

The Influence of Science Education Professional Development on African
American Science Teachers' Conceptual Change and Practice

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Abstract

Conceptual change as a professional development model has moved elementary science teaching beyond lecture and the memorization of facts to science instruction congruent with the National Science Education Standards (National Research Council, 1996). However, research on the effectiveness of conceptual change teaching reveals some of its limitations. Specifically, little is known about the influence of conceptual change teaching on African American teachers' science pedagogy with African American students.

This study employs case study methodology to explore the influence of science education professional development based on the conceptual change model of teaching on teachers with varying levels of science education experiences, science content knowledge, teaching experience, and leadership experience. The study addresses the following questions: 1) How do African American teachers describe the influence of a science education professional development program on their teaching of science to African American students? 2) How do African American teachers describe their beliefs about conceptual change teaching after participating in professional development programs? 3) Is there a relationship between self-reported conceptual change teaching practices and actual classroom practices? 4) Is there a relationship between reported changes in conceptual change teaching practices and the content of the professional development institutes? Ethnographic data were obtained from classroom observations and semi-structured interviews with seven African American educators teaching elementary science in an urban school district.

These data were collected following these lead science teachers' four year of professional development in a science education professional development program.

Findings from the study indicate that African American teachers who participated in the science education professional development program incorporated several tenets of conceptual change in their science instruction. These included the use of questions (recall), hands-on activities, and collaborative groups. This study also revealed that African American teachers used their knowledge of African American students' cultural experiences to teach science. The African American teachers used culturally specific analogies, praise, and motivation in ways that extended beyond their professional development training. The findings of this study have implications in educational curricula, teacher professional development, and on science classroom practices.

Introduction

Numerous researchers have identified the influence of professional development on science teaching and student learning (Louckes-Horsley, Hewson, Love, & Stiles, 1998; McDermott & DeWater, 2000; Radford, 1998; Stein, Norman, & Clay-Chambers, 1997; Stein, Smith, & Silver, 1999; Supovitz, Mayer, & Kahle, 2000). Researchers suggest that professional development improves science teachers' content knowledge and pedagogy (Radford, 1998; Supovitz, Mayer, & Kahle, 2000). Additionally, teachers report that their participation in professional development activities enhances their confidence to teach science and facilitates change in their attitudes and beliefs about the nature of science teaching and student learning (Stein, Norman, & Clay-Chambers, 1997; Stein, Smith, & Silver, 1998).

To alter teachers' beliefs about the nature of science teaching and student learning, science educators and professional development programs have used conceptual change teaching (Akerson, Khalick, & Lederman, 2000; Neale, Smith, & Johnson, 1990; Stofflett, 1994; Stofflett & Stoddart, 1994; Thorley & Stofflett, 1996). Conceptual change is defined as the process through which people's central organizing concepts change from one set of concepts to another (Posner, Strike, Hewson, & Gertzog, 1982). Conceptual change involves individuals realigning, reorganizing, and replacing existing concepts to accommodate new ideas. Conceptual change teaching entails teachers focusing on students' ideas, predictions, and explanations about phenomena. Lessons often include

“discrepant” events, which contradict students’ preconceptions, create cognitive dissonance, and prompt students to search for better explanations.

Training in the conceptual change model is geared toward the development of specific pedagogical strategies. In classrooms where conceptual change teaching is implemented, teachers act as facilitators and students work collaboratively to acquire scientific knowledge. Highly skilled teachers who use conceptual change teaching have a comprehensive understanding of science concepts, identify students’ misconceptions, and create lessons to address students’ misunderstandings. Teachers trained in the conceptual change model learn to (a) elicit students’ prior conceptions and predictions about science phenomena; (b) use laboratory activities and/or other experiences to challenge students’ science conceptions, which are often inconsistent with science facts; (c) encourage students to resolve internal cognitive conflict through class or group discussions; (d) give students repeated opportunities to reuse newly encountered scientific ideas in similar and novel contexts; and (e) ask students to clarify scientific explanations and interpret observations and results from activities (Minstrell & van Zee, 2000). Teaching strategies that promote conceptual change allow teachers and students to develop appropriate perspectives about the nature of science (NOS) and scientific phenomena (Akerson, Khalick, & Lederman, 2000; Anderson & Smith, 1987; Hewson & Hewson, 1988; Neale, Smith, & Johnson, 1990; Posner et al., 1982; Smith, Blakeslee, & Anderson, 1993). Additionally, conceptual change teaching contributes to students’ science achievement.

