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Mathematics Teachers' Use of the Culturally Relevant Cognitively Demanding Mathematics Task Framework and Rubric in the Classroom

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Because of the increasing diversity in many classrooms as well as the need to make mathematics relevant for all students, it is important for teachers to implement culturally relevant pedagogy, but also challenge students by maintaining the cognitive demand of mathematics tasks. The purpose of this study is to learn best practices for designing and implementing culturally relevant cognitively demanding (CRCD) mathematics tasks and using the CRCD Mathematics Task Rubric (Matthew, L., Jones, S., & Parker, Y.A., 2013) to examine teacher-created tasks. Teachers who chose to participate in the study took a first step in becoming culturally relevant educators.

Purpose

Because of the increasing diversity in many classrooms as well as the need to make mathematics relevant for all students regardless of cultural background or background characteristics (Berry and McClain, 2009; Gay, 2000; Guitierrez,2013; Ladson-Billings, 1995, 2009; Malloy and Malloy, 1998), it is important for teachers to be familiar with and implement culturally relevant pedagogy, but also to continue to challenge students by maintaining the cognitive demand of a high level mathematics task. In the 2014 Position Statement, *Access and Equity in Mathematics Education*, the National Council of Teachers of Mathematics (NCTM) states that creating, supporting, and sustaining a culture of access and equity require being responsive to students' backgrounds, experiences, cultural perspectives, traditions, and knowledge when designing and implementing a mathematics program (NCTM, 2014). The *Professional Standards for Teaching Mathematics* (NCTM, 1991) speaks about mathematics tasks as

being the basis of opportunity for students to learn. Therefore, to ensure that students have the opportunity to engage in high-level thinking, teachers must regularly select and implement tasks that promote reasoning and problem solving (NCTM, 2014).

Over the last 20 years many education researchers have called for more cultural approaches to pedagogy and several mathematics educators (Enyedy & Mukhopadhyay, 2007; Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Ladson-Billings, 2009, 1997, 1995; Leonard, 2008; Leonard & Guha, 2002; Matthews, 2003; Tate, 1995) have explicated critical features necessary for implementing culturally relevant pedagogical practices in mathematics.

Some researchers (Ellis and Berry, 2005; Gay, 2000) have found that students of color are often subjected to instructional strategies that emphasize authoritative, didactic, and/or whole group instruction, which may not be conducive to their learning styles and are not consistent with the Mathematics Teaching Practices described by the NCTM 2014) in the *Principles to Actions*. The intention of this paper is to present and analyze the kinds of tasks that overcome these kinds of difficulties by [using] a guiding framework for building mathematics tasks that are both cognitively demanding and culturally relevant and then using a rubric to rate the level of cultural relevance that occurs in the tasks. "This work very intentionally delves into the world of practice for teachers" (Matthews, Jones and Parker, 2013, p. 125).

Theoretical Framework

The current study advances the work described in the book, *The brilliance of Black children in mathematics: Beyond the numbers and toward a new discourse* (Matthews, Jones, & Parker, 2013). In this work the authors designed a framework for

creating culturally relevant cognitively demanding (CRCD) mathematics tasks and a rubric for assessing the level of cultural relevance in a cognitively demanding mathematics task.

The basis of the CRCD Mathematics Task Framework (see Appendix A) is drawn from two perspectives: (a) a definition of higher level, cognitively demanding mathematics tasks given by Stein, Smith, Henningsen, and Silver (2009), and (b) features of mathematics tasks extracted from the existing literature on culturally relevant teaching (Ladson-Billings, 2009, 1997, 1995; Leonard and Guha, 2002; Matthews, 2003; Tate, 1995).

Cognitively Demanding Mathematics Tasks

Stein, Smith, Henningsen, and Silver (2009) distinguish between lower-level and higher-level mathematics tasks based on the cognitive demand placed on students. Lower-level tasks are classified as *memorization* and *procedures without connections to understanding, meaning or concepts*. Both represent limited opportunities for students to understand important concepts.

A feature of both *memorization* and *procedures-without-connections* (Stein et al., 2009) tasks is that explicit connections are not made to students and their communities. These tasks limit the opportunity for students to make connections with familiar contexts, and even work to affirm the notion of mathematics as a disconnected, static domain of knowledge (Matthews, Jones and Parker, 2013).

At the other end of the spectrum, Stein et al. (2009) classified two types of higher level cognitively demanding tasks: *procedures with connections to understanding, meaning and concepts*, and *doing mathematics*. Tasks classified as *procedures with*

connections require students to use procedures (or algorithms) in ways that build conceptual understanding of important mathematical ideas (Matthews, Jones and Parker, 2013).The second category of higher level tasks, *doing mathematics*, is often nonalgorithmic, unpredictable, and requires multiple ways of representing concepts. Open-ended word problems which might involve a series of steps and representations including symbolism, graphs, and verbal explanations often fall into this category. Stein et al. (2009) further suggest that an essential feature of higher level mathematics tasks is that they require students to draw from "relevant knowledge and experiences and make appropriate use of them in working through the task" (p. 6). "It must also be understood that these experiences [of students] are undoubtedly cultural in nature" (Matthews et al., 2013, p. 128).

Culturally Relevant Pedagogy

Ladson-Billings (2009) espouses that "culturally relevant teaching is a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (p. 20). Schools often do not meet the needs of culturally different students because they do not provide a social context for learning that allows the students to access knowledge in ways that are comfortable and familiar to them.

Another element of culturally relevant pedagogy, indicated by Gutstein et al. (1997), suggests that "teachers must possess empowered, non-deficit views of their students". An implication of this type of orientation might be supported by a mathematics task that allows students to ask questions of self and others – tasks that

focus on the classroom community or the community at large (Matthews, Jones, & Parker, 2013).

Culturally Relevant Cognitively Demanding Mathematics Tasks

Building from the perspectives on the culturally relevant teaching of mathematics Matthews et al. (2013) extended the Stein et al. (2009) Mathematics Task Framework to include relationships, culture and social change as the literature suggests. Matthews et al. extended the descriptions of the two higher level cognitive demand categories: (a) *procedures with connections to concepts, meaning and understanding of mathematics, culture and community*, and (b) *doing mathematics* for the purpose of becoming empowered intellectually, culturally, politically and socially. These two reworked classifications would require teachers of mathematics to rethink the extent to which selected mathematics tasks challenge culturally diverse students to ask relevant questions of themselves and the world around them.

The CRCD Mathematics Task Framework will serve as a tool to guide teachers in the selection of mathematics tasks that, coupled with the social and learning conditions in which the tasks are experienced, will provide cognitively demanding mathematics for culturally diverse students.

