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The development of a model of culturally responsive science and mathematics teaching

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Abstract

This qualitative theoretical study was conducted in response to the current need for an inclusive and comprehensive model to guide the preparation and assessment of teacher candidates for culturally responsive teaching. The process of developing a model of culturally responsive teaching involved three steps: a comprehensive review of the literature; a synthesis of the literature into thematic categories to capture the dispositions and behaviors of culturally responsive teaching; and the piloting of these thematic categories with teacher candidates to validate the usefulness of the categories and to generate specific exemplars of behavior to represent each category. The model of culturally responsive teaching contains five thematic categories: (1) content integration, (2) facilitating knowledge construction, (3) prejudice reduction, (4) social justice, and (5) academic development. The current model is a promising tool for comprehensively defining culturally responsive teaching in the context of teacher education as well as to guide curriculum and assessment changes aimed to increase candidates' culturally responsive knowledge and skills in science and mathematics teaching.

Keywords: Culturally responsive teaching, Content integration, Facilitating knowledge construction, Prejudice reduction, Social justice

El desarrollo de un modelo de enseñanza de ciencias y matemáticas sensibilizado con la cultura

Este estudio teóricamente cualitativo fue conducido para responder a la necesidad de un modelo inclusivo e integral para guiar la preparación y evaluación de los candidatos a maestros en la enseñanza culturalmente sensible. Con el fin de mejorar los resultados educativos de estudiantes lingüística y culturalmente diversos, las investigaciones indican que es necesaria una reforma en la formación del profesorado para satisfacer adecuadamente las necesidades de todos los estudiantes.

Como formadores de docentes, iniciamos un estudio teórico para responder a la inmediata necesidad de un modelo inclusivo e integral para guiar la preparación y evaluación de futuros maestros en la enseñanza con sensibilidad cultural. Específicamente, desarrollamos y piloteamos un modelo para guiar la preparación y evaluación de candidatos a maestros de la enseñanza culturalmente sensible de ciencias y matemáticas. El proceso para desarrollar este modelo de enseñanza con sensibilidad cultural incluyó tres fases: una exhaustiva revisión de la literatura; una síntesis de la literatura y categorización temática sobre la disposición y comportamiento hacia la enseñanza con sensibilidad cultural; y la puesta en práctica con los candidatos a maestros para validar la utilidad de las categorías y generar ejemplos específicos de comportamiento para representar cada categoría.

Durante la segunda fase del proceso para desarrollar un modelo de enseñanza con sensibilidad cultural, el primer autor sintetizó la literatura en cinco temas relacionados con la enseñanza con sensibilidad cultural: (1) integración de contenido, (2) facilitación de la construcción del conocimiento, (3) reducción de prejuicios, (4) justicia social, y (5) desarrollo académico. Cada categoría fue definida funcionalmente para poder explicar el comportamiento y disposiciones asociadas con la enseñanza culturalmente sensible.

Los resultados revelaron que la mayoría de los participantes demostraron el uso e integración de modelos culturales, al igual que integraron contenido con afinidad cultural semejante a la de ellos y mantuvieron altas expectativas para todos los estudiantes. Los maestros facilitaron la construcción de conocimiento partiendo de lo que los estudiantes ya sabían y usando experiencias reales para ilustrar conceptos científicos y matemáticos claves y esenciales. Los participantes

demonstraron su compromiso a reducir el prejuicio a través del uso de la lengua materna de los estudiantes en el aula, de la comunicación con los padres, de la demostración de técnicas que fomentan interacciones positivas entre los estudiantes, y de la construcción de un ambiente seguro en el salón de clases. Aunque la categoría de justicia social fue más difícil de analizar, se encontró evidencia que por lo menos cuatro participantes reconocieron la necesidad de motivar a los estudiantes a pensar de manera crítica y socio-cultural. Finalmente, todos los participantes demostraron habilidad para crear oportunidades y usar estrategias educativas basadas en investigaciones para ayudar al desarrollo académico de sus estudiantes. Este modelo inclusivo e integral sirve como una herramienta práctica para situar la enseñanza con sensibilidad cultural a la vanguardia de programas en la formación docente, especialmente en las áreas de educación de ciencias y matemáticas, ya que históricamente en estos campos se ha luchado mucho para integrar elementos multiculturales dentro de la práctica.

