# Chapter 39
# Science Education Research Involving Blacks in the USA During 1997–2007: Synthesis, Critique, and Recommendations

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In the mid-1990s in the USA, equity by way of the slogan "science for all" became more prominent in science education discourse. Debates, efforts, and research on how to achieve equity in science education ensued. In this chapter, the authors review research studies in science education involving one US group for which equity has historically been and continues to be an issue. The authors review investigations from 1997 to 2007 involving Blacks, a general term used to denote African-Americans who are individuals with an African ancestry directly linked to the founding of the USA, and Blacks who are individuals of the African Diaspora who immigrated to the USA. The authors synthesize the literature and discuss the relevancy of the literature corpus to the status of US Blacks in science education.

The chapter contains five major sections. The first section details the selection of studies. The second and third sections describe the more recent context of US science education. In the fourth section the authors present a synthesis of the science education research and the usefulness of the research in relation to the status of Blacks in science education is the focus of the final section.

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## Literature Identification

Using the terms "Black" and "African-American," the authors thoroughly searched science education research journals with impact factors that placed them among the top 100 journals in education and educational research journals in the Social Science Citation Index. The impact factor represented the average number of times articles from a specific journal published in 2005 and 2006 had been cited in 2007 Journal Citation Reports (JCR). JCR calculated the impact factor by dividing the number of citations in 2007 by the total number of articles published in 2005 and 2006. The JCR list of 100 education and educational research journals included the following science education research journals: *Journal of Research in Science Teaching*, *Science Education*, *International Journal of Science Education*, and *Research in Science Education*. Because research published in the previously listed journals frequently cited research from the *Electronic Journal of Science Education*, *School Science and Mathematics*, and *Cultural Studies of Science Education*, the authors also searched these journals. Additional journals searched by the authors included *International Journal of Science and Mathematics Education*, *Journal of Science Education and Technology*, *Journal of Science Teacher Education*, and *Journal of Women and Minorities in Science and Engineering*. These searches produced 70 articles.

## Context of Recent Science Education Reform in the USA

At the national level, current reform in science education is embedded in a standards-based movement (Vinovskis 2009). This movement is rooted in the 1983 National Commission on Educational Excellence report, *A Nation at Risk* (National Commission on Excellence in Education 1983). As the movement evolved, the federal government's influence on state education policies, including policies related to science education, increased and the broad goals espoused in the science education reform documents of the 1980s were reflected in state curricula as subject area learning standards.

In 1985, the American Association for the Advancement of Science (AAAS) launched Project 2061. Described as a long-term initiative to alter precollege education in specific academic disciplines, Project 2061 developed two documents that impacted curricula, *Science for All Americans* (American Association for the Advancement of Science (AAAS) 1989) and *Benchmarks for Science Literacy* (AAAS 1993). These documents emphasized content knowledge and skills necessary for developing a scientifically literate society.

During the administration of President George H.W. Bush, federal and state policymakers took the first tentative steps toward full-scale standards-based reform. In 1989, Bush called together the nation's governors for a 2-day conference. The conference produced six national education goals dubbed "America 2000." These goals included one that would bear directly on the evolving standards-based movement that would highlight competencies in specific subjects in grades 4, 8, and 12 (Nelson et al. 2006).

Two distinct groups initiated efforts to define competence in a subject area. First, the US Department of Education provided grants to national organizations to assist in the development of national standards in core academic subjects. In 1996, the National Research Council (NRC) published the *National Science Education Standards* (NSES). These standards, which shared Project 2061's focus on scientific literacy in the USA, featured inquiry teaching, professional development, assessment, program development, and science education as a system. Second, through its Goals 2000 legislation passed in 1994, the presidential administration of Bill Clinton provided federal funds to support the states' development of their own teaching and learning standards for core subjects. Forty-seven states and the District of Columbia applied for the Goals 2000 funding (United States Department of Education 1998). State standards for science were strongly influenced by NSES.

In 2001, under the administration of George W. Bush, the Elementary and Secondary Education Act (ESEA) was revised (Vinovskis 2009). Known as "No Child Left Behind" (NCLB), ESEA shifted the burden of standards-based reform squarely on the shoulders of the states. In order to receive some form of federal support, particularly those designated for students living in poverty, states were now required to develop academic performance standards for K–12 students in core academic subjects including science. In addition to these standards, states were required to develop one statewide accountability system to determine if schools and school districts were achieving yearly benchmarks of adequate progress in core subjects. Finally, ESEA also mandated that test scores be disaggregated so that the achievement disparities between racial, ethnic, and socioeconomic groups would be visible to educational stakeholders.