Creating Culturally Relevant Cognitively Demanding Mathematics Tasks

In Matthews et al. (2013), 11 graduate students used the CRCD Mathematics Task Framework to construct culturally relevant tasks for middle grades students in the areas of algebra, data analysis, and geometry. The teachers were instructed to select five cognitively demanding tasks and modify them to be more culturally relevant. The

framework gave teachers the opportunity to consider the complexities of creating CRCD mathematics tasks.

Matthews et al. (2013) shared 10 of the 55 CRCD mathematics tasks (see Appendix B) created by this first cohort of teachers who used the CRCD Mathematics Task Framework. This first cohort of teachers served as a starting point for other teachers who wish to investigate the use of the CRCD Mathematics Task Framework for creating a more culturally relevant classroom.

Task creation is by far only the beginning. In Ladson-Billings' seminal work with successful teachers of African American students, she was very deliberate in her focus on teaching practice and not curriculum. She states, "It is the way we teach that profoundly affects the way that students perceive the content of that curriculum" (2009, p. 15). Therefore, culturally relevant pedagogy necessitates that teachers learn about students, their culture, and their backgrounds (Johnson, 2009; Ladson-Billings, 1997; Nieto, 2010). Teachers must be the driving force to creating a culturally relevant classroom (Ladson-Billings, 2009). Similarly, Matthews et al. (2013) has found that the contexts of the tasks alone will not necessarily make for a culturally relevant environment. It is the thinking behind the tasks and the actions during implementation that make them culturally relevant. Without the appropriate set up of the task and the accompanying discussion and connection to the students and/or their communities, the task although created as culturally relevant will lose its relevance. Thinking in this manner will undoubtedly challenge the reliance that practitioners have on the use of textbook contexts to frame the cognitive experiences of children.

Matthews et al. (2013) describes CRCD mathematics tasks as the following:

Culturally relevant, cognitively demanding mathematics tasks are mathematically rich, higher-level cognitively demanding and embedded in cultural activity, personal and social change. The context of the task draws from students' community and cultural knowledge. But, the use of context goes beyond content modification and explicitly requires students to inquire (at times problematically) about themselves, their communities, and the world about them. In doing so, the task features an empowerment (versus deficit or color-blind orientation) toward students' culture, drawing on connections to other subjects and issues. CRCD tasks ask students to engage in and overcome the discontinuity and divide between school, their own lives, community and society, explicitly through mathematical activity. The tasks are real-world focused, requiring students to make sense of the world, and explicitly to critique society—that is, make empowered decisions about themselves, communities and world. (p. 132)

To become more adept at culturally relevant approaches to teaching, teachers, themselves will have to become more knowledgeable and build relationships with students and communities. "Culturally relevant teaching opens the classroom discourse to different ways of knowing and talking about mathematics" (Leonard & Guha, 2002, p. 118).

Matthews et al. (2013) reported on CRCD mathematics tasks created by the first cohort of teachers. The authors shared the teachers' rationales and themes for the types of problems created. The remainder of this paper provides a description of the current study in which teachers used the CRCD Mathematics Task Rubric (see Appendix C) to determine the level of cultural relevance in the teacher-created CRCD mathematics tasks.

In addition, teachers' use of the rubric and their reflections will be reported. Teacher reflections about student engagement with the CRCD mathematics tasks will be reported in the future.

Methods

Ten graduate students from a mid-size university in the Northeast region of the United States completed a *Reflective Practices in Mathematics Education* course and were invited to participate in this exploratory study about creating, assessing, and implementing CRCD mathematics tasks. These students, who are also practicing teachers, were already familiar with the framework and rubric as they had assignments in the course where they explored the framework to create CRCD mathematics tasks and they used the rubric to determine the level of cultural relevance of cognitively demanding tasks. This study will provide teachers already familiar with the CRCD Mathematics Task Framework and Rubric the opportunity to use these tools in practice.

Of the 10 secondary teachers who completed the course, five of them agreed to participate in the study and completed consent forms (see Appendix D). These five teachers completed the following activities as part of the course:

A. Read three articles on culturally relevant teaching then evaluated up to ten mathematics tasks and described the level of cognitive demand and the level of cultural relevance. Participated in a class discussion of the findings. All ten teachers completed Part A.
B. Completed a final project (see Appendix E) on culturally relevant teaching where they created or modified a CRCD mathematics task and then implemented it with their students, provided a brief description of the mathematics required to solve

the task, classified the cognitive demand of the task, evaluated the level of cultural relevance, critiqued the CRCD Mathematics Task Rubric, and wrote a two-page reflection about culturally relevant teaching.

C. In the upcoming fall the university professor and classroom teachers will collaborate to plan and implement CRCD mathematics tasks in grades 7-12 mathematics classrooms.

D. Teachers will provide a reflection about students' engagement with the tasks.

Once the teachers accepted the invitation to participate in the study, they were told that their assignment responses would be cut-and-pasted into a master document to be analyzed. The professor/researcher would search for themes and patterns in the data using a grounded theory approach (Strauss & Corbin, 1990). Grounded theory is a qualitative approach that allowed the researcher to focus on how the theory about culturally relevant teaching is grounded in the data collected from these teachers.

It was explained that the identity of data sources would not be a focus with this study; therefore, once their responses were cut-and-pasted into the master analysis document, the copies of their responses with names would be shredded. Only final project data from students (n=5) who completed and returned an informed consent form was used. All group discussion data was used because individual students were never identified in the overhead transparency sheets used to report on group consensus decisions made about the cognitive level and cultural relevance of selected tasks.

Teachers were informed that their participation in the study would answer the following anticipated questions: (1) What are the characteristics of mathematics tasks that secondary teachers create when the goal is to create a CRCD mathematics task, (2) How

does the CRCD Mathematics Task Framework and Rubric assist teachers in creating and assessing CRCD mathematics tasks, and (3) What are teachers perceptions of how students engage with CRCD mathematics tasks. The goal of the study is to connect research to practice about the creation and implementation of culturally relevant cognitively demanding mathematics tasks.

Data Analysis

Using a grounded theory approach, the researcher seeks to derive theory about teachers' use of the CRCD Mathematics Task Framework and Rubric. The researcher will use multiple steps of data collection and interpretation to link participant actions (Gay, Mills, & Airasian, 2006) and reflections to the literature on culturally relevant pedagogy. In the first round of data collection, the researcher used a variety of data sources including teachers' final project, group discussion notes, and teachers' completed CRCD Mathematics Task Rubrics with reflections about each of ten tasks critiqued. The researcher read through the data sources several times, taking notes each time. During the first read, the researcher noticed themes that teachers reflected on and discussed. This first reading allowed for the first step in the grounded theory process which is open coding.