Framing the study

Given that Hispanic student enrollment has increased by 64 % over the 10-year period from 1992–1993 to 2002–2003 (Fry 2006), it has become increasingly important for educational institutions to evaluate their historic struggle to effectively educate this growing population. For example, currently only 58 % of all Hispanic Latino/a students graduate from high school on time, compared to 78 % of Whites (Editorial Projects in Education 2008) and only 20 % of them leave high school prepared to enter college (Greene and Winters 2005). In order to improve the educational outcomes of culturally and linguistically diverse (CLD) students in general, research indicates that reform is needed in teacher education to more adequately prepare teachers to meet the needs of all students. The Holmes Group began reporting and outlining plans for improving teacher quality as early as the mid-1980s (Holmes Group 1986). Building on this research, John Goodlad (1994) outlined 19 postulates to guide education reform efforts at the college and university level. The Holmes Group (Holmes 1990) and Goodlad's postulates include a focus on preparing teachers to be responsive to the increasingly diverse needs of society.

While a growing body of research, such as that by Ana María Villegas and Danné E. Davis (2008), indicates the need for and the many

benefits to recruiting CLD students into teacher education, it also is critically important for colleges of education to consider the ways in which they are preparing *all* teacher candidates within their current programs to be culturally responsive. Despite the documented need for more experience, the majority of teacher education programs require students to complete only one multicultural education course as part of their curriculum. Furthermore, teacher candidates often are not given opportunities to apply their newly gained understandings of CLD students in a diverse field experience prior to graduation (Cochran-Smith and Fries 2005). Thus, many of the students who graduate from these traditional programs continue to feel inadequately prepared to teach children of diverse backgrounds (Grant and Gillette 2006). As a result, traditionally trained teachers struggle in relating to their diverse students, which could lead to “lower student participation, and result in teachers’ misconceptions of student motivation, ability, and potential” (Rueda, Monzó, and Higareda 2004, p. 57). More specifically, these new teachers are less likely to integrate culture and language diversity into the content that they teach (Gutierrez 2006).

To address such issues, in 1995, the National Science Teachers Association issued a statement with regard to multicultural education in which they outlined five tenets necessary for teachers, teacher educators, and licensing programs. According to Jewell Cooper and Catherine Matthews (2005):

Science teachers must become acquainted with their students, especially within the communities in which they live. By doing so, science becomes a contextualized engagement and a culturally relevant experience, one that allows students to link their daily experiences to what they do in class.... Teachers must educate themselves through personal investigations and professional development in the historical contributions of different ethnic groups to the development of science. (p. 52)

In a study published in 2006, Rochelle Gutierrez provides us a glimpse into what this type of culturally responsive teaching can accomplish in the parallel field of mathematics. In her study, White educators were able to accelerate urban Latina/o students through upper level mathematics curriculum by providing them access within a culture of respect and possibility. Teacher leaders within this study were particularly skilled in differentiated instruction and liberating

pedagogy. They viewed students' bilingualism as a vital, integrated resource in the classroom, and not as a hindrance.

As Gutierrez illustrates, the traditional approach to teaching and teacher education is no longer adequate. In order to meet the complex needs of the twenty-first century, US schools must "successfully teach many more students from much more diverse backgrounds. And they must help them master more challenging content many times more effectively than they have ever done before" (Cooper and Matthews 2005, p. 13). According to National Commission on Teaching and America's Future's, part of reinventing teacher preparation is acknowledging the need to educate future teachers to work in non-traditional classrooms with students from very different backgrounds. Many experts in the field indicate that, "to successfully move beyond the fragmented and cursory treatment of diversity that currently prevails, teacher educators must first articulate a vision of teaching and learning within the diverse society we have become" (Villegas and Lucas 2002, p. 2). This vision should be evident in the instructional methods used and promoted within teacher education programs as well as in the attitudes and dispositions of both faculty members and pre-service teachers within them (Currie 1981).

The need for a model of culturally responsive teaching

As teacher educators, we initiated a theoretical study in response to these national reports and the current need for an inclusive and comprehensive model to guide the preparation and assessment of teacher candidates for culturally responsive teaching. More specifically, we sought to develop and pilot a model to guide the preparation and assessment of culturally responsive teaching among science and mathematics teacher candidates. Based on a thorough review of the literature, there are many quality approaches to multicultural education. There are models for addressing culturally and linguistic diversity in K-12 schools in broad and very specific ways. But we struggled to find a unifying approach in teacher education to guide the preparation and assessment of culturally responsive teaching.

For example, there are several quality models in the field, such as sheltered instruction, that are helpful in identifying specific strategies for working with English Learners (ELs) (Echevarria, Vogt, and

Short 2004). However, they are very specific to ELs (Carr et al. 2007) and cannot be used as a comprehensive approach to preparing and assessing teacher candidates' effectiveness with all CLD students in all content areas. There are others, such as Randall B. Lindsey, Kikanza J. Nuri Robins, and Raymond D. Terrell's (2009) cultural proficiency model that work well for increasing the cultural awareness of teachers through the use of guided discussion and reflection. However, while effective for use in exploring teacher's beliefs and attitudes and promoting awareness, the model is broad and lacks specific exemplars to guide and assess teacher candidate's behaviors and dispositions while working with CLD populations. The book, *Teaching science to every child: Using culture as a starting point* by John Settlage and Sherry Southerland (2007) provides more in the way of effective teaching strategies for teaching science to diverse students. However, it does not provide a specific structure for actually assessing teacher candidates' overall culturally responsive teaching in word and deed.