The revision of ESEA has been criticized for its emphasis on standardized test scores as the sole measure used to hold schools and districts accountable. Further, the law has been condemned for its punitive measures, the loss of federal funding and transfer options for unsatisfied families, for schools and districts that fail to meet their state's definition of adequate yearly progress. Science educators have argued that the reforms resulting from NCLB have harmful consequences to both students and teachers. Prior to 2007 – the year in which testing in science was mandated to begin – science instruction was sometimes sacrificed to reading and math instruction and standardized test preparation. The emphasis on standards and test preparation also deprofessionalized teachers' work, reducing it in some cases to a nearly scripted experience (Settlage and Meadows 2002). Finally, the reform movement has been condemned because of its one-size-fits-all approach to teaching and learning. This is particularly true of students from marginalized groups and students living in poverty (Crocco and Costigan 2007). In the midst of over two decades of reform that promoted quality science education for all, the status of Blacks in US science education remains abysmal.

## Status of Blacks in Science Education

The relative position of Blacks as a collective to other groups in the USA is evident in the economic and education domains of US society. Statistics indicate that in 2006, Blacks comprised 12% of the US population but had the greatest percentage living in poverty; 24% in contrast to 8% for Whites, 8% for Asians, and 21% for Hispanics of any race (United States Bureau of the Census 2007). These disparities not only exist in economics, but also in education.

Generally, the quality of science teachers is determined by the number of years of teaching experience, the extent of undergraduate and graduate science coursework, and performance on teacher licensure examinations (Young 2005). Teachers with 5 or more years of experience, who have undergraduate or graduate degrees in the subjects in which they teach, and whose performance on certification examinations exceeds a specified cutoff score are considered teachers of acceptable quality. Richard Ingersoll (2002) found that teachers with less than 5 years of teaching experience, who have less than an undergraduate minor in the areas in which they teach, and who are not fully certified in their assigned areas comprise the teaching workforce in high-poverty and high-minority schools. High-poverty and high-minority schools are defined as schools with student populations of 75% or more from economically disadvantaged backgrounds and of students of color, respectively (National Center for Education Statistics (NCES) 2007). Blacks were more likely to attend such schools.

Statistics also show that many Blacks are more likely to be placed in lower-level science courses and that Black males are more likely to be found in special education classes and less likely to be found in gifted and advanced science courses (Atwater 2000; Rascoe and Atwater 2005). Research typically characterized the instruction of science courses taught in the standard or low academic tracks as back-to-the basics with drill and memorization as both the means to and ends of learning (Gilbert and Yerrick 2001). In the instances in which Black students enrolled in advanced science courses or specialized science classes, they reported unwelcoming environments marked by negative perceptions, low teacher expectations, little encouragement, strained teacher and student interactions and relationships, and various personal and institutional challenges to meaningful learning (Brand et al. 2006; Griffard and Wandersee 1999). Additionally, racial disparities in the offering of advanced placement (AP) courses in science in relation to the ethnic makeup of schools have been documented. Daniel Solorzano and Armida Ornelas (2004) documented that schools that had high enrollments of Black students were less likely to offer AP courses and schools that provided AP courses offered few of them. In 2007 Black students who made up approximately 14% of graduating seniors comprised about 6% of AP examinees in biology, around 6% in environmental science, and 4% in chemistry (College Board 2008).

The status of underserved students and their success regarding AP exams are areas of concern for the College Board. The College Board (2008) defines an equity and excellence gap, a case in which the percentage of underserved students who have access to and success on the AP exam is less than the percentage of underserved students in the entire class of 2007. The College Board examined all 50 states and the District of Columbia in relation to an equity and excellence gap for Black, Hispanic, or Native American students. The College Board found that 17 out of 51 sites eliminated an equity gap for Native American students, 15 eliminated an equity gap for Hispanic students but only one out of 51 sites eliminated an equity gap for Black students (College Board 2008).

As denoted in the synopsis of the status of US Blacks, Blacks as a collective have limited access to quality science education (Hewson et al. 2001) which goes beyond shared physical space highlighted in the desegregation and civil rights legislation (Tate 2001). From 1997 to 2007, a portion of science education research conducted in the US involved Blacks. What areas did these studies investigate? What additional insights beyond the statistics on the status of Blacks in US science education can be gained from these studies?

## Synthesis of the Literature

Using the purposes of studies, the authors divided the investigations into several categories. Articles comprising the three largest categories are presented here. In this section, the authors synthesize the literature under subheadings that reflect the categories.

