Culturally Relevant Teaching in Science Classrooms:

Addressing Academic Achievement, Cultural Competence, and Critical Consciousness

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This article provides classroom examples and commentaries for extending and deepening culturally relevant science teaching efforts in classrooms. It examines instructional efforts used by one of the authors with high school and university students. Together, the three authors rethink and reconsider several aspects against a culturally relevant pedagogical backdrop. The commentary points out considerations for focusing on student achievement, cultural competence, and critical and sociopolitical consciousness. The necessity and difficulty of centering culture, equity, and power relations are emphasized.

The Sociopolitical Context

In light of challenges faced by the increasing racial and ethnic diversity among students in pre-K-12 schools in the U.S. and the accompanying decline in diversity among the population of teachers, culturally relevant teaching has become a promising and compelling educational and ethical consideration and movement (McKinley, Jones, & Castagno, 2008). However, conversations regarding culturally relevant teaching typically occur in academic circles and have been sluggish in reaching practitioners. In our professional development sessions with practitioners, science and mathematics teachers frequently misperceive culturally relevant teaching to be appropriate for language arts, social studies, and fine arts, but not for the so-called “hard sciences.” Responding to the need to make culturally relevant science discourse accessible to practitioners, this article provides three examples of a science teacher’s efforts and a commentary on how to go beyond superficial efforts and attain more authentic culturally relevant teaching.

During the last few decades, a considerable number of mathematics educators have addressed ethnomathematics and culturally relevant mathematics (e.g., Berry, 2008; Davis & Martin, 2008; Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Joseph, 1987; Ladson-Billings, 1997; Lynn, 2006; Martin, 2007; Matthews, 2003; Rousseau & Tate, 2003; Tate, 1995). Likewise, there has been a shift from the notion that science education is value- and culture-free, and ethnoscience is also on the rise (Kahle, Meece, & Scantlebury, 2000; Lee & Buxton, 2008; Lee & Luykx, 2007; Luykx & Lee, 2007; Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006; Roth & Tobin, 2007).

Based on our experiences and perusal of literature, there are few classroom models of culturally relevant science (and mathematics) teaching. The lack of translation of cultural aspects of science to the classroom may be explained in part by the low priority placed on science in schools (Wood & Lewthwaite, 2008). Despite academic science literature to the contrary, the narrow definition of science education as the teaching of “facts” is quite common in schools, coupled with a general absence of instruction and curriculum regarding the ways in which culturally and linguistically diverse students’ knowledge and experiences relate to science disciplines (Emdin, 2010; Lee & Luykx, 2005). As is typical in the academy, there is much theoretical talk about culturally relevant pedagogy, but few explicit classroom examples which help teachers envision possibilities and gain insight on ways to deepen their understanding of the complexities involved in the process. As one science educator recently queried, *so how does culturally relevant teaching look in an actual classroom*?

In this article, we share three examples of initial ventures by one of the authors[1] into using culturally relevant science teaching as a viable possibility for bridging the distances between school instruction and ways of knowing and realities within the homes and communities of culturally diverse students. We focus specifically on African American students, but the general tenets can be extrapolated for other cultural groups as well. As African American professors, we find that many educators do not tend to think of African American students in cultural terms (Ladson-Billings, 2000). However, we recognize African Americans as a distinct cultural group which shares collective experiences and lived realities that extend across socioeconomic and geographical boundaries (Boykin, 1994; King, 2005; Ladson-Billings, 1999, 2000). While African

Americans hold multiple identities and are not monolithic, we also share collective memories, history, and contemporary realities that cannot be overlooked or disregarded.

Drawing from Martin's (2007) framework, three types of knowledge/skills are needed to teach African American students effectively: 1) deep content knowledge; 2) strong pedagogical content knowledge; and 3) strong culturally relevant pedagogy. The first two are frequently discussed and are not the focus of this article. Sharing concrete examples of culturally relevant science teaching is both a strength and caveat of this article. On the one hand, sample classroom examples can illuminate the process for teachers and help translate theory into practice. On the other hand, readers may overlook the complexities of the process and reduce it to "recipes" or activities. Our intent is to suggest general *tenets* for the process of changing the *structure, assumptions, and nature* of science teaching. Like the examples presented, it is not unusual for practitioners to begin the process by adding multicultural information and contributions of famous people into the existing curriculum. This article provides insights and guidance for practitioners who wish to deepen their efforts in using a culturally relevant pedagogical framework. We conclude that without centering issues of power, equity, and culture, efforts will remain superficial and will not likely address the intended long-term goals of reducing structural inequities in school and society (Castagno, 2009).