As teacher educators, we were left with the questions:

- What does culturally responsive teaching among teacher candidates look like?
- What are the characteristics and behaviors that culturally responsive (pre-and in-service) teachers demonstrate in practice?

This paper will focus on the process and outcomes of the theoretical research that lead to an integrated model for use in the preparation and assessment of culturally responsive teaching among teacher candidates.

The process of developing a model of culturally responsive teaching

According to Michael Fullan (2007), "Educational change depends on what teachers do and think-its as simple and as complex as that" (p.129). Therefore, we argue that an effective model for culturally responsive teaching must consider the dispositions and teaching performances that become what teachers do and think. In order to

implement a curriculum that effectively addresses dispositions and behaviors, teacher preparation programs need a robust and comprehensive model to guide instruction and assessment of culturally responsive teaching. This process involved three steps: a comprehensive review of the literature; a synthesis of the literature into thematic categories to capture the dispositions and behaviors of culturally responsive teaching; and the piloting of these thematic categories with teacher candidates to validate the usefulness of the categories and to generate specific exemplars of behavior to represent each category. This three-step process resulted in a model, in matrix format, based on theoretical categories and subcategories with specific examples of behavior that can be used to guide and assess culturally responsive teaching.

Approaches on effective teaching in the multicultural classroom

In an extensive review of the literature, the lead author identified three major approaches or areas of research on effective teaching for CLD students: multicultural education, culturally responsive teaching, and culturally relevant pedagogy. These overarching areas of research include the work of many researchers who have established various frameworks for working with specific populations or assessing particular student characteristics.

The need for multicultural education

Early in the 1970s, the American Association of Colleges for Teacher Education (AACTE) began to address the need for Multicultural Education, and in 1972 a commission released the “Statement on Multicultural Education.” In his description of this statement, William Currie (1981) writes, “... schools and colleges must assure that their total educational process and educational content reflect a commitment to cultural pluralism” (Currie 1981, p. 169). The aim of the AACTE was to encourage teacher preparation programs to prepare future teachers for the diversity they would find in their classrooms. A few years later in 1979, NCATE released a standard for multicultural education stating:

Multicultural education should include but not be limited to experiences which: (1) promote analytic and evaluative abilities to confront issues such as participatory democracy, racism, sexism, and the parity of power; (2) develop skills for values clarification including the manifest and latent transmission of values; (3) examine the diverse cultures and the implications for developing teaching strategies; and (4) examine linguistic variations and diverse learning styles as a basis for the development of appropriate teaching strategies. (Banks 1981, p. 171)

The role of the culturally responsive teacher

Sonia Nieto (2004) worked with teachers and conducted research to expand our understanding of multicultural education and culturally responsive teaching. In her definition she outlined seven basic characteristics of multicultural education. According to Nieto, multicultural education is: “antiracist education, basic education, important for all students, pervasive, for social justice, a process, and critical pedagogy” (p. 346).

Building on the work of Banks, Nieto, and the organizations mentioned above, several researchers studied teachers who were committed to the values set forth in the early days of multicultural education. Gloria Ladson-Billings was among the first to clearly define what it meant to be a culturally relevant teacher:

I suggest that culturally relevant teaching must meet three criteria: an ability to develop students academically, a willingness to nurture and support cultural competence, and the development of sociopolitical or critical consciousness. Next, I argued that culturally relevant teaching is distinguishable by three broad propositions or conceptions regarding self and other, social relations, and knowledge. (Ladson-Billings 1995, p. 483)

According to Ladson-Billings, in order for CLD students to succeed academically, a culturally relevant teacher must “provide a way for students to maintain their cultural integrity while succeeding academically” (p. 476). This type of teacher values the diversity in her classroom rather than seeing it as a barrier to academic success. Ladson-Billings goes on to state that a culturally relevant teacher supports, “the development of socio-political or critical consciousness” (p. 483). In this respect she believed that teachers have an obligation

to educate their students to be active members of society and to question social inequalities.

A few years later, Geneva Gay (2003) took the definition of culturally relevant pedagogy, proposed by others, and began describing culturally responsive teaching practices in a similar way; “culturally responsive teaching is defined as using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively” (Gay 2003, p. 106). She believed that a culturally responsive teacher understood the cultural characteristics of his/her students and knew “detailed factual information about the cultural particularities of specific ethnic groups” (p. 107). Gay also felt that it was important for teachers to be able to modify the existing curriculum to address the needs of all students in the classroom, thus making connections between the students’ home and school environments. To address the needs of society as a whole, Gay noted that a culturally responsive teacher must create a positive learning environment, hold high expectations for all students, and communicate effectively with CLD students and their families. The final aspect of her vision for culturally responsive teacher was the use of learning strategies or, “the act of teaching is matching instructional techniques to the learning styles of diverse students” (p. 112).

