pre-service teachers' performance teaching mathematics to students in urban, high-needs schools. I want to let you know that Heather will not have access to this recording or any transcripts nor will she know about anything that you say in this interview until after the semester is over and she has submitted your final grades. The things that you say during this interview will not impact your grades or your standing in the methods course in any way.

During this interview I will first be asking you some questions about your experiences as a student of mathematics as well as some questions about your beliefs about mathematics as a subject. Then I will read you some teaching scenarios that I would like you to respond to them as if you were a teacher. I have each scenario printed on an index card for you to reference as you talk about it. I want to remind you that your participation is voluntary and so you can choose to stop this interview at any time or choose not to answer any questions or respond to any scenario that you want.

[Post-interview only: At the end of the teaching scenarios, I will ask you to look over your Task Revision Project. Specifically, after you have had a chance to look through the comments I gave you, I want to give you an opportunity to respond to those comments.]

I am going to start recording now if that is ok with you.

Do you have any questions before we get started?

Interview Questions

1. Tell me about your experiences in math classes when you were in middle school.
    a. What were your favorite mathematics topics? Why?
        i. Did you find that your favorite topics were easy or challenging for you? Why?

b. What mathematics topics did you find relatively easy to understand? Why were they easy for you? What made them easy in general?
    i. What did your teacher(s) do to ensure that they were easy for you?

c. What did you struggle with in mathematics in middle school? Why do you think you struggled?
    i. How did you get help? Who helped you, if anyone? What did they do that was helpful?
    ii. What could your teacher have done to help you understand better?

2. What kind of mathematics student do you consider yourself?
    a. Can you compare yourself to other types of math students?
        i. [Examples if needed: A student who does not (or does) like math. A student who is good at applying procedures/memorization. A student who is a good problem solver. A student who does (or does not) like real-world problem situations. A student who does (or does not) like to work in groups.]
        ii. How are you different from them? Similar to them?
    b. Has the type of mathematics student you are changed throughout your life? In what ways? In what ways has your ability to do mathematics changed?

Interviewer: Ok next, I am going to provide you with some teaching scenarios that I would like you to comment on. I will read the scenario out loud to you as you read along on the index card. I will then ask you some questions related to this scenario about what you would do as the teacher.

[**Note to the interviewer:** The purpose of these scenarios is to get at the preservice teachers' beliefs about teaching mathematics to minority students in urban, high-needs schools. Therefore, not only should you get them to talk about how they would respond to the scenario, you should try and get at why they chose to react that way. For example, for the question about an ideal class to test curriculum materials in, saying that they would use a high-level/ability class says something, but I want to know why they would choose such a class. There are guiding/probing questions to help with this, but keep it in mind throughout.]

Scenario	Probing Questions
Imagine there are two different middle schools with very similar populations of students: Lafayette Middle School and Lancaster Middle School. Specifically, the student population at both schools is very diverse with approximately equal distributions of White, African American, Hispanic, and Asian American students. However, Lafayette Middle School is in a middle-class suburban area whereas Lancaster Middle School is in a large, low income urban area where 50% of its students participate in the free and reduced-price lunch program. Both schools offer an advanced algebra course for their eighth grade students. The students who take this course are the students who have performed well in mathematics classes in the past and on standardized tests. At one school, the population of students in this course matches the population of students at the school in that there is a relatively even mix of White, African American, Hispanic, and Asian American students in the course. At the other school, however, the students in the advanced algebra course do not match the population of students at the school in that the students are mostly White.	**Which of the two schools do you think has the students that match the population of the school in the math class?** Why do you think that? Why do you think one school has a course where the students match the population of the school whereas the other one didn't? **Why do you think the discrepancy between the two classes exists? What reasons can you give for this difference?** Why do you feel that way? **Why do you think the discrepancy exists within the class at the school where the students were mostly White?** Why do you feel this way? Tell me about a time (in your life, during a course or field experience, etc.) that has influenced your thinking about the differences between the two courses. [They could respond that the difference may be due to chance (i.e., it's a coincidence that this happened). If this happens, ask them to assume that this

	is not a random occurrence and that the other middle schools in each of these areas are experiencing similar differences.]
You have a student named Alicia in your classroom. She lives in a low income, urban neighborhood, participates in the free and reduced-price lunch program, and has parents who both work full time. Alicia consistently struggles in your math class. Alicia often turns in incomplete homework or fails to turn it in and does poorly on tests and quizzes. During class, Alicia seems uninterested and often asks: "When am I going to need this?" She also talks to her friends a lot and distracts them from paying attention.	**Why do you think Alicia is acting out in class?** Why do you feel these factors are contributing to Alicia's actions? What can you do as the teacher to find out? **What can you do as her teacher to help her be more successful in mathematics?** Are there specific teaching strategies you would use? Why would you use them? Tell me about some other things you might do. Why?
You decide to talk to Alicia's mathematics teacher from last year. This teacher said: "Alicia acted that way all year. She consistently performed poorly on her assignments and rarely turned in complete homework. However, she is not a very strong math student and so I suspect much of her behavior has to do with her math ability."	**What is your reaction to what this teacher said?** **What does this information tell you about Alicia's mathematics ability?** **What does this tell you about her math ability now and in the future?** **What does this information tell you about what to do as Alicia's current math teacher?**