Culturally Relevant Pedagogy (CRP)

Culturally relevant pedagogy "empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (Ladson-Billings, 1994, p. 18). Teachers who practice culturally relevant teaching use cultural knowledge, prior experiences, frames of reference, and performance styles of culturally and linguistically diverse (CLD) students to make learning encounters more relevant to and effective for them (Bonner, 2009; Gay, 2000). Culturally relevant teaching focuses on: 1) academic excellence that is not based on cultural deficit models of school failure; 2) cultural competence which locates excellence within the context of the students' community and cultural identities; and 3) critical consciousness which challenges inequitable school and societal structures (Ladson-Billings, 2002). While many erroneously think that the main focus of culturally relevant teaching is solely on affirmation of CLD students, it should be stressed that *academic achievement* is a central goal of culturally relevant teaching. Unquestioningly, as students become culturally competent, their cultures are indeed affirmed (as is currently the norm for White students in most schools). However, culturally relevant teaching *must* result in student learning. Unlike most classrooms, culturally relevant classrooms do not devalue the cultural knowledge and worldviews of students of color. Students' learning is placed in a relevant context while students also become more proficient at understanding their cultures. The critical consciousness/sociopolitical dimension of culturally relevant pedagogy offers a critique to the notion that content knowledge and content pedagogical knowledge are neutral and "objective." The cultural fingerprints of content knowledge and instruction are made evident, critiqued, deconstructed, and reconstructed. Culturally relevant pedagogy (CRP) assumes that the way teachers teach profoundly impacts students' perceptions of the content of the curriculum (Ladson-Billings, 1994). Culturally relevant pedagogy can be eloquently summarized by Ellison (2008),

> [I]f you can show me how I can cling to that which is real to me, while teaching me a way into the larger society, then I will not only drop my defenses and my hostility, but I will sing your praises and help you to make the desert bear fruit [no pagination].

Culturally contextualized instruction holds the most promise for the academic success not only for students of color but for White students as well (Pritchy-Smith, 1998). In order to develop exemplary abilities in any content area, teachers must be able to link instruction to what is already familiar to their students. This may require teachers to engage in micro-ethnographies of sorts to develop an in-depth understanding of children's communities, families, leisure activities, and worldviews. Culturally relevant teaching includes not only learning *about* the lives of CLD students, but learning *from* them as well. Information learned about and from students can be used to transform classrooms into culturally relevant contexts.

Culturally Relevant Science Instruction

Culturally relevant teaching is congruent with the national science education standards (National Science Teachers Association, 2003) definition of scientific inquiry: "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (National Research Council, 2000, p. 23). However, a key distinction between scientific inquiry and culturally relevant science is the degree of emphasis on sociopolitical and critical analyses. In the examples that we share, we explicitly make the point that conventional instruction, curriculum, and assessment will need to be rethought and reframed in culturally relevant classrooms.

Colombian ethnolinguist, Mario Edgar Hoyos, distinguishes between *curriculum* and *curricula* (M. E. Hoyos, personal communication, September 24, 2007). He defines *curriculum* as the "typical Eurocentric course of study and content that is thinly disguised as universal and classic. It is a universalistic, one-size-fits-all model" that is typically used in classrooms. Contrastingly, *curricula* are described as powerful and multiple possibilities, adaptations, modifications, and deconstructions of the former which allow for a broader, comprehensive, and more varied version of the former curriculum. In the case of the author's (CKJ) classroom, centering African and African American culture moves the narrowly defined *curriculum* to the status of *curricula* which is more inclusive. Like other scholars studying culturally relevant science (McKinley, Jones, & Castagno, 2008), CKJ wanted to know, ''How can science teachers enable all students to study a Western scientific way of knowing and at the same time respect and access the ideas, beliefs, and values of non-Western cultures?'' (p. 743). Her intent was not to supplant the "science curriculum." Rather, she sought to add multiple perspectives, critiques, and counter-stories which required attention to particular cultural contexts. Consider the three examples below, followed by a tri-vocal commentary by all three authors, including CKJ.