Finally, Ana María Villegas and Tamara Lucas (2002) outlined a plan for curriculum development in the preparation of culturally responsive teachers:

Six Strands ... give coherence to our curriculum proposal for preparing culturally responsive teachers: (1) gaining sociocultural consciousness; (2) developing an affirming attitude towards students from culturally diverse backgrounds; (3) developing the commitment and skills to act as agents of change; (4) understanding the constructivist foundations of culturally responsive teaching; (5) learning about students and their communities; and (6) cultivating culturally responsive teaching practices. (p. 26)

This definition of a culturally responsive teaching combined many of the characteristics of Gay’s (2002) description of culturally responsive teachers.

The first strand of the Villegas and Lucas (2002) plan identified sociocultural consciousness as “an understanding that people’s way of thinking, behaving, and being are deeply influenced by such factors as race/ethnicity, social class, and language” (p. 22). Thus a culturally

responsive teacher takes the students' background into consideration when developing curriculum and interacting with students and their families. The second strand in their plan discussed the need for teachers to have an "affirming attitude towards students from culturally diverse backgrounds" (p. 23), meaning that culturally responsive teachers have high expectations for all students, they believe all students are capable of learning, and all students bring valuable experiences to the classroom. In the third strand, Villegas and Lucas call on culturally responsive teachers to "act as agents of change" (p. 5), to be willing to advocate for their students, and challenge the social inequities inherent in schools. The fourth strand described culturally responsive teachers' ability to assist their students in facilitating knowledge construction by building on what students bring with them to the classroom, thus having a constructivist view of learning. The fifth strand stresses the importance of teachers knowing their students and their communities. In this way culturally relevant teachers gain, "insight into how their students' past learning experiences have shaped their current views of school and school knowledge" (p. 26). The final strand sought to link all of the previous five strands in a comprehensive, all encompassing view of culturally responsive teachers and their ability to use what they know about their students to teach effectively.

In science education, Rutherford (1996) published a monograph that described the American Association for the Advancement of Science's (AAAS) Project 2061 and how teacher preparation could be enhanced through tools developed to support teachers in helping all students to "think critically and independently, and to lead interesting, responsible, and productive lives in a culture that is increasingly reliant on science and technology" (Rutherford 1996, p. 7). At the same time, the National Research Council published the National Science Education Standards. The standards for teaching addressed "what teachers of science at all grade levels should understand and be able to do" (NRC 1996, p. 4). There are six areas of focus: The planning of inquiry-based science programs, the actions taken to guide and facilitate student learning, the assessments made of teaching and student learning, the development of environments that enable students to learn science, the creation of communities of science learners, and the planning and development of the school science program (NRC 1996).

These four areas of the Standards all aim to provide teachers support structures in order to be effective in educating all children. The Standards also address the critical need to consider equity throughout the educational system and to promote in teachers a belief that all students can learn and contribute to the classroom by implementing strategies that are aimed at a diversity of learning cultures and styles. “The diversity of students’ needs, experiences, and backgrounds requires that teachers and schools support varied, high-quality opportunities for all students to learn science” (NRC 1996, p. 4).

After reviewing all the theories, plans, and suggestions related to effective teaching for CLD students, we found *culturally responsive teaching* to be the most inclusive term with the greatest potential for addressing both the internal and external characteristics of effective teachers.

Thematic categories to define culturally responsive teaching

During the second phase of the process to develop a model of culturally responsive teaching, the first author synthesized the literature into five themes related to culturally responsive teaching: (1) content integration, (2) facilitating knowledge construction, (3) prejudice reduction, (4) social justice, and (5) academic development. For the purposes of our model, these themes will be referred to as thematic categories. The synthesis of the literature also generated definitions of the teaching practices and dispositions related to each thematic category. Content integration was defined as the inclusion of content from many cultures, the fostering of positive teacher-student relationships, and holding high expectations for all students. The facilitation of knowledge construction was defined as the teachers’ ability to build on what the students know as they assist them in learning to be critical, independent thinkers who are open to other ways of knowing. Prejudice reduction was defined as the teacher’s ability to use a contextual factors approach to build a positive, safe classroom environment in which all students are free to learn regardless of their race/ ethnicity, social class, or language. Social justice was defined as a teacher’s willingness “to act as agents of change” (Villegas and Lucas 2002, p. 5), while encouraging their students to question and/or challenge the status quo in order to aid them in “the development of

sociopolitical or critical consciousness” (Ladson-Billings 1995, p. 483). Academic development was defined as the teacher’s ability to “create opportunities in the classroom” (Villegas and Davis 2007, p. 139) that aid all students in developing as learners to achieve academic success, and the use of research-based instructional strategies that reflect the needs of a diversity of backgrounds and learning styles (see **Table 1**). For the purposes of our model, these definitions serve as subcategories to help define the dispositions and behaviors associated with culturally responsive teaching.