Five themes initially emerged from the teachers' reflection data: 1) changes to be made to the mathematics, 2) changes to the wording of the task, 3) the mathematics required to engage with the task, 4) clarification of the task, and 5) discussion of or stating the real world context or community issue involved in the task. In a second reading, the researcher coded teacher statements according to the five themes. A statement was considered a complete idea until the subject changed. The researcher

grouped statements according to themes and found that teachers responded to two themes (themes #3 & #5) in the majority of their statements.

In addition, the researcher found several subthemes including student interest and cognitive demand of tasks. The cognitive demand subtheme was important because by the time the teachers use the rubric, the tasks are supposed to already be considered high level mathematics tasks.

Finally, the researcher read through the statements using a constant comparative method (Corbin & Strauss, 1990; Strauss & Corbin, 1990) to reveal connections, overlaps and any other ideas that might be revealed. This initial coding and data analysis provide the researcher with categories (reported here as themes) that will inform the next iteration of data collection and analysis. The second phase of data collection will include field-notes from classroom observations and teachers' reflections about their implementation of CRCD mathematics tasks. The process of reading, coding, and comparing this new data will help the researcher develop each theme (or category) "in terms of its properties and dimensions" (Corbin & Strauss, 1990).

The small number of participants did not allow for writing theory in this phase of the research; however, it does add to the growing literature on culturally relevant pedagogy and the use of the CRCD Mathematics Task Framework and Rubric of which task creation and implementation play a critical role. In the next phase of data collection and analysis, the researcher seeks to generate a substantive theory explaining the characteristics, thoughts and actions of teachers who choose to teach using CRCD mathematics tasks. In addition, the researcher hopes to learn how they choose or create

CRCD mathematics tasks and what the implementation looks like during classroom instruction.

Results

Level of Cultural Relevance of Selected Mathematics Tasks

Using the CRCD Mathematics Task Rubric, teachers found that five of the ten mathematics tasks were moderately to highly culturally relevant. They found *Weighty Issues*, *So You Think You Can Draw*, *Driving Decisions*, *Buying Beads for Christmas Stockings*, and *How Much Does a Locust Eat* to be the most culturally relevant of the ten tasks they were asked to critique. Table 1 shows the means for each task. Means were found by averaging the Likert-type ratings for each description of culturally relevant criteria. I used numbers to denote each level/degree of cultural relevance: high (3), moderate (2), and low (1) and calculated means for the teachers that completed this assignment.

Table 1.
Teacher's Rubric Rating (Means) of CRCD Tasks

Task	Mean (n=4 to 8)	Teacher Comments
Weighty	2.47	Discussed mostly in teacher's comments about connections to the real world, society and the local community (Theme 5). Teachers felt that this problem would allow students to explore factors that lead to child obesity including social and economic factors. This problem is also open for social discussion and requires students to make conclusions about society and students may bring in their own cultures related to this issue.
Drawing	2.27	This task had the most comments in Theme #3 where teachers discussed the mathematics connected to the problem. Most teachers were able to agree that this problem had cultural relevance to inner city students; however, one teacher didn't see the cultural relevance without the added commentary to understand the culture of tagging/graffiti. All teachers agreed the use of the coordinate plane is highly mathematical and the connection to art could add to the social critique of the task.
Driving	2.25	Teachers all agreed that this task connected nicely with students in high school because of student interest. To make the task more culturally relevant, it could be extended to include discussions about being socially conscious about the environmental impact of hybrid cars and how cars are manufactured in other countries. Making a connection to our economy would extend this problem as well as having a discussion about families that own and don't own cars.
Locust	2.18	The Locust task was connected more to students directly than to the society at large because it involves students having to do research about their own school. This task can be extended to a conversation about food consumption in the United States and in their own school cafeteria. One teacher thought it was a great problem because middle schoolers like bugs (student interest emerged as another theme).
Beads	2.01	Teachers saw the Beads task as one that has nice connections to issues in society such as charitable organizations with tax exempt status, child foster care, doing good deeds and Sunday school Catholic beads/Religion. The problem may cause students to think about their own community. One teacher thought that Christmas should be changed to holiday.
Mathathon	1.95	Teachers did not agree on this problem. Some thought it was not socially relevant while others thought that an issue such as cancer affects a lot of people and therefore is a hot topic for discussion. There could be a cultural connection to pledge drives for certain causes.
Pencils	1.84	This task was described as having a real world connection to budgeting, sales and critiquing society about the problems that people face with high prices, poverty and challenges some families face. Mathematically, this task requires students to think and involves a multistep process.
Videos	1.83	Video games could be interesting for some students and can open up a discussion on the high price of video games, wasted money (according to some people) and video game addiction. The mathematics could involve finding the more economical plan.
Earning	1.57	Although some people might do this job for a living, some students might not relate to cutting lawns and trimming bushes. On the other hand, this task could connect school to real life for some students or have students solve landscaping calculations which is a career that some people have in society. One teacher cautioned about stereotyping Mexican [Americans] as doing this type of job/career.
Discount	1.41	Getting a Discount is a real world connection for most students; however, there is not much critique on society, therefore has low cultural relevance.

Note: One teacher dropped the course

A summary of teacher's comments is included in the table. *Weighty Issues* had the highest mean score for being culturally relevant. Teachers felt that the task highlights an important cultural issue – child obesity. One teacher suggested extending the task students could discuss factors that contribute to being overweight. For this task, even rubric item number 8 was satisfied which says that the task has an explicit goal to critique society. This rubric items was not satisfied in many of the teacher-created tasks.

So You Think You Can Draw was also scored as being highly culturally relevant. One teacher however, thought the task had no real cultural relevance (without a description of the drawing) and another teacher thought it was geared more toward inner city students.

Another notable task, *Buying Beads for Christmas*, could be extended many ways including discussions about non-profit organizations, types of dread beads, foster children, etc. One student thought this task would only apply to Catholic students because he related the beads to those that he received in Sunday school at church.

In addition to discussing the cultural relevance of the tasks, teachers made many comments about the mathematics required for students to access the tasks. Statements such as students must: convert dollars to cents; use multiple representations such as verbal, tables, symbols and graphs; use linear, quadratic and exponential models; make predictions, use algebra, calculate the costs of renting videos, determine the better buy, determine the cost of gas, connect to coordinates on an xy-plane, domain and range; use several series; use multi-step mathematics; use of systems of equations, and explain and justify their solutions.

Mathematics Represented in CRCD Mathematics Tasks

In prior work with the CRCD Framework, Matthews (2003) found that teachers he worked with struggled to see mathematics as a relevant, cultural discipline from which cultural and societal inquiry can emanate and flourish. In addition, some of those teachers feared that teaching with cultural referents would take away from the mathematics. However, by participating in the exercise of starting with complex tasks and modifying them using the CRCD Framework, helped teachers see that it could be done. In addition, the process required them to consider their students and how the task could relate to their real lives, their communities and/or the world at large.