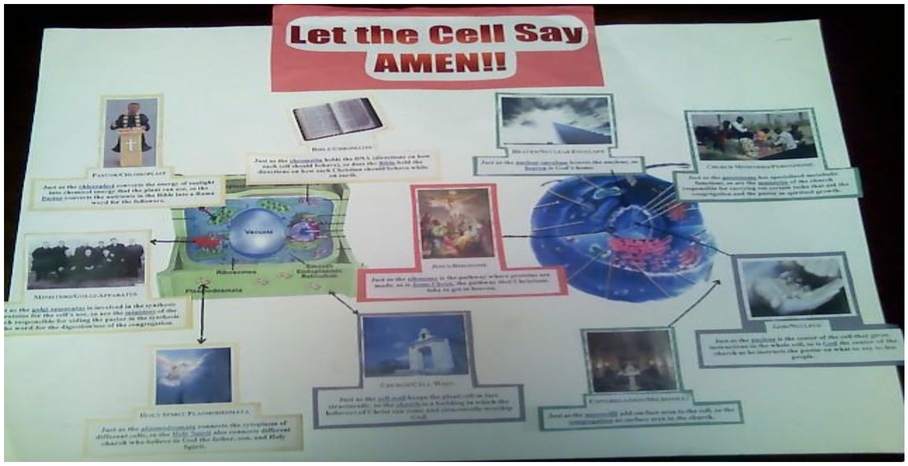
CRP Example 1: Cell Analogies Collage

CKJ's interest in learning how to teach science more effectively to African American students led her to venture into culturally relevant teaching. Her openness to feedback indicates that she views herself as a learner who recognizes that becoming a culturally relevant teacher is an ongoing journey. As will become evident, her first efforts focused primarily on engaging students (with little or no emphasis on critical and sociopolitical consciousness). With an unspoken and commonly espoused goal of increasing the number of African American scientists, she sought to increase students' critical thinking skills by demonstrating the interdisciplinary nature of science and defying the notion that science learning is boring and irrelevant to real life settings. She also wanted students to learn scientific terminology which could be used in dialogue with other scientists and in understanding science content.

Balancing her expectation for students to learn the course's content with the realization that students did not find the mundane memorization of science vocabulary engaging, she reasoned that the study of cells would lend itself to interesting and relevant activities. CKJ found and adapted a cell analogies collage from AccessExcellence.org. The activity challenges students to make original analogies between cell structures and everyday objects and experiences.

To learn the chapter's vocabulary words, students were asked to use personal references to develop analogies. CKJ spent time explaining analogies and giving examples (e.g., "The nucleus is like a brain because it controls and coordinates the activities of the whole cell in the same way the brain controls and coordinates activities of the body"). Students had to select at least 10 words from the chapter's vocabulary list. At first her students showed little enthusiasm, but when they were able to bring their own interpretations, they became invigorated. They found magazine and newspaper pictures of everyday objects that had personal or cultural references that also had a similar function (or use) as each cell structure or organelle. Students used themes such as: 1) *Let the Cells Say Amen* (See Figure 1 and Table 1 in the Appendix); 2) *What's a Cell to a Cello?*; 3) *CEO and Cells*; and 4) *Willy Wonka and the Chocolate Factory*. This activity implicitly and explicitly taught students the strategy of inventorying their interests and passions and relating it to what they were learning. In many ways, it validated the students' worldviews and experiences, and they began to see science as less remote and the terminology as less convoluted.

Figure 1. Cell analogy using Christianity



In terms of outcomes, CKJ's efforts helped improve student achievement, engagement, and interest. To hear students who had historically experienced little success in science exclaim their interest in taking other coursework was its own reward. Even more importantly, CKJ has noted that her efforts to engage students culturally and actively over the past four years have resulted in increased vocabulary scores and critical reasoning. For example, students' test scores from this chapter ranged from 75-90% instead of the typical 60-85% when analogies were not used as an instructional strategy.

Commentary on CKJ's Cell Collage Activity

Viewing the cell collage activity through the lens of the three dimensions of culturally relevant teaching (academic achievement, cultural competence, and critical consciousness), this activity produced mixed results. Academically, according to the records, students increased their passing rates on the vocabulary tests and are now more likely to integrate the vocabulary into their discussions and to understand scientific terminology. Yet, this is a very cursory level of achievement, and we do not want to leave the impression that culturally relevant teaching can be reduced to a bag of pedagogical tricks or one-time activities. All of us agree that an isolated activity cannot meet the larger goal of reversing students' unfavorable view of science or increasing the likelihood of pursuing careers in science. The activity can serve as a rudimentary introduction to the notion that students can view concepts through their own cultural and personal lenses. Yet, this notion has to be probed through ongoing dialogic exchanges and opportunities to **read** and **act** on their lived experiences and worlds (Freire, 1970/1999). Students can explore who they are and what they already know and how this applies to science in their personal spaces. Importantly, they will need opportunities to examine whose ideologies, knowledge, and worldviews are represented in the content and standards and whose are not. We will discuss this later after examining all three activities. While CKJ does a series of interesting and engaging activities in her classroom, they are loosely connected and would benefit from a cohesive, culturally relevant pedagogical framework which extends beyond definitions of academic achievement that are narrowly defined by mastery of the chapter's vocabulary.