Piloting and finalizing a model of culturally responsive teaching

The third and most critical aspect of the model development process was to use the thematic categories and subcategories as tools to assess culturally relevant teaching practices of undergraduate teacher candidates. This process allowed us to determine the usefulness of the categories and subcategories and to generate specific examples of teaching practices to represent each category. A qualitative exploratory case study was conducted involving 12, non-traditional, Latino/a students as they progressed through a teacher education program. A qualitative design such as this was appropriate since the outcomes of the study included descriptions and interpretations arising from discovery, insight, and analysis (Creswell 2007). These 12 candidates were part of a federally funded scholarship program known as Synergy as well as the federally funded Teacher Quality Enhancement grant, Equity & Access, that provided the infrastructure necessary for the delivery of a distance-based teacher education program. The 12 CLD teacher candidates completed all coursework for teacher licensure.

The 12 teacher candidates were followed from their first block of science and mathematics methods courses and field experiences through their final student teaching semester. During this time period, each candidate planned and taught multiple lessons and units and was observed numerous times by cooperating teachers, clinical instructors, and all three authors. Evidence from all science and math instruction was collected and analyzed, including: (1) artifacts of teaching such as philosophy of teaching statements, candidate summaries of classroom and school contextual factors, lesson plans, post teaching self-reflections, and logs of professional responsibilities; (2) observations of

teaching; (3) final evaluations of field experiences and student teaching; (4) as well as audio taped interviews. All interviews were audio taped and transcribed and observations were directly observed and recorded on notes or videotaped.

The first author used a thematic approach for analysis given the wide variety of qualitative data collected (Miles and Huberman 1994). Using the theoretical categories (Aronson 1994) to guide the analysis, she read and coded all data, making initial notes on the various texts (Lincoln and Guba 1985). She then created an electronic matrix document for each theoretical category with the student teacher names along the far left column and the subcategories as headings across the top. The data were re-examined for evidence to support each theoretical category and subcategory. The first author recorded example behaviors, phrases, and quotes under the appropriate theoretical category and subcategory on the matrix in columns adjacent to each candidate name. In this fashion an example of teaching practices was recorded for all 12 candidates under each category and most subcategories. The first author shared this analysis and the resulting matrix with the other two authors serving as peer debriefers to enhance the trustworthiness of the analysis. The peer debriefers examined all electronic matrix documents, results, and conclusion statements throughout the entire data analysis process.

This analysis validated the usefulness of the theoretical categories and subcategories and generated examples of teaching behaviors to clarify the meaning of each theoretical category (Hernandez 2011). The resulting matrix finalized the development process producing a model to guide and assess culturally responsive teaching (see Table 2).

Final thoughts

Evidence gathered from the 12 CLD teacher candidates was easily coded under each theoretical category: (1) content integration, (2) facilitating knowledge construction, (3) prejudice reduction, (4) social justice, and (5) academic development. The example behaviors, phrases, and quotes coded under each theoretical category revealed that the majority of participants demonstrated the use of cultural models as well as their like-cultural backgrounds in order to integrate

Table 1. Thematic Categories of Culturally Responsive Teaching

Banks (1980 and 2004) (Multicultural Ed)	Sonia Nieto (2004) (Multicultural Ed)	Gloria Ladson-Billings (1992) (CRT)	Geneva Gay (2000) (Cult. Resp. Tchng)	Villegas and Lucas (2002) (CRT)	Synthesis
<p>Content integration Content integration—the extent to which teachers use examples and content from a variety of cultures and groups to illustrate key concepts, principles, generalizations, and theories in their subject area or discipline</p>	<p>Pervasive—it permeates everything: the school climate, physical environment, curriculum, and relationships among teachers and students and community. Multicultural ed is a philosophy, a way of looking at the world, not simply a program or a class or a teacher. (p. 354)</p> <p><i>Critical pedagogy</i>—it acknowledges rather than suppresses cultural and linguistic diversity ...it reflects on multiple and contradictory perspectives to understand reality more fully. (p. 359)</p>	<p>Conceptions regarding self and others; they cajoled...the student to work at high intellectual levels; teachers made a conscious decision to be part of the community from which their students come; attempt to support and instill community pride</p>	<p>Is multidimensional—encompasses curriculum content, learning context, classroom climate, student-teacher relationship, instructional techniques, and performance assessments</p>	<p>(2) developing an affirming attitude towards students from culturally diverse backgrounds; acknowledge the existence and validity of a plurality of ways of thinking, talking, behaving, and learning. (p. 23)</p>	<p>Content integration is the inclusion of content from many cultures, the fostering of positive teacher-student relationships, holding high expectations for all students, and the use of research-based instructional strategies that reflect the needs of a diversity of backgrounds and learning styles</p>