As part of the current study, I found that many of the Common Core Content Standards (see Figure 1) for grades 6 – 8 and high school were captured within teachers' assignments and discussions. For example, under the *Geometry, Functions, Expressions & Equations* Standards, teachers noted using multiple representations such as use of verbal/symbols/tables/graphs in the *Driving Directions* task. Use of the coordinate plane, domain and range was used in the *So You Think You Can Draw* task. Systems of equations and linear/quadratic/exponential models were used in the *Math-a-thon* task. In the *Buying Pencils* task, the *Number System* Standard was used by having students estimate and calculate costs including converting dollars to cents and by having students determine accurate prices in the *Earning Money* task. The *Statistics and Probability* Standard is addressed by students' use of extending a series and the use of statistics in the *Weighty Issues* task.

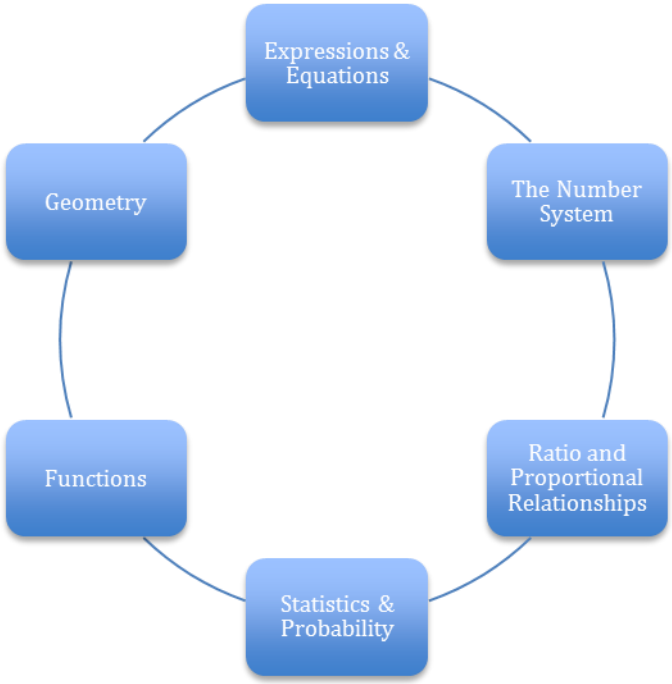

Figure 1. Common Core Content Standards for Grades 6 – 8 (http://www.corestandards.org/Math/)

Teachers also discussed strategies that would fall under the Common Core Mathematics Practice Standards (see Figure 2) such as requiring students to think and having students work backward to find a solution (Practice Standard #1), students finding multiple solutions and making connections with other content areas (Practice Standard #7), students justifying their solutions (Practice Standard #3) and students having to work through problems without any guidance (Practice Standard #1). Students had to interpret the reasonableness of their results in Weighty Issues which addresses Practice Standard #3. The tasks created by the teachers for their final projects included mathematics concepts such as:

- Writing and solving equations (*Functions* Standard, Practice Standard #1),
- reading a map using scale factor including using a ruler properly (*Proportional Relationships* Standard for middle school, Practice Standards #4 & #5),

- density and percent error (*Functions* Standard, Practice Standards #2 & #6),
- finding mean/average (*Number & Quantity* Standard, Practice Standard #2),
- calculating and comparing prices (Practice Standards #2 & #6), and
- area (*Geometry Standard* and Practice Standards #2, #4 & #6).

The *Ratio* and *Proportional Relationships* Standards from the middle grades are replaced by the *Algebra* and *Modeling* Standards in the high school content standards and those high school standards were also covered in the mathematics tasks that teachers created to be culturally relevant.

Mathematics Practice Standards
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Figure 2. Common Core State Standards. (http://www.corestandards.org/Math/)

Use of the CRCD Mathematics Tasks Rubric: Lessons Learned

I analyzed the use of the rubric by teachers and discovered that some aspects of the rubric were covered very well while other criteria for cultural relevance were rarely used in the teacher-created mathematics tasks.

In Table 2, I used numbers to denote each degree level: high (3), moderate (2), and low (1) and calculated means for the teachers who completed rubrics for selected tasks. From the weighted means I was able to see which criteria of the rubric seemed to

appear the most in teacher-created mathematics tasks.

Table 2.

Teachers' use of the CRCD Mathematics Tasks Rubric with Likert Scale Scores and Weighted Means for the Degree of each Description of CR Criteria

Description	Degree in Task Structure			
	High (3)	**Moderate (2)**	**Low (1)**	**Weighted Means** $n = 59$
Number of scores for 10 mathematics tasks reported by 4 – 8 teachers.				
1. Mathematics task explicitly requires students to inquire (at time problematically) about themselves, their communities, and the world about them.	16	24	19	1.55
2. May draw from connections to other subjects and issues.	12	31	16	1.53
3. Mathematics task draws from students' community and cultural knowledge.	14	21	24	1.83
4. Task may explicitly seek to add to this knowledge through mathematical activity.	16	23	18	1.96 $n = 57$*
5. Task is mathematically rich and cognitively demanding, embedded in cultural activity.	24	27	8	2.27
6. Task asks students to engage the discontinuity and divide between school and their own lives – home and school.	16	28	15	2.02
7. Task is real-world focused, requiring students to make sense of the world through mathematics.	29	28	2	2.46
8. The explicit goal of the task is to critique society – that is, make empowered decisions about themselves, communities and world.	8	15	36	1.53

*Two teachers did not report a score for Description #4

Analysis of teachers' use of the rubric helped to illuminate that criteria number 8, the explicit goal of the task is to critique society, had the lowest scores of being included in the tasks created by teachers. Weighty Issues was one of the only tasks that satisfied rubric item #8. This may mean that criteria number 8 was the most challenging to incorporate. This assumption needs to be researched further. One may ask if criteria number 8 is necessary in every culturally relevant mathematics task. Ladson-Billings

(2009) indicates that critique of the current social order is a major outcome of culturally relevant teaching. I believe this means that social empowerment must be the essence of your instructional strategies even if every task does not involve critiquing society. This also may mean that teachers need help with incorporating criteria number 8 into a mathematics tasks. Some researchers (Bartell, 2013; Gutstein, 2012; Gutstein et al., 1997; Moses & Cobb, 2001; Tate, 1995) have provided suggestions for teaching mathematics with a more culturally relevant approach and teaching mathematics for social justice and these strategies can assist teachers with implementing criteria number 8 into their mathematics instruction.