### *Studies of Students' Perceptions and Attitudes*

These studies, which were divided into two groups, investigated students' perceptions about scientists and their attitudes toward science. The first subset of these articles situated the significance of students' perceptions and attitudes in the students' future choices regarding science. The second set examined perceptions among different subgroups of students.

As part of the first subset of articles, Janice Terry and William Baird (1997) highlighted the low number of women in science elective courses and careers. They examined high school students' attitudes toward women in science with respect to 17 variables. They found statistically significant and positive correlations among the students' attitudes toward women in science and mothers' nonscience occupations, science plans, education level plans, careers in science, female influence at school, female influence on future planning, and female influence regarding a science career. With respect to the variance in students' attitudes toward women in science, gender accounted for most of the variance followed by science ability, level of education the student planned to complete, and career interest outside of science. Shannon Gilmartin et al. (2007) extended investigation of the attitudes toward women in science factor beyond attitudes and examined how the percentage of female science faculty was related to high school students' perceptions, achievement, views, self-concept, and college major aspirations. The results indicated that the percentage of female faculty in high school science departments was not related to students' perceptions and stereotypical views of science, students' science self-concepts, and students' college major aspirations. Keeping in line with this focus on gender in science, Eileen Parsons (1997) studied Black high school females' images of the scientists and discussed these culturally influenced images as windows to self-concepts and future career choice. With regard to students' images of the scientist, Jason Painter et al. (2006) examined the impact of students' interviewing of scientists involved in a multiyear project on nano-scale science. They found that the interviews helped to alter students' perceptions of scientists as male, always in a lab coat, only doing experiments, being weird/ boring, and always working alone; this alteration in perception remained 1 year later. The last study of this subset that couched the significance of students' attitudes and perceptions in decision-making explored course enrollment decisions in relation to gender and students' learning experiences in contexts classified as high and low learning cycle classrooms (Cavallo and Laubach 2001). In classrooms where learning cycle instruction was salient, significantly more females planned to enroll in science elective courses, and males, had higher science enjoyment, and viewed science as more gender inclusive.

The second set of articles that investigated students' attitudes and perceptions looked at differences among subgroups of students that explicitly included racial/ethnic comparisons. Douglas Huffman et al. (1997) studied students' perceptions of learning environments among different groups of students within the same science classes. The results showed that Black students perceived classes as less involving than White students. Faye Neathery (1997) examined the correlations of students' attitudes toward science with gender, race/ethnicity, ability, grade level, and science achievement and found statistically significant relationships for gender, ability, grade level, and science achievement; a significant relationship was not found for race/ethnicity for the large sample in which all non-White students were grouped together as minority. Like Neathery (1997), Sheldon Woods and Lawrence Scharmann (2001) classified non-White student participants into one group for an analysis that focused on high school students' perceptions of evolutionary theory in relation to science locus of control, logical reasoning ability, race/ethnicity, gender, grade level, and teacher. Statistically significant correlations were used to determine the order for entry into a forward regression analysis of which race/ethnicity, gender, grade level, and teacher did not meet the criteria. Logical reasoning accounted for 10% and science locus of control for 1% of the variance in students' perceptions of evolutionary theory.

## *Impact Studies*

The studies classified as impact studies examined the effects of curricula and instructional strategies on various student outcomes. Student outcomes ranged from achievement to social activism, with most studies examining achievement. The foci of many of these studies examined curricula and instructional practices that aligned with science education reform advocated in NSES.

In a large-scale quasi-experimental study that involved the professional development of teachers in standards-based science teaching and their implementation of such teaching, Jane Kahle, Judith Meece, and Kate Scatlebury (2000) found that standards-based teaching positively influenced the achievement and attitudes of

African-American students who attended urban schools. Similar results emerged for curricular interventions. For example, the enactment of inquiry units during the teaching of a state's science curricula improved student achievement not only in terms of recall but also in the comprehension of specific content knowledge (Singer et al. 2003); in the acquisition of certain inquiry skills (Keselman 2003; Keys 1998); in relating scientific concepts (Rivet and Krajcik 2004); and in the ability to transfer the scientific understanding to new situations (Fortus et al. 2005). Some researchers also examined the effects of interventions on the achievement gap among different demographic groups. Sharon Lynch et al. (2005) in their study of a curriculum intervention did not find a narrowing of the achievement gap among demographic groups but noted that for groups not utilizing the curriculum the gaps appeared to widen. In contrast, Okhee Lee et al. (2005) who examined curricula and instructional practices reported a narrowing of the achievement gap among different demographic groups at the end of the school year during which the study was conducted. Other studies showed that specific tools or teaching methods positively influenced outcomes of interest. These studies featured broad approaches like the use of science, technology, and society (STS) to more specific methods like using descriptive drawings.