Table 1 (continued). Thematic Categories of Culturally Responsive Teaching

Banks (1980 and 2004) (Multicultural Ed)	Sonia Nieto (2004) (Multicultural Ed)	Gloria Ladson-Billings (1992) (CRT)	Geneva Gay (2000) (Cult. Resp. Tchng)	Villegas and Lucas (2002) (CRT)	Synthesis
<p>Knowledge construction—the extent to which teachers help student understand, investigate, and determine...biases...influence...knowledge</p>	<p>Basic education—at the very least we would expect all students to be fluent in a language other than their own, aware of the literature and arts of many different peoples, and conversant with the history and geography not only of the US but also of African, Asian, Latin American, and European countries</p>	<p>Conceptions regarding knowledge: knowledge was about doing: teachers helped their students engage in a variety of forms of critical analyses</p>	<p>Is emancipatory—liberating in that it releases the intellect of students of color from the constraints of mainstream ways of knowing</p>	<p>(4) understanding the constructivist foundations of culturally responsive teaching: To support students' construction of knowledge, teachers must help learners build bridges between what they already know and believe about the topic at hand and the new ideas and experiences to which they are exposed. (p. 25) (6) cultivating culturally responsive teaching practices." (p. 27); create classroom environ. to encourage students to make sense of new ideas, rather than memorize information (p. 280</p>	<p>Facilitating Knowledge Construction is defined as the teacher's ability to build on what the students know as they assist them in learning to be critical, independent thinkers who are open to other ways of knowing</p>
Facilitating knowledge construction					

Table 1 (continued). Thematic Categories of Culturally Responsive Teaching

Banks (1980 and 2004) (Multicultural Ed)	Sonia Nieto (2004) (Multicultural Ed)	Gloria Ladson-Billings (1992) (CRT)	Geneva Gay (2000) (Cult. Resp. Tchng)	Villegas and Lucas (2002) (CRT)	Synthesis
<p>Prejudice reduction</p> <p>Prejudice reduction—focuses on the characteristics of students’ racial attitudes and how they can be modified by teaching methods and materials</p>	<p><i>Antiracist education</i>—pays attention to all areas in which some students are favored over others: the curriculum, choice of materials, sorting policies, and teachers’ interactions and relationships with students and their families</p> <p><i>Important for all students</i>—Multicultural ed. is by definition inclusive. ...it is about all people, it is also for all people, regardless of their ethnicity, social class, language, sexual orientation, religion, gender, race, or other difference ... students from the dominant culture need ME more than others because they are ... the most miseducated about diversity</p>	<p>A willingness to nurture and support cultural competence, while maintaining cultural integrity</p>	<p>Is transformative—defies conventions of traditional education; it is explicit about respecting the cultures and experiences of ethnic students of color and uses these as worthwhile resources for teaching and learning</p>	<p>(1) gaining sociocultural consciousness; an understanding that people’s ways of thinking, behaving, and being are deeply influenced by such factors as race/ethnicity, social class, and language. ...[they must come to] understand their own sociocultural identities but also come to recognize the intricate connection between schools and society. p. 22</p>	<p>Prejudice reduction is defined as the teacher’s ability to use a contextual factors approach to build a positive, safe classroom environment in which all students are free to learn regardless of their race/ethnicity, social class, or language</p>

Table 1 (continued). Thematic Categories of Culturally Responsive Teaching

	Banks (1980 and 2004) (Multicultural Ed)	Sonia Nieto (2004) (Multicultural Ed)	Gloria Ladson-Billings (1992) (CRT)	Geneva Gay (2000) (Cult. Resp. Tchng)	Villegas and Lucas (2002) (CRT)	Synthesis
Social justice	Empowering school culture—examination of grouping, labeling, sports participation, disproportionality in achievement, and the interaction of the staff and the students across ethnic and racial lines...	Education for social justice—developing a multicultural perspective means learning how to think in more inclusive and expansive ways, reflecting on what we learn, and applying that learning to real situations. (p. 355)	The development of sociopolitical or critical consciousness; helping students to recognize, understand, and critique current social inequalities	Is validating—using the cultural knowledge to make learning encounters more relevant and effective	(3) developing the commitment and skills to act as agents of change;	Social justice is the teacher's willingness "to act as agents of change" (Villegas), while encouraging their students to question and/or challenge the status quo in order to aid them in "the development of sociopolitical or critical consciousness" (Ladson-Billings)
Academic development	Equity pedagogy—exists when teachers modify their teaching in ways that facilitate ... achievement of students from diverse racial, cultural, and social class groups	<i>Is a process</i> —it is ongoing and dynamic, it involves primarily relationships among people, it concerns intangibles	An ability to develop students academically.	Is comprehensive—teach the whole child; high expectations, skill instruction, interpersonal relationships built; Is empowering—enables students to be better human beings and more successful learners; encourages students to take risks in learning	(5) learning about students and their communities; last paragraph p. 27...strategies to help preservice teachers create opportunities in the classroom...	Academic development is defined as the teacher's ability to "create opportunities in the classroom" (Villegas) that aid all students in developing as learners to achieve academic success