Tate (1995) provides us an example in his seminal research with Mrs. Mason, a middle school teacher of predominately African American students. She found success when she allowed her classes to be issue driven rather than content driven. She had students pose problems they felt were negatively impacting their community and in doing so students could, 1) start with what was familiar to them, 2) feel empowered to work on something meaningful to them, and 3) resolve a problem that was connected to their realities. In one of Mrs. Mason's classrooms, students decided to "embark on an effort to close and/or relocate 13 liquor stores within 1000 feet of their school" (p. 170). The students did the appropriate research and ultimately used mathematically-based arguments to plead their case to their city council. In the process students used mathematics content such as fractions, decimals, percentages, scaled drawings (maps), and distances in a real life situation. In the end, students were successful in school and in changing their community for the better.

When reflecting on the tasks and using the rubric to assess the level of cultural relevance a task possessed, teachers made the majority of their statements (60%) about community/society or real life situations. They also talked a lot about the mathematics involved in the tasks (47 of 135 or 35% of the statements focused on mathematics content). The remainder of teacher talk was about poverty/inner city issues and other important issues such as cancer, athletes endorsing unhealthy foods, and families who cannot afford to shop at Penney's, just to name a few.

One other aspect of the course was a final reflection that really provided more in-depth information about teacher's growth in thinking about culturally relevant teaching. I have chosen two teachers both who have expressed the desire to continue to learn more about the process of making a transformation in their teaching to become culturally relevant practitioners. Both teachers feel that they already take their students' interests into consideration when planning instruction; however, they were both struck by what they had not considered after learning it in the course. As the saying goes, "You don't know what you don't know." These two teachers acknowledge that and are ready to start the process of becoming culturally relevant educators.

Selected Teacher Comments

Teacher One was a teacher who expressed a great deal of reflection and understanding of the changes needed to teach mathematics in a culturally relevant way. In response to Ladson-Billings (1995) call for students developing a critical consciousness through which they challenge the status quo of the current social order Teacher One finds this statement "particularly powerful; we want [students] to stand up and incite change! Change the social perceptions and rise up! The idea is really glorious;

however, the implementation seems to be the tricky part." After reading some of the literature, particularly an article by Tyrone C. Howard (2003), this teacher was stunned to realize how little she had thought about her own cultural experiences, and how these experiences might affect her teaching. She goes on to say that she chooses to believe that she can connect culturally with her students by embracing and accepting and learning from them and their experiences This teacher said that reflection was not something new to her; she says that she has been practicing reflective teaching since she began teaching. Her exemplary reflections that follow would not be expected of a new teacher or one new to reflective practices in teaching.

The teacher reflected about learning about cognitively demanding tasks through the cases in the Stein, Smith, Henningsen, and Silver (2009) book.

> The cases that we read in the text were very interesting. They really made me think about how I teach; do I give too much away to my students? Am I preparing the right types of questions to ask them? Am I giving them enough time to complete this activity on their own, finding their own way so that the cognitive demand is kept at a higher level? Upon reading most of the cases I would go back into my classroom and really try some of the practices that I thought would have benefited the teachers we read about. Many times those practices were more difficult than I had thought to implement. For example, not easing up on the level of cognitive demand is difficult to do when students are constantly bombarding the teacher with questions about whether they are completing the task correctly. I found that if I tried to anticipate the problems

they would face and then come up with some really great questions to ask them to help them solve their problems themselves, they would persevere.

The student also reflected about culturally relevant pedagogy.

As I said earlier, the culturally relevant cognitively demanding portion of the class is what I think is the most interesting to me. I have spent my entire teaching career teaching students who, for the most part, are culturally different than me. I don't know whether I was oblivious to that idea, or whether I believed it was incorrect to identify them as different than me, or if I thought it was incorrect to identify myself as different than them, but the fact is, I am different than my students. Not only am I different than my students, but each student is different than the next. They are not all the same. Each is exposed to a different set of cultural norms and it is important to embrace that in the classroom, not hide it. I am really fascinated by the idea that culturally relative pedagogy has implanted into my head: I see myself as a facilitator in the middle of a diverse population of people, each with different things to teach each other about themselves and different things to learn about the others around them. I see myself as the person who models the embracing and showcasing of the importance of these beautiful and amazing differences in us all. I see this as a multidirectional flow chart of ideas. Learning about the culturally relevant pedagogy and teaching has made me more cognizant of the prior knowledge of my students. For example, today in class we went over an inequality problem about which ski mountain offers a better deal for ticket prices. I realized before we started the problem that most likely not everyone in class knew how tickets worked at ski mountains. Maybe they didn't know why you were even charged a ticket price. So

we talked about it. We talked about what getting a better deal meant. Even kids who hadn't the prior knowledge about skiing were able to answer the question at the end.

Teacher two reflected in this way,

> I learned a lot about Culturally Relevant Teaching. Prior to this class, I was not familiar with this concept. Now, I know what is meant by cultural pedagogy and I know that in order to successfully teach and engage our students, they need to be exposed to examples that are meaningful to them. This class was interesting and made me think about my teaching. I will implement some of the ideas I learned in this class when I teach my students. I learned that "culture" is very important and lessons need to be meaningful to our students.

Concluding Statement

Many researchers have called for a culturally relevant approach to teaching mathematics. This sentiment is echoed in prominent mathematics education literature (NCTM, 2014). It is also understood that teaching with culturally relevant pedagogy is complex and involves much more than choosing a task and implementing it. Ladson-Billings (2009) makes it a point that her focus is on teaching practice rather than on curriculum. I agree with that sentiment; however, knowing that the mathematics tasks is the basis of opportunity for students to experience the full power of mathematics, Matthews et al. (2013) provided teachers a tool to assist them in taking their current curriculum and modifying it to be more culturally relevant. We found in previous research (Matthews, 2003; Matthews et al., 2013) and in the current study that some teachers needed assistance in doing just that. The CRCD Mathematics Framework and Rubric provided a first step for teachers in graduate level programs to provide more

culturally relevant cognitively demanding mathematics tasks to their students. The mathematics represented in the teacher-created tasks included challenging mathematics content areas covered in the Common Core State Standards. In addition the nature of the tasks addressed the Common Core Mathematics Practice Standards. The framework and rubric along with candid discussions about the existing literature on culturally relevant teaching offered teachers a starting point in their practice to become culturally relevant educators. Next steps in this research include characterizing the implementation of these tasks in practice including student engagement with the tasks.

This study was limited by the small number of teacher participants. Suggestions for future study include continuing to explore teachers' use of the CRCD Framework and Rubric to create and implement CRCD mathematics tasks for use in the classroom. Further characterization of the use of these tools and the subsequent implementation of CRCD mathematics tasks including students' engagement with the tasks is desired. Ultimately and in the long run, the goal is to establish best practices in connecting mathematics to students' lives to better engage students and to improve mathematical literacy.