An STS approach to teaching global warming indicated that more students expressed awareness of social activism more frequently after STS instruction but the approach failed to alleviate difficulties of 5th graders in conceptually understanding the topic (Lester et al. 2006). Kellah Edens and Ellen Potter (2003) found statistically significant differences on posttests that assessed students' conceptual understanding of the law of conservation of energy under three learning conditions. One condition involved explanatory text accompanied with journal writing, another highlighted explanatory text with illustrations that students reproduced in their journals, and the last condition used explanatory text with drawings students generated. The learner-generated drawing and the drawing reproduction groups scored significantly higher than the writing group. In a similar vein, Linda Cronin-Jones (2000) examined students' conceptual understanding and attitudes toward ecology in three different instructional conditions. Students received no instruction, traditional instruction (guided reading, lecture, demonstrations, discussions, role playing, indoor lab activities, slide and film presentations), or experimental schoolyard instruction (guided reading, lecture, demonstrations, discussions, role playing, outdoor lab activities, and field observations). Analysis of variance yielded significant effects for content knowledge and attitude posttest comparisons. The mean content knowledge posttest scores of the experimental outdoor group were higher than the traditional classroom group who significantly outperformed the "no instruction" group. Post hoc comparisons indicated that the attitude posttest scores were significantly more positive for the experimental and traditional groups in comparisons to the control group; however, the mean attitudes posttest scores for the traditional and experimental groups did not differ. In addition to examining changes in conceptual understanding, Robin Ward and James Wandersee (2002a, b) explored the impact of Roundhouse diagramming, a visual organizer, on metacognition and performance as measured by grades. Students utilizing Roundhouse diagramming improved in the aforementioned domains. Related to investigating the effects of tools and methods on conceptual understanding, one study explored what kinds of authentic, real-world situations are inquiry-rich and science-content-rich for students (Lee and Songer 2003). Another study examined the relationships among genetics content knowledge, moral reasoning, and argumentation quality (Sadler and Donnelly 2006), of which a significant contribution of content knowledge and moral reasoning to variations associated with argumentation quality was not found.

## *"Creating Space" Studies*

With respect to science teaching and learning, science classrooms are cultural interface zones (Norman et al. 2001) where the cultures of schools, teachers, students, and science interact. Stacey Olitsky (2007) examined successful classroom interactions within these cultural interface zones. These interactions were marked by entrainment, a common rhythm and mood that increased positive feelings about group membership. The participants shared a mutual focus, engaged in side talk, and actively contributed to group solidarity. In his study of interactions in two teachers' classrooms, Kenneth Tobin (2006) described both successful and unsuccessful interaction rituals. Unsuccessful interaction rituals rather than successful ones are more typical for Black students in US science classrooms. Often, cultural interface zones are sites of conflict for these students (Norman et al. 2001).

The conflicts that arise in cultural interface zones in the science classroom have many different manifestations. For example, in their investigation, Maria Varelas et al. (2002) explored the connecting interfaces of three genres, recognizably organized social activities in which all participants contribute. They unearthed through the students' genres of rap songs and plays, the tensions surrounding affect and thinking about science content; teacher-instituted structures that comprised classroom genres; and the science genre that consisted of students' uses of various tools and lab activities. Other studies featured the teachers' and students' management of these conflicts. In Gilbert and Yerrick's (2001) study, student–teacher negotiations of these tensions influenced the quality of science instruction in the participating rural science classrooms. In response to the tensions, students developed identities that worked against academic achievement. Similarly, other studies documented conflicts among the identities students constructed of themselves as science learners and the identities they developed within their homes and communities (Brown 2004; Brickhouse et al. 2000). The previously surmised conflicts within the cultural interface zones in the science classroom necessitate cultural border crossings (Aikenhead and Jegede 1999). The articles classified as creating space studies investigated various vehicles or boundary spanners (Buxton and Carlone 2005), material and symbolic, used to facilitate border crossings into school science.