content while holding high expectations for all students. They facilitated knowledge construction by building on what their students knew and by using real world models to illustrate key scientific and mathematical concepts. All of the student teachers demonstrated their commitment to prejudice reduction through the use of native language support in the classroom as well as when communicating with parents. They also demonstrated techniques meant to foster positive student-student interactions, and to build a safe classroom environment. Although the social justice category was more difficult to analyze, there was evidence that one student teacher in particular advocated for her students directly, and at least three participants saw the need to encourage their students to think critically and socioculturally. Finally, all of the participants demonstrated their use of visuals, hands-on activities, modeling, and Sheltered Instruction to illustrate their ability to create opportunities in the classroom (Echevarria and Graves 1998) and to use research-based instructional strategies as evident in the academic development category.

It was a challenge to find evidence of dispositions or behaviors related to social justice. Consequently, this is the theoretical category with the fewest examples. Social justice was defined, from the review of the literature, as the teachers' willingness "to act as agents of change" (Villegas and Lucas 2002, p. 5), while encouraging their students to question and/or challenge the status quo in order to aid them in "the development of sociopolitical or critical consciousness" (Ladson-Billings 1995, p. 483). Only a few of the students actually discussed their need to advocate for their students and families as well as a desire to help them to develop a social conscious and to be positive members of society. However, since social justice is strongly linked to culturally responsive teaching in the literature and since our model of culturally responsive teaching was piloted on undergraduate teacher candidates, we have elected to maintain this component in our model.

Advocacy comes in many forms, and according to Villegas and Lucas (2007), "Teaching is an ethical obligation. ... To meet this obligation, teachers need to serve as advocates for their students, especially those who have been traditionally marginalized in schools" (p. 6). The way in which most of the student teachers demonstrated advocacy was during their interactions with the parents of the children in their classrooms during parent-teacher conferences. The development of

social consciousness also can be a challenging task for many teachers, especially those who are new to the classroom. “Not only must teachers encourage academic success and cultural competence, they must help students to recognize, understand, and critique current social inequalities” (Ladson-Billings 1995, p. 476). However, based on the data collected as part of this study, the teacher candidates did not illustrate or model the development of socio-political consciousness during science and math instruction.

Such actions can be daunting to a new teacher concerned about creating controversy in a community where they themselves have been marginalized. The purpose of schools can be defined using two areas of thought: (1) schools are meant to educate and challenge young minds to think critically and to become agents of change themselves, and (2) schools are meant to maintain the status quo. Unfortunately, the region of the Midwest where this study was conducted tends to hold the latter more conservative perspective. For example, the rapidly changing demographics of the community have not always been welcomed. Most of the 12 teacher candidates studied had worked in the school districts where they completed their student teacher internship and knew the political climate surrounding them. This could have deterred their efforts to advocate for change, especially given their tenuous position as teacher candidates.

So one barrier to assuming the role of agents of change may have been the teacher candidates' lack of experience, while another might have been the environment in which these teacher candidates trained, worked, and lived. Another possible reason social justice was not demonstrated is that, although a topic in several classes, social justice was simply not a strong enough component or not adequately modeled in our teacher education program particularly in terms of science education. Even though national standards include science in personal and social perspectives, traditional science teaching in the US is not politically or socially oriented. A final explanation is methodological. The data specifically collected during this study might not have been the best sources of evidence of social justice practices. Clearly, the theoretical category of social justice needs further exploration and validation in practice.