	What are the most important things you should address as her teacher? Are there specific teaching strategies or practices you would use in the classroom to help Alicia? Why would you do those things? Aside from addressing these things you feel are most important, is there anything else you would do? Why?
After that conversation with Alicia's previous math teacher, you decide to talk to some of Alicia's other teachers about her behavior and performance. Alicia's current English teacher tells you that Alicia does very well in class. Alicia loved the unit on fairy tales, especially when the teacher incorporated fairy tales that related to the African American culture. Alicia works well with her peers and is often found helping them with reading as well as comprehension. The teacher also pointed out that Alicia spends much of her time at the local church community center. While there, she participates in a number of different activities including getting homework help, playing games with other children, and helping tend to the community garden. For example, Alicia and some of her friends helped the adults figure out how much of each vegetable they needed to plant based on the needs of the church and community. She also helped them determine how much plastic they needed to cover the garden when they saw that frost was coming that could damage the plants. Alicia also really loves music and especially likes to dance. She spends time with her friends creating music and dance moves that go along with it. They focus on different beats and come up	**How does this information help you when teaching Alicia mathematics?** What of this information do you think is important for you to know? Why? **Describe an example of how you would use at least one of these pieces of information in your teaching.** What made you choose that particular piece of information?

with many different patterns with the music and with their dance moves. When creating dance moves, they not only need to be aware of what looks good, but how to place their legs, arms, etc. so that they can balance properly. Alicia also likes to go grocery shopping with her mother. She often helps her mother figure out how much they should buy of each item on the shopping list for her family while staying within their budget for food.	
Sofia joined your school this year as an English language learner in your seventh grade mathematics class in an urban, high-needs school. Before entering the school, Sofia spoke almost no English. Her previous schooling was in Spanish and her reports indicate that she was an above average student. The transfer to this school has been difficult for Sofia. She left a close circle of friends in Mexico and for the first few weeks appeared insecure and reserved. At the present time, Sofia's English is insufficient for her to deal with the more complex vocabulary required in math class.	**Describe what you would do as the teacher in this situation.** How can you use the information given about Sofia to help her in mathematics class?
Ms. Haverford is a mathematics teacher at Aurora Middle School. This school is located in a low income urban area. The majority of the students in the school receive free and reduced-price lunch. The school consists of a majority of African American students (about 52%), about 15% White students, 20% Hispanic (many of whom are English language learners or bilingual), 9% Asian American, and 4% Native American. Ms. Haverford's class is representative of this population of students. On a typical day in her classroom, Ms. Haverford goes over the homework from the night before by asking students for the answer to each problem and going over any problems that they had trouble with, making sure each student understands. Then	**Describe the reaction you have to the teaching practices of Ms. Rossi.** **Under what circumstances do you feel this is a good way to teach?** **Under what circumstances would you suggest doing something different?** Would your suggestions change if this wasn't a mathematics class? Would your suggestions

Ms. Haverford introduces a new mathematics topic, models how to do it for the class, and goes through another example with the whole class allowing the students to describe each step in the process for the class. Then, Ms. Haverford gives the students more problems to work on. Some days she lets the students do this in groups or with a partner. However, she sometimes limits the number of times she does this because she says: “There are some students who have behavior issues regularly and so I need to make sure all students are able to stay on task to complete the assignment.” Finally, Ms. Haverford goes over the answers and assigns students homework. Before the students leave her room, they fill out an exit ticket. This exit ticket could be another problem or a written prompt asking them to describe what they learned or what they struggled with that day.	change based on the achievement level of the students in the class? Would your suggestions change based on the English proficiency level of the students?
You are teaching seventh grade at Easton Central School; a K-8 school in a large city. A month before the school year starts, you are asked to test a new seventh grade mathematics curriculum that centers on students grappling with challenging, high-level mathematics tasks. You have your choice of two classrooms with which you can test this curriculum. In the first classroom, 51% of the students are females, 5% are from single-parent families, and 3% participate in the free or reduced-priced lunch program. In addition, the student population is fairly homogenous in that most of the students (90%) are White and 10% are African American. The students in this classroom all perform above-average on the state assessments and are all expected to be placed in an advanced algebra class in eighth grade. Also, a few (2%) of students have individualized education plans. In another class, 48% of the students are females, 20% are from single-parent families, and 23%	**Which classroom would you choose to test this curriculum in and why?** Which characteristics of this class are desirable to you? **If you could teach the curriculum in any way you wanted, what would you do?** **[Ask if they choose the first classroom:]** **Now assume you have to teach this curriculum in the second classroom.** **Would you do anything different than you would for the first classroom?**