Jhumki Basu and Angela Calabrose Barton (2007) used funds of knowledge, practice-based cultural understandings of a community that have accumulated over time, to facilitate border crossing. Basu and Calabrose Barton (2007) investigated the connections among students' funds of knowledge and their sustained interest in science. Students exhibited a sustained interest when there was a strong connection between science and authentic opportunities that advanced students toward their visions of their own futures; a strong correspondence between science and students' views of science as useful; and a strong link between science and environments that nurtured relationships that reflected the values of their communities. To uncover the students' funds of knowledge, several studies employed cogenerative dialogues.

Cogenerative dialogues are critical discussions that are structured to engage participants in sharing. Christopher Emdin (2007a) used cogenerative dialogues to elicit students' perspectives on corporate (i.e., notions of achievement defined by benchmarks via standardized testing) and communal practices (i.e., science as a social activity and ideas of success linked to students' ways of knowing and being) in relation to their engagement and success in science. Emdin (2007b) then identified students' out-of-school communal rituals and supported their enactment within the science classroom which enabled the students' success in science and navigation of existing corporate structure and corporate rituals that dominated schooling. Emdin (2007a, b) employed cogenerative dialogues as an elicitation tool to uncover students' funds of knowledge that were then used to facilitate the students' cultural border crossings. In contrast, Gail Seiler (2001) used cogenerative dialogues as a direct means to border crossing. In cogenerative dialogues, students used their own discourse patterns to engage in science talk. This sense of ownership, illustrated in the use of the students' own discourse patterns in Seiler's (2001) study, became a tool to facilitate cultural border crossings in the final two studies of the "Creating Space" Studies section in this chapter.

Rowhea Elmesky (2005) and Rowhea Elmesky and Kenneth Tobin (2005) used a documentary production project with students in order to make science their own. As a part of the process of producing the documentaries and the science content of the documentaries, the students contextualized the scientific abstractions within their cultures as specific embodied practices. In the manifestations of high-energy levels, rhythm, singing, and dancing, the students collectively reproduced and enacted their own culture as a vehicle to understanding scientific concepts. Consequently, students expressed a value in participating in science either as a prerequisite or corequisite in achieving their personal aspirations.

## Critique and Recommendation

An extensive search of 12 science education literature sources over a span of 10 years produced a total of 70 articles that explicitly identified Blacks or African-Americans as participants in research studies. Of the 70 articles, authors of 51 (73%) of the articles provided racial/ethnic information explicitly (e.g., numerical breakdown) or implicitly (descriptors in the journal title or findings) for the study samples and 21 (30%) disaggregated results by race/ethnicity. The majority of the studies that identified the race/ethnicity of participants used the identifier "Black." Although the synthesized literature provides some insights on the status of Blacks in science education, two primary constraints exist.

First, in relation to the corpus of studies in science education for the past decade, 70 studies is a relatively small number of projects involving Blacks. Similar to the indictment made against reform that promotes science for all, the small number of studies involving Blacks utilized a one-size-fits-all approach. The studies' findings were presented as though they were equally relevant and valid for all participants in the study, regardless of the status of the group to which they belonged. By default, the findings of these studies were most pertinent to the group that comprised the majority of the studies' samples of which a subset included a Black majority. In these cases where the majority of the study participants were identified as Black, significant differences that exist among collectives of the African Diaspora who immigrated to the USA and African-Americans, a collective with an African ancestry directly intertwined with the founding of the USA, were not acknowledged. Failing to distinguish among non-Blacks, African-Americans, and individuals of the African Diaspora who immigrate to the USA inadequately portrays the challenges encountered both by African-Americans and African Diaspora immigrants (Lehner 2007).

Second, with the exception of a few investigations, the studies did not address phenomena in relation to conditions specific to Blacks. In his critique of NSES, Alberto Rodriguez (1997) discussed the invisibility of students from diverse groups in the text despite numerous photographs of diverse students throughout the document. This invisibility critique is also relevant for historical and contemporary science education reform in the USA and the vast majority of science education research involving Blacks.

Even in light of the previously described constraints, the science education research involving Blacks provided information that can prove useful in improving the status of Blacks in US science education by way of science education reform. With regard to what should be addressed in science education reform, the studies on students' perceptions and attitudes described factors that may curtail or encourage students' participation in science. With respect to what may constitute science education reform, the impact studies indicated that some curricula and instructional implementations improved achievement and reduced the achievement gap among different demographic groups. In relation to how to tailor science education reform to address the needs of different groups so it can work to achieve science for all, the creating space studies provided insights on how to mediate various conflicts that may hinder Black students' involvement in and learning of science. On the one hand, the studies indicate progress; on the other, they signify the very difficult work that lies ahead.

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