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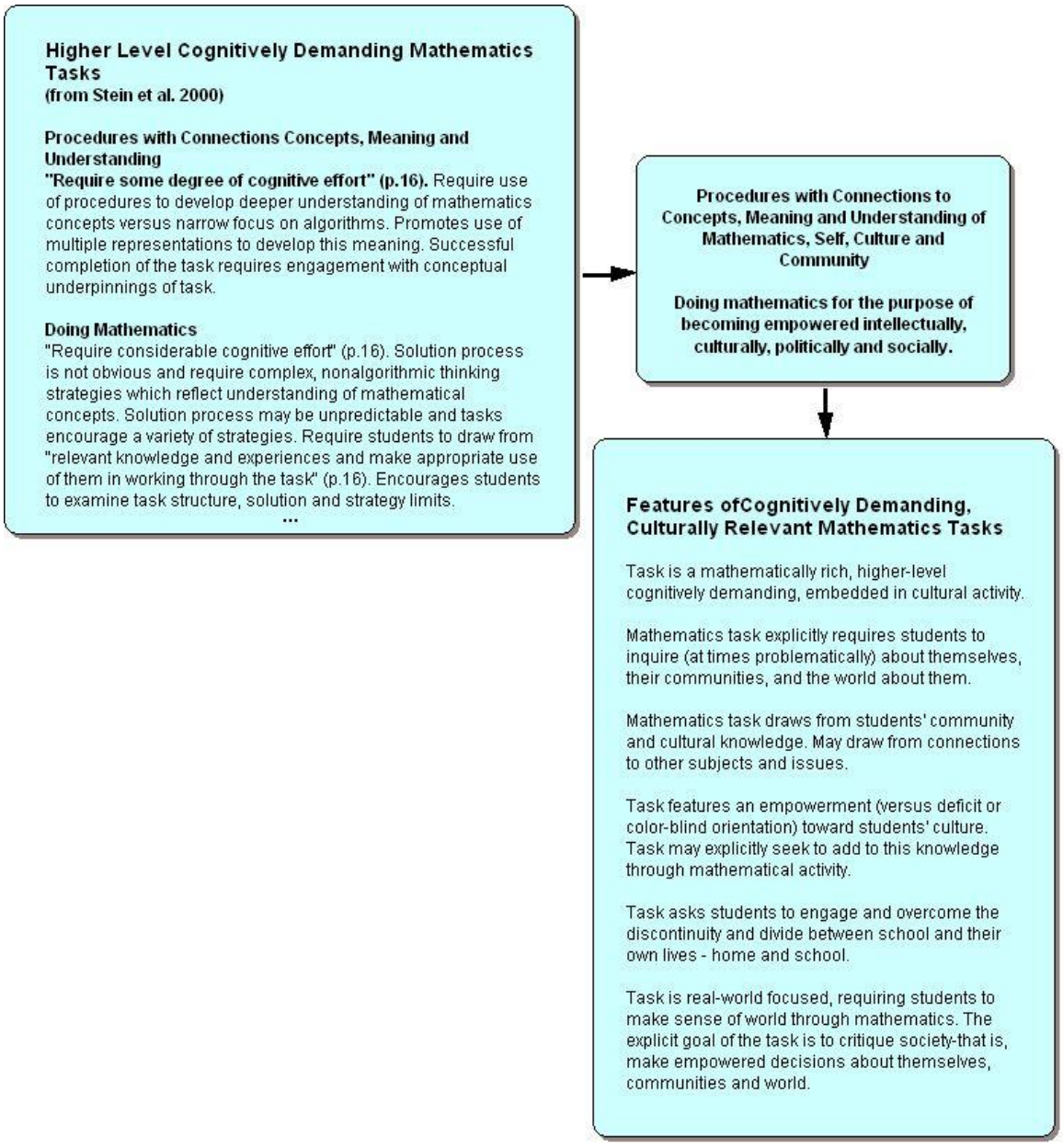
Appendix A

Culturally Relevant Cognitively Demanding (CRCD) Task Framework



From Matthews, L. E., Jones, S. M., & Parker, Y. A. (2013). Advancing a framework for culturally relevant, cognitively demanding mathematics tasks. In J. Leonard & D. Martin (Eds.),*The brilliance of Black children in mathematics: Beyond the numbers and toward a new discourse*. Charlotte, NC: Information Age Publishing.

Appendix B

Ten Tasks Critiqued by Graduate Students

Earning Money One summer you charge $20 to mow a lawn and $10 to trim bushes. It is one week before school starts and you want to make $300 in one week to buy new shoes and clothes before school starts. For every lawn you mow, you also trim the bushes. How many lawns did you mow? If you do not trim any bushes during the week, how many lawns will you have to mow to earn that $300? Explain your answers using verbal, graphical, tabular, and symbolic representations.
Renting Video Games You have a Playstation 2 and you like to rent games before you buy them. There are two video stores near your house and you are trying to decide which to join. One video store charges $8 to rent a video game for five days. You must be a member to rent from the store, but membership is free. The other video store charges only $3 to rent a game for five days, but the membership is $50 per year. Which plan is more economical? Estimate how many video games you rent during the year. Which plan would you choose? Justify your choice.
Getting a Discount J C Penney's is having a Friends and Family Day sale where you can save an additional 20% off all prices. You would like to buy your dad a new SouthPole sweater for Christmas. The regular price is $40. The sale sign says take 30% off. What would be the cost of the sweater after the discounts? Explain how you calculated the sale price.
Buying Pencils Mom is on a tight budget for your back to school supplies. Each of the six children in your family needs six pencils to start the year and Mom would like one, too. She found a great sale on mechanical pencils. For every two mechanical pencils Mom buys at the regular price, she gets a third mechanical pencil for a penny. She was so happy because she only spent $4.62 for 37 pencils. Find, in cents, the regular price of one pencil.
Buying Beads for Christmas Stockings Your Sunday school class is filling stockings for foster children this Christmas. You have been saving your money and decide to use it to buy dread beads for the girls' stockings. When you go shopping, you find out that the store adds a 5 percent sales tax to every purchase. If you did not have to pay tax, you could have bought three more beads for the same amount of money. How many beads did you buy?
How Much Does a Locust Eat? In your Social Studies class you learned that a large swarm of 50 billion locusts can eat 3,000 tons of crops in a single day. Many restaurants offer hamburgers that weigh a quarter pound (meat only before cooking). Suppose everyone in your school ordered a quarter-pound hamburger for lunch. How many school days would it take for all the students in your school to eat the amount eaten by the swarm in a single day? Explain how you found your answer.
Weighty Issues According to a 2006 report from the Centers for Disease Control, 33.6% of Americans between the ages of 2 and 19 are either overweight or on the brink of becoming so, up from 28.2% in 2000. That's about 25 million overweight kids. Assuming this trend continues at a constant rate, how many kids do you predict to be overweight in the year 2050? What about the year 2100? Is it reasonable to assume a constant growth rate for this trend? Why or why not.