However, conceptual change teaching has some limitations. Specifically, the influence of conceptual change teaching on African American students' achievement in science is rarely discussed in the literature. Furthermore, with the exception of an article by Settlage and Meadows (2002), the perspectives and practices of African American teachers who have participated in science education professional development and who educate African American children are generally absent from the science education literature, particularly the literature on conceptual change teaching in science. Perhaps knowledge of exemplary African American teachers' instructional styles with and perspectives towards educating African American students would reveal variables that may positively influence the science performance of African American students in urban schools, given that a correlation had been documented in other descriptions of exemplary African American teachers in other subjects like mathematics and English (e.g. Foster, 1990, 1997; Ladson-Billings, 1994). This research is an attempt to set in motion an agenda to reveal the pedagogy and perspectives of African American science teachers who participated in a science education professional development program funded by the National Science Foundation.

Purpose

The purpose of this study was to explore the influence of science education professional development on seven African American science teachers' conceptual change and practice with elementary African American students in an urban school district. In particular, this study focused on the

impact of professional development based on the conceptual change model of teaching on African American teachers' science pedagogy and on their conceptions about the nature of science, science teaching, and student learning.

Specifically, the purpose of this study was to: (a) determine African American teachers' perceived influence of a science education professional development program on their science instruction with African American students, (b) identify the beliefs and attitudes of African American science teachers about conceptual change teaching after their participation in a science education professional development program, (c) determine if a relationship exists between self-reported changes in conceptual change teaching practices and actual classroom practices, and (d) ascertain if a relationship exists between self-reported changes in conceptual change teaching strategies and the content of the science education professional development program. The following questions guided the research: 1) How do African American teachers describe the influence of a science education professional development program on their teaching of science to African American students? 2) How do African American teachers describe their beliefs about conceptual change teaching after participating in a professional development program? 3) Is there a relationship between self-reported changes in conceptual change teaching practices and actual classroom practices? and 4) Is there a relationship between reported changes in conceptual change teaching practices and the content of the professional development institutes?

Literature Review and Significance

Students of European and Asian descent continue to score higher than most African American students on all measures of academic achievement (NAEP, 2004, 2000, 1996). Even more disturbing is the science achievement of African American students. Trend analysis show that the gap between students of European and Asian descent and African American students continues to persist despite decades of intervention programs designed to increase African American students' performance in the discipline (Campbell, Denes, & Morrison, 2000; Clark, 1996; Programme for International Student Assessment (PISA), 2003; Rose-Century, 1997; Third International Math Science Study (TIMSS), 2003).

For example, data from the National Center for Educational Statistics (NCES, 1999) show that in 1970 the difference in science achievement scores between Black and White 9 year olds was 57 and in 1999, the score difference continued at 41. The same trend was evident among 17 year-old students. In 1970, the difference in science achievement scores was 54 and in 1999 the difference was still 52. Currently, PISA, an assessment that measures 15-year-olds' capabilities in reading literacy, mathematics, and science literacy, report that the achievement gap in science is still too large at the high school level. PISA data show that Black students trail their white counterparts by 100 points, and Hispanic students are 74 points lower than the average U.S. score of 491.

Science educators attribute the persistent achievement gap to several variables. These variables include student perceptions, uneven distribution of qualified science teachers, science teachers' content knowledge, and school environments (Barton, 2002; Bissell, 2001; Ware, Richardson, & Kim, 2000). Findings from a study by Bissell (2000) indicates that perceptions about who participates in science influences African American students' performance in science classrooms. Bissell concluded that external variables contribute to African American students' perceptions of science as "the purview of white males" (p. 70). Subsequently, African American students' misperceptions decreases their confidence to engage in science related activities (Bissell, 2001; Oakes, 1990a; Oakes, 1990b).

A second variable is the uneven distribution of qualified science teachers. Demographic data show that students in urban schools are predominately low-income and minority and depending on the region of the country, the student population in high-poverty urban school districts is either African American or Hispanic. Utilizing demographic data and data from the National Center for Educational Statistics (2000), researchers further documented the uneven distribution of qualified teachers between high poverty and low poverty schools. For example, Oakes, Muir, and Joseph (2000) reported that students in urban schools have fewer teachers with undergraduate degrees in science than their suburban peers. Further, Ingersoll (1998) reported that 20% of science teachers in high poverty urban schools teach out of field compared to 14% in suburban schools where the majority of students are from higher socioeconomic

backgrounds. Thus, researchers conclude that the disproportionate number of unqualified science teachers teaching in high poverty urban schools contributes to the low performance of African American students on standardized science achievement measures.