So what about increasing the students' cultural competence? Many African American students have had little or no exposure to information regarding scientists in the African diaspora. Whenever possible, CKJ provides powerful counter-narratives by using scientists of color (and females) so that students understand that science is not the purview of White men and also learn of strong science legacies among people of the African disapora. A caveat is that cultural information presented should not be fragmented, presented on the periphery of the unit, or glossed over (Boutte, 1999). A good place to start is to explore scientific funds of knowledge in students' own communities and spaces.

Discussion on cells can include the work of scientists like Dr. Ernest Just (Black Inventor, 2010; Hayden, 1970) whose work has not been amplified in most science books. Dr. Just sought to understand the world of the cell and sought to find "truth" using scientific methods and inquiry, challenging the theories of leading biologists of the 19th and 20th centuries. His scholarship contributed to scientific understanding of the process of artificial parthenogenesis and the physiology of cell development.

Culturally relevant pedagogy should not be narrowly defined as teaching only within the classroom setting, but should keep larger global perspectives and relevance to real world events as important considerations. Students who are faced with daily inequities are likely to identify Dr. Just's experiences with racism and prejudice which ultimately led him to leave the United States and study in Europe in 1930. Comparisons and contrasts between various eras can also be discussed.

Dialogue regarding the different epistemological stances and the idea of "truth" can be **critically** explored. Doing so will require CKJ and other science educators to suspend the typical **covering** of topics to the **uncovering** of multiple perspectives. Yet, given the realities of classrooms, educators often fear that dialogues of interrelated issues not included in the **standards** will detract from student learning. In CKJ's case, we can see that this was not the case and the academic outcomes of students were increased. More importantly, students actually liked CKJ's classes and enjoyed learning about science.

As CKJ continues to develop her culturally relevant pedagogical skills, she can begin to help students increase their sense of agency as scientists. This can lead to inquiry efforts which address ethnoscientific problems in their communities and in the world, such as investigating the relationship of zinc levels and prostate cancer in African American males. CKJ may also consider using hip hop pedagogy to teach science concepts as well as to critique scientific racism (Emdin, 2008).

CRP Example 2: Extracting DNA Activities

This series of activities was done with a group of African American high school students as part of a summer program designed to increase students' awareness and interest in science-related disciplines and careers. The DNA extraction activity introduces students to various biological techniques. The activity integrated technology by having students visit the *Extracting DNA-Virtual Lab* (http://learn.genetics.utah.edu/content/labs/extraction/).The website provides students with a general idea of the process of extraction and its importance in biotechnology. Students followed links from the virtual lab to: *Extracting DNA from Anything* http://learn.genetics.utah.edu/content/labs/extraction/howto/. This activity was completed in class using various items such as chicken liver, strawberries, green split peas, and/or broccoli. Because most of the students were familiar with Crime Scene Investigation (CSI) television shows (e.g., *CSI-Miami, CSI-Las Vegas, and CSI-New York*), the idea of studying DNA biotechniques connected to their lives on some level. The shows allowed students to see how practical applications of DNA technology are used in our daily lives, from medical applications to forensic evidence. Additionally, students are familiar with talk shows such as *Maury*, which use DNA samples to determine paternity. This prior knowledge is useful in introducing students to the concept of ABO and Rh blood typing, invaluable tools in the fields of medicine and criminology.

For this activity, students tested four synthetic blood samples to identify the ABO and Rh blood types (see Figure 2). This activity introduced students to different blood types and how blood types are inherited. To reinforce students' knowledge and to show cultural relevance, students identified and researched a selected blood disorder or condition (i.e., thrombosis and sickle cell). Engaging in scientific inquiry, the product of this assignment was a PowerPoint Presentation® which included: 1) causes; 2) diagnosis; 3) symptoms and complications; 4) data and statistics with a special focus on how it relates to African American populations; 5) tips for healthy living (again with a focus on the cultural relevance); and 6) the cost to society.