So You Think You Can Draw

Your sister loves street art. You would like to recreate one of her favorite pieces for her birthday. You decide to create a poster board replica of this piece even though you're not an artist. Suddenly a deeper side of the image strikes you.

This is going to be easy! You notice the tip of his nose at (0,0), the bottom lip at (0,-2)……Where is his right eye, …the bottom of his chin, …..the large patch of grass? What is the domain and range? Explain your reasoning. Try creating a replica on poster board.

photograph © copyright 1994 Ted Mikalsen

Artwork ©1994 Dave Kinsey (aka Büst) in Atlanta, GA. Photographer © 1994 Ted Mikalsen. Used with permission from www.graffiti.org

Math-a-Thon

You are helping to raise money for cancer research at St. Jude's Children's Research Hospital by participating in your school's Math-a-Thon. You will take pledges from your community based on the number of math problems you answer correctly.

- Your neighbor pledges $6.00 per problem.
- Your teacher pledges $1.00 for the first problem, $2.00 for the second problem, $3.00 for the third problem, and so on.
- Your Mother pledges $.10 for the first problem, and will double it for each problem after that.

Describe the number of problems you must solve for each of the three pledges to make the most money.

Driving Decisions

You family's SUV uses gas at a rate of 17 miles per gallon of gasoline. Its current sale value is $16,000. You see a commercial for a new hybrid car advertised at $22,000 that uses gas at a rate of 40 miles per gallon of gasoline. Estimate the mileage your family vehicle drives per week, and decide if your family should keep your current automobile or sell it and buy a hybrid. Defend your position using tabular, graphical, symbolic, and verbal representations.

Adapted from Matthews, L.E., Jones, S.M., & Parker, Y.A. (2013). Advancing a framework for culturally relevant, cognitively demanding mathematics tasks. In J. Leonard & D. Martin (Eds.),*The brilliance of Black children in mathematics: Beyond the numbers and toward a new discourse*. Charlotte, NC: Information Age Publishing.

Appendix C

Culturally Relevant Cognitively Demanding (CRCD) Task Rubric

Description	Degree in Task Structure		
	High	Moderate	Low
Mathematics task explicitly requires students to inquire (at time problematically) about themselves, their communities, and the world about them.			
May draw from connections to other subjects and issues.			
Mathematics task draws from students' community and cultural knowledge.			
Task may explicitly seek to add to this knowledge through mathematical activity.			
Task is mathematically rich and cognitively demanding, embedded in cultural activity.			
Task asks students to engage the discontinuity and divide between school and their own lives – home and school.			
Task is real-world focused, requiring students to make sense of the world through mathematics.			
The explicit goal of the task is to critique society – that is, make empowered decisions about themselves, communities and world.			

From Matthews, L.E., Jones, S.M., & Parker, Y.A. (2013). Advancing a framework for culturally relevant, cognitively demanding mathematics tasks. In J. Leonard & D. Martin (Eds.),*The brilliance of Black children in mathematics: Beyond the numbers and toward a new discourse*. Charlotte, NC: Information Age Publishing.

Appendix D

RESEARCH INFORMED CONSENT

For

Mathematics Teachers' Use of the Culturally Relevant Cognitively Demanding (CRCD) Task Framework and Rubric to Create CRCD Mathematics Tasks

Shelly M. Jones, Ph.D., Associate Professor
Central Connecticut State University
Department of Mathematical Science

1. Invitation to Participate and Description of the Project. In our Math 547 class we discussed the need to incorporate cultural references in mathematics tasks. We learned that the Connecticut Common Core of Teaching (2010) requires teachers in Connecticut to create a classroom climate that is responsive to and respectful of the learning needs of students with diverse backgrounds, interests and performance levels. We were also introduced to a body of literature about culturally relevant teaching. You are being asked to participate in a study for the purpose of answering the following questions: (1) What are the characteristics of mathematics tasks that secondary teachers create when the goal is to create a CRCD mathematics task, (2) How does the CRCD Mathematics Task Framework and Rubric assist teachers in creating CRCD mathematics tasks, and (3) What are teachers perceptions of how students engage with the CRCD mathematics task. The goal of the study is to begin to connect research about CRCD mathematics to practice. Ultimately and in the long run, the goal is to begin to establish best practices in connecting mathematics to students' lives to better engage students and to improve mathematical literacy.

2. Description of Procedure. If you participate in this study, you will be asked to sign an informed consent form giving the Principal Investigator (PI) the permission to use information from your previous assignments in Math 547 on creating and implementing CRCD mathematics tasks. Remember that we did the following:

- We read two articles on culturally relevant teaching then evaluated seven mathematics tasks and described the level of cognitive demand and the level of cultural relevance. We had a class discussion of the findings.
- We had two options for a final project. One of the options was an assignment on CRCD mathematics tasks. If you chose this option, you had to: Create and complete a CRCD mathematics task, provide a brief description of the mathematics involved to solve the task, classify the cognitive demand of the task, evaluate the level of cultural relevance, critique the CRCD framework (&rubric), write a two-page reflection about Culturally Relevant Teaching.
- If you did not choose the CRCD final project, you are still eligible to participate, as all students took part in the class discussion about the seven CRCD mathematics tasks.

- The PI will gather information from assignments (collected via email attachment or scanned in and emailed). Patterns will be analyzed and discussed in a future article to be written and submitted for publication.

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3. Risks and Inconveniences. Participating in this research study should pose no risks to you.
Once you accept an invitation to participate in the study, your responses to the research questions will be cut-and-pasted into a new master document to be analyzed. Patterns will be found and a big picture created using narrative analysis (Riessman 2002, 2008), which is a form of qualitative analysis in which the analyst focuses on how respondents make sense of events and actions in which they have participated.
The identity of data sources is not important to this study; therefore, once your responses are cut-and-pasted into the master analysis document, the copies of your responses with your name will be shredded. Only final project data from students who complete and return an informed consent form will be used. All group discussion data will be used as individual students were never identified in the overhead transparency sheets used to report on group consensus decisions made about the cognitive level and cultural relevance of the seven selected tasks.

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4. Benefits. The classrooms of today in any town/city in Connecticut are becoming more diverse in many ways; therefore, as a student in Math 547 you may have benefitted from learning about the theoretical underpinnings of culturally relevant teaching. In addition, those students who chose the CRCD final project, may have learned first hand other resources to engage students in mathematics tasks and to possibly improve student learning in mathematics. All students also had a chance to hear about a variety of teachers' experiences using CRCD mathematics task in Connecticut classrooms.