participate in the free or reduced-price lunch program. In addition, the student population is very diverse with 37% White, 25% African American, 23% Hispanic, and 15% Asian American. Also, approximately 8% of students have limited proficiency in English. Finally, the majority of the student body performs well on state assessments, but 10% of students have individualized education plans and 15% participate in federally funded programs designed to assist students who are at risk of failing to meet the state standards.	What would you do and why? What about this classroom made you do something different?
You are looking for a new job as a middle school mathematics teacher. You are applying at Clarence Middle School in a middle class suburban neighborhood. The students at the school are majority Hispanic (42%) and African American (43%) with the rest being split among White, Asian American, and Native American. Very few students receive free and reduced-price lunch (about 8%). The students at the school are performing slightly above average on state and national assessments in mathematics.	**What challenges, if any, do you think you will face teaching mathematics at this school?** Why might these be particularly challenging for you?
Mr. Smith is a sixth grade mathematics teacher. The students in his classroom come from very different cultural backgrounds. Mr. Smith tells you that he was told at a professional development that teachers should adapt his instructional practices to the distinctive cultures of African American, Latino, Asian and Native American students. He said "I think it could be good to do this every once in awhile to get the interest of the students, but I don't think it is necessary, especially when I have to cover so much material for the exam."	**Describe how you would react to what this teacher said.** Do you agree or disagree? Why?
Imagine you are a seventh grade mathematics teacher at a professional development on multicultural education. One of your colleagues turns to you and says: "I don't see why I have to worry about student's culture in my teaching because mathematics is a universal subject. It's the same everywhere!"	**What is your reaction to your colleague's comment?** Do you agree or disagree? How would you respond to that teacher and why?
You have recently graduated and are currently	**Which job would you want**

looking for a teaching job in a particular city. You have applied to a large number of schools in both suburban and urban areas and have been on multiple interviews at some of these schools. You got offered a job at Orchard Park Middle School in a suburban neighborhood and at Grover Cleveland Middle School in an urban neighborhood. The population of students at both of these schools is relatively evenly distributed among White, African American, and Hispanic students. The students at both schools perform slightly above average on state and national standardized tests.	**to take? Why?** How strongly do you feel about teaching at one school versus the other? What about the school environments made you choose that school? Tell me why or why not you would take a job in an urban school.
You have just been told that Grover Cleveland Middle School is in a high-needs area where a large number of students (61%) participate in the free and reduced-price lunch program. Also, the job at Orchard Park is no longer available due to budget cuts so the only job offer you have now is at Grover Cleveland Middle School.	**Would you want to take this job? Why or why not?**

That was the last scenario. Thank you for your responses. Is there anything else you would like to say about any of the scenarios we talked about today?

Ok. I have one last question for you.

1. What do you think are the most important things that you can do as a mathematics teacher to ensure students who are different from you in terms of race, culture, or socioeconomic status are successful?
    a. Are there specific teaching practices you would use? Why?

[**Post-interview only:** The last part of the interview is to revisit your Task Revision Project. Hopefully you have had a chance to read over the comments that were given to you when the project was graded.

Do you have any questions about any of the comments you received?

After reading the comments, is there anything you would like to change about the task that you wrote? Why or why not?

The interviewer should point to different comments and have the student address them. Ask probing questions as needed.]

Appendix F

CONCEPTIONS ANALYTICAL FRAMEWORK

Category	Code
1. Deficit/Stereotypical Conceptions	1. Stereotypes based on race 2. Stereotypes based on income 3. Stereotypes based on students in urban schools 4. Getting to know students isn't necessary 5. No need to incorporate students' backgrounds into instruction 6. Students/parents not valuing education 7. Deficit beliefs – lower ability, lower motivation, behavior problems 8. Challenging curriculum inappropriate for some students 9. Fixed mind-set: math ability is ingrained/natural **10. Holding different expectations for all students (achievement)** **11. Favoring direct instruction for some (or all) students** **12. Basic skills first**
2. Color- or Culture-Blind Conceptions	1. Getting to know students' culture or race not important 2. Equality over equity (treat everyone the same rather than equitable) 3. Same "good" pedagogy works for all students 4. Math is culturally neutral/math is universal 5. Students are students: students' race, culture, etc. do not play a role in instruction
3. Missionary Conceptions	1. Need to "save" students from culture/home lives 2. Making an impact in an urban area that needs it **3. Being a role model for urban students**