In addition to unqualified science teachers, school environments have also been identified as a way of explaining the science achievement gap. In a report to policy makers, Barton (2002) revealed that minority students, especially those attending urban schools, have less access to advanced level science courses than students attending suburban schools. Mendoza and Johnson (2000) reported that deficiencies in educational resources including physical infrastructure, technological resources, and curricula standards circumvent African American students' access to high quality science instruction. Moreover, researchers report that in high schools populated by large percentages of low-income African American students, advanced courses such as chemistry and physics are not offered. Consequently, the science achievement of African American students is jeopardized.

Variables that contribute to the science achievement of African American students are well documented in the science education literature. These explanations have been important in that data have allowed policy makers and funding agencies to channel more funds towards the purchase of science materials and apparatus and to the professional development of science teachers in urban school districts. Funding agencies have expected that science education professional development courses would address urban elementary

teachers' science development and subsequently spur science achievement among African American students. Nevertheless, the science achievement gap persists and recent evidence indicates that it is widening.

A review of the science education literature reveals that few science educators have investigated the influence of variables such as teachers' ethnicity and culture on African American students' science performance. This has been the case even though several science education reform initiatives have been implemented in school districts with large numbers of African American teachers educating African American children. Lack of attention to the influence of science education professional development on African American teachers' perspectives and practices is prevalent during an era where science educators express the need to include students' cultural experiences in science lessons (e.g. Barba, 1998; Barton, 2001; Fradd & Lee, 1999, Tobin, Roth, & Zimmerman, 2001). Therefore, the question of how teachers can make adequate connections between science content and students' culture, without themselves possessing an adequate knowledge or familiarity with low-income urban African American students' cultural experiences, remains unanswered.

The omission of significant discussion on the relevance of teachers' ethnicity on African American students' science achievement is not surprising given the description of teachers that are included in science education research. For example, an examination of the sample population data for several empirical studies revealed that mostly white females participated in studies that examined the influence of conceptual change teaching on science teachers' attitudes,

beliefs, and instructional practices (Kahle, Meece, & Scantlebury, 2000; Radford, 1998; Roychoudhury & Kahle, 1999; Supovitz & Turner, 2000).

The predominance of white teachers' pedagogical perspectives and science teaching practices seems reasonable. White females comprise 87% of the teacher workforce (United States Department of Education, National Center for Educational Statistics [NCES], 1999-2000). African American teachers comprise only 7% of the teacher workforce. However, African American teachers represent the largest number of minority group teachers in the United States and, although their numbers are small, African American teachers' perspectives and practices regarding the education of African American students are important. According to Foster (1990), "the failure to include the voice and perspective of experienced exemplary African American teachers means that researchers may be cutting off an important source of understanding about how to improve the education of poor African American children" (p. 139). Therefore, an investigation into the voice and perspectives of African American teachers regarding the science achievement of African American students is crucial. Professional development experiences perhaps may foster African American teachers' interest in revealing their science pedagogical strategies before and after participation in systemic science education professional development initiatives.

This study represents an effort to bridge current models of professional development with the need to investigate other variables that have not been sufficiently explored and that could possibly contribute to the science achievement of African American students in urban schools. Perhaps knowledge

of exemplary African American teachers' instructional styles with and perspectives towards educating African American students would reveal variables that may positively influence the science performance of African American students in urban schools, given that a correlation had been documented in descriptions of exemplary African American teachers in other subjects (e.g. Foster, 1990, 1997; Ladson-Billings, 1994).

Significance

Unlike science educators, multicultural education scholars have closely examined the relationship between teacher ethnicity and African American students' academic success (e.g. Foster, 1997; Stanford, 1997; Walker, 1996). Tobias (1992) notes that to achieve maximum impact in science, "minority students should be provided, more frequently than they currently are, with teachers of their own ethnic background who understand their problems and can serve as role models" (p. 14). Moreover, several multicultural scholars report the unique pedagogy and perspectives of exemplary African American teachers of African American students (Cochran-Smith, 1997; Irvine, 1990, 2002; Ladson-Billings, 1994; Stanford, 1997, 1998; Walker, 1996, 2000). These scholars state that the instructional practices of exemplary African American teachers often lead to academic success for African American children.