Figure 2. Students working on DNA samples provide a counternarrative to dominant imagery of White and male scientists.

Commentary on DNA Activities

Typical for initial ventures into culturally relevant teaching, an underlying subtext of the activity is for students to have "fun" and to be actively engaged. Some aspects of all three dimensions of CRP are evident but can be prodded.

This unit yields itself to the possibility of investigating genealogy studies that are being conducted by The National Geographic (2010) researchers and others who collect mitochondrial DNA and/or Y chromosomes. This can lead to very complex dialogues of genetics and history (e.g., how African Americans genealogies were affected by the trans-Atlantic slave trade and related ethical issues). Opening up such possibilities could lead young scientists (students) to pursue efforts which may be useful one day in providing African Americans with more information about their African lineage which was systematically destroyed during the slave trade.

A critique of Nobel Prize winner James Watson's scientific work in light of his recent racist statements about Africans and Blacks being intellectually inferior (Boston Globe, 2007) could also be reexamined regarding the role that his beliefs may have played in research questions and conclusions. A dialogue on the topic helps make "scientists" less remote and also allows for examination of the relationship to research, questions posed, methods used, and biases. Seeing science as a human and cultural construction is key.

Charles Drew's (Black Inventor, 2010; Lonesome & Huggins, 1990; Love & Franklin, 1997; Whitehurst, 2001) discoveries relating to the preservation of blood could serve as a counternarrative to discussing only White scientists. By separating the liquid red blood cells from the near solid plasma and freezing the two separately, Drew found that blood could be preserved and reconstituted at a later date. His system for the storing of blood plasma (blood bank) revolutionized the medical profession. He also established the American Red Cross blood bank, of which he was the first director, and he organized the world's first blood bank drive, nicknamed "Blood for Britain."

Sociopolitically, students can discuss the controversy surrounding Dr. Drew's death. While driving to a science convention, he fell asleep and was seriously injured in rural North Carolina. In 1950, in the South, Dr. Drew was not admitted to an "all-White" hospital. Students can research the details of his death to determine the role that racism played. Some sources indicate that Dr. Drew needed a transfusion and was denied one; others disagree and said that he was not admitted to the White hospital, but was admitted to a "mixed-race" medical facility (Black Inventor/Drew, 2010). Dialogue, inquiry, and critical analyses on this topic position students as teachers/learners, which is the hallmark of culturally relevant science teaching. It also connects science to other disciplines such as history in this case and can propel students to take reflective action to address global problems in their communities and in society.

CPR Example 3: Integumentary System Unit

CKJ was able to see numerous possibilities for making the study of the integumentary system accessible to her university freshmen biology students. Given the sociopolitical nature of skin color, studying the integumentary system lends itself to a discussion of melanin (different levels of melanin by racial groups, skin tones, and benefits).

Since science is conceived as a socially and culturally constructed discipline, the inclusion of non-Western, indigenous, or other racial/ethnic traditions of knowing is important in culturally relevant science classrooms (Lee & Buxton, 2008). For example, CKJ's discussion of skin and hair led to the discussion of Madame C. J. Walker's (2010) development of Black hair products as well as the politics of Black hair. Chemical names of specific hair dressings, the impact that chemicals have on hair, as well as the safety and potential dangers of inadequate testing can be included. Even in racially integrated classes, through scientific inquiry students can examine their own personal hair/skin care products including testing, marketing, and ingredients for different types of skin and hair. While African American students can certainly serve as experts and informants on Black hair, educators will also need to spend some time studying Black hair in order to present information in a culturally informed manner.

It is important to note that in culturally relevant classrooms, conventional methods and assessments may be used when appropriate. For example, CKJ consulted the following website, and students tackled mini and mega quizzes on the topic: http://www.zoology.ubc.ca/~biomania/tutorial/skin/outline.htm. In this example, not only did this unit allow students to understand the basics of the integumentary system as one of our body's systems, but they were able to connect the concepts to their daily living experiences and worldviews as well.

Many students were excited to learn more about Madame C. J. Walker (Altman, 1997) and realized that she played a role in their learning about science and science ethics. Most of the students surmised that Ms. Walker tested her products either on herself or family and friends and understood that her products were not tested to the extent products are tested today. The healthy discourse students had about product testing was refreshing, especially as they discussed their homemade hair/skin care products. In the end, students had a better understanding about skin and hair and the ethics and safety of product testing. They also were able to see how culture is related to modern day science, which was the underlining goal of the unit.