5. Financial (or other) considerations: You will have no financial obligations for participating in this study. If you prefer to return the informed consent form in the regular U.S. mail, the PI will provide you with a stamped, self-addressed return envelope. Please request this option by replying to the PI via email.

6. Confidentiality. Any and all information obtained from you during the study will be confidential. Your privacy will be protected at all times. You will not be identified individually in any way as a result of your participation in this research. The data collected however, may be used as part of publications and papers related to this research.

7. Voluntary Participation. Your participation in this study is entirely voluntary. You may refuse to participate in this research. Such refusal will not have any negative consequences for you. If you begin to participate in the research, you may at any time, for any reason, discontinue your participation without any negative consequences. Selecting the CRCD final project (or selecting the TEAM final project) in no way effected your grade in Math 547. If you feel otherwise, please see contact information below for CCSU Human Studies.

8. Other considerations and questions. Please feel free to ask any questions about anything that seems unclear to you and to consider this research and consent form carefully before you sign.

Authorization: I have read the above information and I have decided that I will participate in the project described above. The researcher has answered my questions. I know what will be asked of me. I understand the purpose of the study. If I don't participate, there will be no penalty or loss of rights. I can stop participating at any time, even after I have started.
I agree to participate in the study. My [electronic] signature below indicates that I have received a copy of this consent form.

Participant's signature_____

Name (please print)_____

Date_____

Thank you in advance for your participation. If you have further questions about this research project, please contact the Principal Investigator, [Shelly M. Jones, at (860) 832-2857, e-mail: jonessem@ccsu.edu].
If you have questions about your rights as a research participant or if you have a research related complaint please contact Dr. Bradley Waite, Chair, CCSU Human Studies Council at (860) 832-3115, e-mail Waite@ccsu.edu.

Sincerely,

Shelly M. Jones, Ph.D.
Associate Professor

Date

To Whom it May Concern:

This is a letter of acceptance for the Culturally Relevant Cognitively Demanding (CRCD) research directed by Dr. Shelly M. Jones of Central Connecticut State University. Dr. Jones will work with [teacher's name and grade level] for one week in Fall 2015.

I am aware that the project consists of three parts: 1) A meeting with a local university professor partner. 2) A work session with teacher and Dr. Jones to create a culturally relevant mathematics lesson using CRCD mathematics tasks, 3) the teacher teaching one to two lessons with Dr. Jones observing and/or co-teaching, 4) A debriefing session with Dr. Jones and university partner, and 5) a follow-up survey for the teacher to reflect on the lesson in terms of cultural relevance, quality mathematics and anticipated future use of CRCD mathematics tasks.

I can attest that the Culturally Relevant Cognitively Demanding (CRCD) research lesson will be delivered in a way that is consistent with normal classroom activities. The classroom teacher will always be in the classroom and will work in collaboration with Dr. Jones.

If you have any other questions or concerns.

Sincerely,

[Principal or Math Administrator]

Appendix E

Final Project: Reflective Practices in Mathematics Education

Overview: Culturally Relevant Cognitively Demanding Tasks

Last class we discussed research done by Stein and colleagues regarding the selection of tasks that are cognitively demanding for students. These cognitively demanding higher-level tasks can either be classified as "Procedures with Connections" or "Doing Mathematics." This week you will read three articles about Culturally Relevant Teaching/Pedagogy. Choose two articles from the Summer 1995 Issue of the Theory and Practice Journal about Culturally Relevant Teaching. The three choices are: McGee and Banks (1995), Tate (1995) and Ladson-Billings (1995). Choose one other more up-to-date article (after 2000) from another source such as the Journal of Urban Mathematics Education for more background information on Culturally Relevant Teaching: http://education.gsu.edu/JUME. You may also search the web or visit the CCSU library homepage for online journals with full access to articles. You will need your CCSU Student ID number and password to access the online journals.

Due to the increasing diversity in many classrooms as well as the need to make mathematics relevant for all students regardless of cultural background, it is important for teachers to be familiar with this type of instruction and tasks. In this assignment, you will choose one of three Number and Operations tasks given below and use a rubric to analyze the task. This rubric is the result of a framework connecting higher level tasks with the perspectives of Culturally Relevant Teaching, thus refining the descriptions of the two categories presented by Stein, Smith, Henningsen, and Silver (2009) as (a) *procedures with connections to concepts, meaning and understanding of mathematics, culture and community*, and (b) *doing mathematics for the purpose of becoming empowered intellectually, culturally, politically and socially*. These two renamed classifications are given for the purpose of having teachers of mathematics rethink the extent to which selected mathematics tasks challenge students to ask relevant questions of themselves and the world around them.

Objectives

- Choose a Number and Operations task from the three choices given and complete the task
- Classify the cognitive demand of the task
- Evaluate the task as culturally relevant or not, using the CRCD Mathematics Task Framework
- Critique the framework used to make the evaluation
- Write a one-page reflection about Culturally Relevant Teaching

Instructions

Choose one of the following tasks to complete and evaluate:

Curfew Controversy

The members of your community were asked to vote on a mandatory curfew of 11:00 for minors under the age of 18 years old. The results were printed in the paper, but there was a misprint; one digit was incorrect.

Yes votes:	13,657	42%
No votes:	186,491	58%

Find the correct number of votes if the misprint is in the "yes" total.
Find the correct number of votes if the misprint is in the "no" total.
Based on the population of your community, describe what you would expect the results to be if minors were allowed to vote on this issue?

Cell Phone Dilemma

Your parents have decided to get you a cell phone. They want you to choose between text messaging or audio communication. Text messaging costs 33 cents per letter. On average a text word is four characters. Audio costs 7 cents per minute. You have a $25 per month limited expense. Which would be your better option? Explain your choice.

Cementing It In

You are setting a basketball goal up using a rectangular support beam. The beam is 3 ½ in. by 5 ½ in. You dug a circular hole 12 inches in diameter and 30 inches deep and set the support in the center. You need to fill the remaining space with concrete. An 80-pound bag mixed with water makes 0.6 cubic feet of concrete. How many bags of concrete must you get to complete this job? Explain and show your solution.

For the selected task, do the following:

- Complete the task and show your work. Provide a *brief* description of the mathematics involved to solve the task
- Classification on Stein and others Mathematics Task Framework (it *should* either be "procedures with connections" or "doing mathematics") and rationale based on readings
- Culturally relevant or not – rationale based on your input in the CRCD rubric
- Reflection/critique of rubric – is it appropriate for determining if a cognitively demanding task is culturally relevant? Why or why not? What is missing? What is helpful?