Specifically, Foster (1990) states that African American teachers frequently operate as surrogate parents, disciplinarians, and advocates for African American students. Irvine (1989, 1990) identifies African American

teachers as mentors who help African American students manipulate school culture. Irvine states:

Teachers have to be cultural translators...They must be thoroughly knowledgeable, sensitive, and comfortable about black children's language, style of presentation, community values, traditions, rituals, legends, myths, history, symbols, and norms....Black teachers are more likely than their White counterparts to be prepared to assume this role of cultural translator" (Irvine, 1989, p. 57).

Furthermore, Hilliard (1998) reports that African teachers hold the future of African people in their hands. He states:

If the African teachers who have access to our children are prepared, conscious, and willing, the development of African children knows no bounds (p. 107).

Therefore, an examination of the ideologies and practices of exemplary African American teachers (Cochran-Smith, 1997; Lipman, 1998) is important to include in the area of science education for the following reasons: (a) a large majority of African American teachers teach in urban schools located in the South and populated by African American students, (b) researchers in multicultural education provide evidence that exemplary African American teachers employ a unique style of teaching that leads to academic success for African American students, and (c) African American teachers function as role models and advocates for African American students and (d) the National Science Foundation has awarded over 35 million dollars to the improvement of science

education in states that have high percentages of African American teachers and students (i.e. Georgia, Florida, Louisiana, Mississippi, and Alabama). Possibly an understanding of the influence of teachers' ethnicity and culture on African American students' science achievement may assist researchers in uncovering additional variables that contribute positively to the science performance of African American students in urban schools.

Review of Literature

Research indicated that professional development based on the conceptual change model of teaching has moved science education beyond the lecture model to instruction that is student centered and inquiry based. Specifically, Neale, Smith, and Johnson (1990), Radford (1998), and Kahle, Meece, and Scantlebury (2000) reported that teachers who participated in standards-based professional development (which includes components of conceptual change instruction) altered their pedagogical approach to science and changed their perspectives regarding the nature of science teaching and student learning. These researchers observed that prior to participating in professional development, teachers in their studies perceived science as a body of facts that students should memorize. After participating in sessions that utilize conceptual change instruction, teachers began to recognize the tentative and empirically based aspects of science. Changes in teachers' conceptions regarding the nature of science allowed them to progress beyond traditional and didactic forms of teaching to instruction that is aligned with the vision of the National Science Education Standards (National Research Council, 1996). However, teachers

found asking questions and engaging students in discussions about science concepts difficult to incorporate into their practice. Neale, Smith, and Johnson (1990), Smith, Blakeslee, and Anderson (1993), and Roychoudhury and Kahle (1999) report that teachers' difficulty in asking and answering questions stemmed from their limited science content knowledge.

Researchers also suggest that professional developers who engaged teachers in hands-on science instruction, allowed teachers to work in cooperative groups, posed closed and open ended questions to the teachers and assessed teachers' understanding of science concepts, facilitated an understanding of science content and enhanced teachers' science pedagogy. For example, Roychoudhury and Kahle (1999) and Wise, Spiegel, and Bruning (1999) reported that after participating in professional development activities of the aforementioned nature, teachers are more likely to return to their classrooms and implement conceptual change teaching strategies. However, researchers warned that professional development programs should consider the organizational culture of schools and the influence it has on teachers' knowledge growth (Smylie, 1995; Louckes-Horsley et al., 1998). In addition to the limitations of professional development reported by researchers such as Louckes-Horsley et al. (1998), Kozaitis (2000) and Smylie (1995), I also noted other limitations in the science education literature. As a whole, professional development in science education does not examine sufficiently the influence of the following on science teaching and student learning: (a) school culture milieu, (b) teachers' social identity (c) teachers' ethnicity, (d) students' ethnicity and culture, (e) teachers'

prior knowledge, and (f) teachers' attitudes, beliefs, and prior socialization to science education. Importantly, research on conceptual change teaching does not examine the pedagogy and perspectives of African American teachers teaching science to African American students. Professional development based on the conceptual change model of teaching in science has yet to meet the challenge of providing all teachers with the appropriate experiences so they can return to their classrooms and engage low-income African American students in meaningful science instruction that values their cultural experiences and equips them to function in a scientifically and technologically oriented society upon completing high school. Furthermore, professional development in science education has not addressed issues related to the influence of teachers' culture and ethnicity on science teaching. Since science education has not developed in the aforementioned area, I also reviewed the literature on exemplary African American teachers and the pedagogical strategies they implement with African American students. The following section is a review of the research on African American teachers' perspectives and practices with African American children.