Commentary on Integumentary System

As in the first two activities, CKJ uses the textbook curriculum as the main source of ideas so that she can address the course's objectives. Yet, as she thinks about Hoya's conception of **curricula**, she understands that the unit can be revisioned based on students' interests. At some point, CKJ may allow students to peruse the syllabus and textbook to determine particular areas of interest that they can engage in in-depth study. Small group inquiries into subjects may help students start to transform the view of science as a pre-set and non-dynamic subject. Allowing them to engage in "scientific processes" (not necessarily standard processes) will be an important part of capturing students' voices and promoting critical consciousness. Here students can learn that many worldviews can and do co-exist. That is, they can come to understand that the textbook is one of many ways of knowing and that theirs may be another epistemology. Hence, they can become proficient in the "mandated" way of knowing alongside their cultural ideas, beliefs, and values (McKinley, Jones, & Castagno, 2008). From a critical point of view, contradictions between various epistemologies do not have to be reconciled. The following section suggests sample topics that may stimulate provocative dialogue and research by students and teachers. The topics are difficult and educators should be willing to position themselves as learners since addressing many of the issues will require consulting several sources and a willingness to accept non-resolution as a possibility for future study.

Problematizing Science as "Factual" and Uncovering Scientific Racism

Probably the most difficult and surprising revelation for teachers and teacher educators who do this culturally relevant pedagogical (CRP) work is that they have to move beyond the typical *neutral, apolitical* stance in science and actively address oppression. This dimension is more than many teachers bargain for or are ready to address. Yet, without doing so, hegemonic principles and Eurocentric knowledge and ways of knowing are unintentionally privileged and reinforced.

In culturally relevant science classrooms, the assumption is that science involves inquiring into one's own world. Hence, science content is not decontextualized from students' and teachers' everyday experiences. Overall, CKJ's activities and engagements sought to tap into students' interests; however, a key part of culturally relevant pedagogy (CRP) is addressing power relations. Because science, like other subjects, is cultural (Lee & Buxton, 2008), inevitably the way that we think about science in the United States reinforces existing power relations in society. That is, Western and European knowledge is privileged in textbooks and classrooms (Barton, Ermer, Burkett, & Osborne, 2003; Davis & Martin, 2008; Ryan, 2008). This CRP framework lends itself to potentially interesting discussions and inquiries in classrooms regarding why the worldviews of some groups are marginalized and devalued. It gives educators a chance to reexamine science content and to problematize the widespread Eurocentric bias in the production and evaluation of scientific knowledge (Davis & Martin, 2008; Gould, 1981; Joseph, 1987). Difficult sociopolitical concepts like *scientific racism* can be explored, and students *and* teachers can begin to uncover inaccurate and incomplete information in the science literature.

"Scientific racism can be defined as the use of scientific methods to support and validate racist beliefs about African Americans and other groups' [sic] based on the existence and significance of racial categories that form a hierarchy of races that support political and ideological positions of white supremacy" (Davis & Martin, 2008, p. 14).

Many students of color recognize the existence of scientific racism even if it is not overtly named by them. This tacit and/or cultural knowledge may manifest itself as resistance to science as is currently taught (Boutte, 2002; Kohl, 2007). Notwithstanding, science educators will need preparation for leading discussions on scientific racism and other sociopolitical realties. Admittedly, this dimension of culturally relevant teaching is typically not addressed because of educators' discomfort and/or little preparation. CRP is openly political whereas conventional teaching is not. Helping educators see the political nature of conventional teaching which privileges Eurocentric culture and positivist epistemologies is a formidable task.

To illustrate the Eurocentric nature of science, consider the typical "linear" steps for the "scientific method" as a framework for investigating the natural world. "Within this tradition, Jean Lamark is credited with discovering a theory of evolution, Watson and Crick discovered the structure of the DNA molecule, and Boyle discovered gas laws" (Barba, 1995, p. 56).

The step-driven scientific method is presented as a single way of investigating the world rather than as open to multifaceted possibilities (Boutte, 1999). According to this line of reasoning, if a scientist or group of people does not follow the step formula, the results are typically not considered "scientific." Yet, for thousands of years, Native Americans of the Southwestern United States, South America, and Central America have cultivated corn. Each year the biggest and best ears of corn were saved by the harvesters and used as seeds the following year. The tradition of sowing only genetically superior seeds resulted in the improvement of corn from stubby little weeds into the current version of well-formed ears of corn (Barba, 1995).