4. Productive Conceptions	1. Culture plays a role in math teaching and learning 2. Getting to know the whole student 3. Need to incorporate students' backgrounds into instruction i. Need to incorporate students' interests into instruction ii. Need to incorporate students' competencies into instruction iii. Need to incorporate students' culture, home, community practices into instruction ~~4. Challenging curriculum appropriate for all students~~ 5. Growth mind-set: all students can learn 6. Students' cultural and community experiences influence how students learn and their prior knowledge 7. Good teaching practices are appropriate for all students **8. High expectations for all students** **9. Need to engage and motivate students** **10. Providing a safe classroom environment** **11. Make connections to real-world contexts** **12. Do not generalize/make assumptions based on demographic information** **13. Teacher is (partially) responsible for student learning** **14. Many factors contribute to student achievement**

Appendix G

SHADOW A STUDENT ANALYTICAL FRAMEWORK

Things Learned about the Student	
Category	**Code**
1. Demographic information	1. Race 2. Socioeconomic status 3. Gender 4. Age
2. Interests	1. School/subject topics 2. Hobbies/sports
3. Culture	1. Visible culture 2. Invisible culture
4. Home/community practices	1. People in family 2. Who they spend time with 3. Family activities 4. Friend activities 5. Neighborhood/community activities **6. After school programs** **7. Shopping habits** **8. Parent/family member jobs** **9. Pets**
5. Behavior/personality at school	1. Personality traits – shy, outgoing, etc. 2. Classroom behavior 3. Academic performance 4. How they interact with peers
6. Mathematics that occurs in these places	1. Interests 2. Home practices 3. Community/neighborhood practices 4. Cultural practices

No Detail	Some Detail	Specific Detail
Description of student includes *some superficial information and no details* about the student's competencies across settings and/or student's interests, culture, and home/community experiences. Little or no discussion of mathematical practices within categories. *Examples of student's competencies are limited* **and** *vague.*	Description of student includes *some superficial information* and *some details* about the students' competence, interests, culture, home/community experiences, etc. Description includes few examples of mathematical practices across and within categories. *Examples of student's competencies are limited* **or** *vague.*	Description of student describes the students' competence across settings and goes into *specific detail* about the students' interests, culture, home/community experiences, etc. Description provides *specific examples* that demonstrate the students' competencies. Examples could be things the *student said or did. This description goes beyond superficial information* such as demographic information. Also, a number of examples of the mathematical practices across and within categories are described.

Application in Mathematics Instruction	
Category	Code
1. Draws upon student information	1. Interest 2. Culture 3. Home/community life 4. Personality trait 5. School/mathematics behavior/learning
2. Math in context	1. Surface level 2. Draws unrealistically on math in context 3. Draws on math in context 4. Does not draw on math in context
3. Math student does	1. Unknown/not discussed 2. Math related but not what student does 3. Math student actually does
4. General teaching strategies	**1. Group work** **2. Individual work** **3. Manipulatives/multiple representations** 4. **Whole class discussions**

Appendix H

PROBLEM-SOLVING INTERVIEW ANALYTICAL FRAMEWORK

Category	Code
1. Claims	1. Understanding 2. Strategies used 3. Persistence ~~4. Student questions~~ 5. Misunderstanding/struggle **6. Confidence** **7. Explaining student thinking**
2. Instructional Approaches	1. Mathematical task examples 2. Use pictures/manipulatives 3. Direct instruction 4. Scaffolding **5. Building positive dispositions** **6. Group work** **7. Support conceptual understanding**
3. Rationale	1. Builds on competency 2. Address weakness

Appendix I

TASK REVISION PROJECT ANALYTICAL FRAMEWORK

Category	Code
1. Launch	1. Maintain cognitive demand 2. Introduce problem context 3. Key mathematical ideas 4. Develop common language
2. Implementation	1. Group work 2. Whole-class discussions 3. Manipulatives **4. Facilitating questions**
3. Rationale	1. Learned about student 2. Math teaching and learning

Appendix J

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

UNIVERSITY OF DELAWARE

RESEARCH OFFICE

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DATE:	August 14, 2013
TO:	Heather Gallivan
FROM:	University of Delaware IRB
STUDY TITLE:	[497397-1] Preservice Teachers' Beliefs about and Performance Teaching Mathematics to Students in Urban, High-Needs Schools
IRB REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	August 14, 2013
EXPIRATION DATE:	August 13, 2014
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # 7

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.