Table 2. A model of culturally responsive teaching

Content Integration		
<p>The inclusion of content from other cultures</p> <ul style="list-style-type: none"> • Incorporating information and/or examples from different cultures. • Making connections to students' everyday lives. • Relating teacher background to their CLD students through language and similarities in home culture. 	<p>The fostering of positive teacher-student relationships</p> <ul style="list-style-type: none"> • Building of positive student-teacher relationships • Building of a safe learning environment to participate in classroom discussions without fear of reprisals or negative comments from the teacher. 	<p>Holding high expectations</p> <ul style="list-style-type: none"> • Holding high expectations for all students in the science and math classroom. • Identifying the importance of high expectations in helping the students to achieve academically as well as socially.
Facilitating Knowledge Construction		
<p>Build on what the students know</p> <ul style="list-style-type: none"> • Demonstrating the ability to build on students' background/prior knowledge as a means to making science and math concepts accessible. 	<p>"Real world" examples</p> <ul style="list-style-type: none"> • Using 'real world' examples during science and math lessons, especially when introducing new concepts. 	<p>Assist students in learning to be critical, independent thinkers who are open to other ways of knowing</p> <ul style="list-style-type: none"> • Assisting students in effective communication. • Motivating students to desire to learn and think independently.
Prejudice Reduction		
<p>The use of native language support</p> <ul style="list-style-type: none"> • Using native language support for ELL students. • Communicating with parents in the native language. 	<p>Positive student-student interactions</p> <ul style="list-style-type: none"> • Fostering positive student-student interactions. 	<p>Safe learning environment</p> <ul style="list-style-type: none"> • Creating a safe environment.
Social Justice		
<p>The teacher's willingness to act as agents of change</p> <ul style="list-style-type: none"> • Advocating for students; act as agents of change. 	<p>Encouraging their students to question and/or challenge the status quo in order to aid them in the development of sociopolitical or critical consciousness accomplished through modeling</p> <ul style="list-style-type: none"> • Encouraging students to question and/or challenge the status quo. • Assisting students in becoming good citizens. 	
Academic Development		
<p>The teacher's ability to create opportunities in the classroom that aid all students in developing as learners to achieve academic success</p> <ul style="list-style-type: none"> • Using a variety of methods to create learning opportunities. • Using visuals, grouping, and hands-on or manipulatives during instruction in order to assist their students in meeting the objectives of the science and math lessons. • Using modeling to illustrate difficult science and math concepts. 	<p>The use of research-based instructional strategies that reflect the needs of a diversity of backgrounds and learning styles</p> <ul style="list-style-type: none"> • Using the sheltered instruction model as well as the SIOP model. • Using real world models such as rocks, plants, clocks, etc. when introducing new or difficult concepts in science and math lessons. • Using whole and small group collaborations. 	

Thoughts on the future of teacher education

As the findings and conclusions indicate, this study holds many implications for teacher education, both pre-service and in-service. Schools need teachers who not only understand the importance of effective science and math instruction, but also who understand the increasingly diverse students in their classrooms. To these ends, teacher education programs must develop strategies to educate all teachers to meet more effectively the needs of diverse learners and to integrate themselves more effectively into the communities where they will teach. In this study, we initially sought to create a framework for specifically identifying culturally responsive strategies in science and mathematics teaching. While content-specific strategies were identified, although not the focus of this paper, this comprehensive and integrated model is quite appropriate for use across content areas. The current model is a promising tool for comprehensively defining culturally responsive teaching in the context of teacher education as well as to guide curriculum and assessment changes aimed to increase candidates' culturally responsive knowledge and skills in key areas. For example, our use of this model indicated a need for coursework or programming that allows candidates to directly address social justice issues and provides methods for candidates to use in dealing with injustices when they encounter them in the schools.

Furthermore, an additional implication of this study relates to the need for a wide variety of data to document teaching behaviors and dispositions. In general, when assessing pre-service and in-service teacher effectiveness, institutions, such as school districts and colleges of education, often base their evaluations on lesson plans and teaching observations only. This study argues for a more comprehensive approach to data collection and evaluation of teacher effectiveness, particularly in demonstrating culturally responsive teaching for all students. Findings suggest multiple sources of data are needed to provide a complete picture of a student's ability or aptitude to be culturally responsive. This is especially true for teacher candidates who are themselves culturally and linguistically diverse. While formal observations are critical for assessing candidate's behaviors and dispositions in action, in order to capture the subtle, yet highly valuable, nuances of their beliefs and attitudes towards learners, additional

artifacts of teaching such as philosophy statements and self-reflections along with face-to-face interviews as well as clarifying discussions with teacher candidates also are essential.

Effective field experience models, such as the Professional Development School model, often have post-lesson debriefings built into their protocol for working with candidates in the field. As in this study, these discussion sessions provide a wealth of information that clarifies and/or expands on what was written in the plan or demonstrated in the lesson. We argue that these implications are applicable to the professional development and assessment of culturally responsive teaching among in-service teachers as well. This comprehensive and integrated model serves as a practical tool for moving culturally responsive teaching to the forefront in teacher education, especially in the fields of science and mathematics education that have historically struggled to integrate elements of multiculturalism into praxis.

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