In this example, Native Americans followed a scientific process (identified the problem, collected information about which ears of corn were the best, formed the hypothesis that planting the biggest seeds would result in an improved plant, conducted experiments in plant growth for thousands of years, and passed on the findings orally to their children). However, Native Americans are not viewed as the founders of genetics research because they did not keep written records of their research or present findings for peer review in the "scientific" community. Credit for the discovery of genetics research is given to Gregor Mendel in many science textbooks. Sociopolitically, culturally relevant teaching would question whether Mendel alone discovered genetics research and would explore evidence of others who had previously discovered this. A Eurocentric view of science which insists on keeping copious notes, writing reports and the like, dismisses and overlooks the research of generations of Native Americans (Barba, 1995). Here it becomes obvious that science is not "objective," "neutral," or "factual." Like all disciplines, it represents the worldviews of the writers of the (science) texts. Why would a Native American or other student of color find this version of science credible, especially when Eurocentric worldviews dominate the texts and discounts other versions?

Current science content which is dominated by discoveries attributed to White males also omits contributions from women whose work was frequently claimed by White male colleagues or husbands (Barba, 1995; Ryan, 2008). There are numerous other examples beyond the scope of this article: Onesimus, an African American slave who shared information from Africa with his master about the smallpox vaccine; Maria Aimee Lullin's discoveries regarding honeybees published under her husband's name, Francois Huber; Rosalind Franklin's contribution to the discovery of Deoxyribonucleic Acid (DNA) being credited to the works of only Watson and Crick; countless unrecorded instances which demonstrate how scientific contributions of women and people of color were deliberately omitted from "scientific" records and false information conveyed to generations of students. Dialogue on such topics reframes science from being static to dynamic and intimates that as more accurate and complete information is uncovered the knowledge base in science should reflect these changes (Kuhn, 1996). Additionally, students can start to look for examples of science in their everyday occurrences.

Traditionally, science content has focused on "received" knowledge which is dominated by Eurocentric thought. Hence, the focus has too often been on giving the right answer versus problem solving and problem posing (Freire, 1970/1999). Culturally relevant pedagogy acknowledges that the history of science and science teaching has been oversimplified. Hence, it seeks to explore science from various ages and civilizations throughout human history.

Given the backdrop of "traditional" approaches, culturally relevant science aims to include voices and worldviews that have been silenced and excluded from the curriculum (Barton, Ermer, Burkett, & Osborne, 2003; Keane, 2008; Mckinley, Brayboy, & Castagno, 2008; Ryan, 2008). This does not mean negating or excluding information from Eurocentric or Western worldviews, but it does mean substantively including other worldviews as opposed to occasional or fragmented instances. Without culturally relevant science approaches, not only will a variety of worldviews be omitted, but existing hegemonic power structures will be reinforced (Ryan, 2008). From a critically conscious perspective, students will move beyond false binaries, dualistic and/or essentialist views which suggest that there is *one* way of knowing science (Fleer, 2008). Hence, when they come to understand that science is also about people's relationships to others and to the phenomenal world, many perspectives (even contradictory or oppositional ones) can co-exist (Fleer, 2008; Keane, 2008). Conceptually, culturally relevant science defies the assertion that there is a singular or normative scientific worldview. It recognizes that there is a wide range of scientific skills and ways of knowing that people display in their lived experiences within diverse communities.

Pedagogically, Fleer (2008) recommends that teachers use a "double move" approach in which they have in mind the everyday practices, traditions, or concepts of their students as well as the Western scientific concept(s) that they want students to acquire. "Having both in mind (double move) allows teachers to be respectful and mindful of the practice traditions, whilst at the same time seeking pedagogical ways of giving more meaning to Western scientific concepts" (Fleer, 2008, p. 785).

It is particularly important for science educators to rethink their approaches for teaching science since many students consider it irrelevant to their lives (Barba, 1995; Boutte, 1999; Lee & Buxton, 2008). Additionally, females and students of color (with the exception of Asian Americans as a group) tend to do less well than White males in science (Boutte, 1999). While no cultural group is monolithic, the inclusion of culturally syntonic considerations for diverse learners is suggested. That is, attention should be given to see if the instruction, curriculum, and assessments are attuned to the students' cultural worldviews. Culturally syntonic examples can include making sure that the imagery in textbooks and classrooms reflect the students, the use of culturally familiar role models, or classroom activities which build on the communication strengths of the students: e.g., oral tradition for African American students (Barba, 1995; Lee & Luykx, 2005).

Conclusion

It is commendable that educators like CKJ have the presence of mind and commitment to believe that high achievement is possible for African American students. The expectation that educators will be able to transform their classrooms overnight is unreasonable and unfeasible. It is important to recognize the hugeness and complexity of what educators on the frontline are up against: the status quo which has built-in reinforcements to protect itself. So we applaud CKJ's efforts while acknowledging that she must delve deeper and be vigilant about addressing issues of equity, power, and culture. Currently, she is focusing narrowly on individual activities which primarily emanate from the textbook.

Since culturally relevant teaching is a bridge to mainstream and other ways of knowing, not all activities/lessons included in classes are expected to focus only on students' respective cultural groups. Understanding students and developing strong relationships and respect is foundational to the process (Bonner, 2009). We have tried to capture a deep sense of centering culture, politics, and achievement in classrooms for culturally and linguistically diverse students. One goal is to find ways to normalize high achievement for African American students so that they will realize and regain their historical legacies of achieving. To do so requires becoming familiar with the context, students, and their cultures. Often additional reading will be necessary, as well as deconstructing, reconstructing, and reframing science teaching to African American and other culturally and linguistically diverse students. Educators will need to engage in an ongoing process of countering pervasive and long-held disbeliefs that African American students are scientifically brilliant and capable. While our focus has been on African American students (whom we do not consider to be monolithic, by the way), the same process is required for other cultural groups. Educators will need to be well-versed in the academic literature and ethnographic information about the centrality of culture in teaching and learning. Attention will need to be given to the educational, social, and political implications of our role as educators in privileging the work and worldviews of White male scientists in classroom instruction and curriculum.

In the process, educators may need to reposition themselves as teachers and learners (Freire, 1970/1999) and view students as a source of information, letting them research topics. Community members and others are also sources of wisdom (Boutte & Hill, 2006). Collaboration with other science educators will likely make the process more interesting and insightful as well as less threatening. Like scientific inquiry, the process of culturally relevant teaching is a dynamic and ongoing process. Educators will need to remain open to refining and transforming their thinking. Culturally relevant teaching is a continuous quest, not a destination. It is hoped that teachers engage in culturally relevant pedagogy not solely to reduce the "achievement gap" or as a trend, but because it is an ethical and educational imperative that all students be effectively taught in light of pervasive and persistent educational trends.

Note

1. We will refer to the author by her initials (CKJ) throughout the article.

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Appendix

Table 1. “Let The Cell Say Amen”: A student project for the Cell Analogies Collage assignment that used Christianity analogies

1. *Chloroplast=Pastor*: the chloroplast converts energy of sunlight into chemical energy that the plant can use as the pastor converts the nutrients in the Bible into a Rama word for the followers
2. *Chromatin=Bible*: the chromatin holds the DNA (directions on how each cell should behave) as the Bible holds the directions on how each Christian should behave while on earth
3. *Nucleus=God*: the nucleus is the center of the cell that gives instructions to the whole cell as God is the center of the church as he instructs the pastor on what to say to his people
4. *Cell Wall=Church*: the cell wall keeps the plant cell intact structurally as the church is a building where the believers of Christ can come and structurally worship God.
5. *Microvilli=Congregation*: the microvilli add surface area to the cell as the congregation adds surface area to the church.
6. *Golgi Apparatus=Ministers*: the golgi apparatus is involved in the synthesis of proteins for the cell's use as ministers of the church are responsible for aiding the pastor in the synthesis of the word for the digestion/use of the congregation.
7. *Plasmodesmata=Holy Spirit*: the plasmodesmata connects the cytoplasm of different cells as the Holy Spirit connect different churches who believe in God, the father, son, and Holy Spirit
8. *Ribosome=Jesus*: the ribosome is the pathway where proteins are made as Jesus Christ is the pathway that Christians take to get to heaven
9. *Nuclear Envelope=Heaven*: the nuclear envelope houses the nucleus as heaven is God’s home
10. *Peroxisome=Church Ministries*: the peroxisome has specialized metabolic functions, as the ministries of the church are responsible for carrying out certain tasks that aid the congregation and the pastor in spiritual growth.