African American Teachers' Perspectives and Instructional Strategies

Germane to teachers' understanding of how students learn is an awareness of the influence of culture on learning (Kozaitis, 2000). According to Barba (1998), culturally diverse learners enter school with a wealth of prior knowledge and are ready to negotiate meaning from the educational environment. Furthermore, Barba reports that teachers need to incorporate culturally familiar analogies. For example, a teacher articulates the similarities between water displacement and gentrification (e.g. low-income parents being displaced from their established communities). Further, Barba states that teachers need to incorporate themes and curricular materials designed to engage students of multiple ethnicities as part of their instructional program. Both Barba and Irvine (1990) report that the use of culturally familiar analogies, themes, and curricula materials builds bridges between the students' prior knowledge and new knowledge. Irvine further noted that Black teachers who share their students' racial and ethnic identities are more likely than white teachers to realize the influence of culture on students' academic achievement and to be prepared to assume the role of cultural translator. Irvine's sentiments are supported by Dilworth (1990) who stated that some teachers of color bring with them an inherent understanding of the backgrounds, attitudes, and experiences of students from minority, particularly African American populations and therefore can help inform majority teachers of effective ways and means to communicate and teach students. Gay (1989, 1994, 2002) further pointed out the importance of understanding the influence of the sociocultural context on student

learning. She states that the means appropriate for teaching poor, urban black students differ from those appropriate for teaching other students because teaching and learning are sociocultural processes that take place within given social systems.

African American teachers act as political advocates for African American students (Foster, 1990, 1997). Comparatively, Irvine (1989) states that minority students need minority teachers who question and interrogate rules and regulations that are not in the best interest of their students. Finally, Walker's research on African American teachers shows that African American teachers understand the relationship between education, economic mobility, and a better quality of life for African American students (1996, 2000, 2001).

With regard to African American teachers' perspectives on organizational change and reform efforts and the influence on African American students' achievement, Foster reports several dichotomous findings. Specifically, following intense interviews, Foster characterized seven African American teachers as cynical, dissenter, coincidental cooperators, and committed advocates. Three teachers were characterized as cynical dissenters, three as coincidental cooperators, and one as committed advocate. However, although participating in the reform initiatives at varying levels, none of the teachers believed that the reform efforts would result in fundamental change in the education of African American students. They viewed the reform initiatives as temporary measures that might result in some curricular, structural, and organizational changes, but would not substantially affect African American student achievement.

Additionally, Foster noted that most teachers in the study expressed loyalty, commitment, and connectedness to black students and community. Further, the African American teachers in the study maintained liberal constructivist educational philosophies towards educating African American students. All teachers believed that African American students, regardless of socioeconomic status, were capable and interested in learning.

In sum, exemplary African American teachers' perspectives towards African American students undergird their pedagogy, extending it beyond technical competence (King, 1992; Stanford, 1997). African American teachers' pedagogy with African American students includes teachers being advocates for, and mentors to, African American students. African American teachers have more positive attitudes about the personality traits, abilities, behaviors, and potential of black children than white teachers according to Irvine (1990). Foster (1990, 1997) and Stanford (1998) report that African American teachers possess a strong belief that black students are capable of succeeding in school, but need supportive relationships with teachers who enable them to succeed in spite of adverse circumstances at home and school. Irvine and Foster further note that African American teachers' pedagogy often stemmed from their prior experiences in the larger American society and from their experiences in schools as students (Foster, 1990). These experiences and perspectives allow African American teachers to support African American students in ways that other teachers may not. Ideally, the perspectives and pedagogical strategies that exemplary African American teachers of African American students employ should be adopted by

all teachers particularly those teaching students with backgrounds different from their own.

Important to note here are two facts. First, while similar background does not insure agreement or disagreement on issues related to schooling and school reform, several studies provide some evidence that different backgrounds can affect how teachers in the same school view similar events, particularly related to the perceptions of what is required to improve education for African American and other at-risk students. Second, the literature on African American teachers suggests that not all African American teachers have positive attitudes towards African American students. In fact, Burstein and Cabello (1995) and Rist (1970) in seminal articles found that some African American teachers had negative attitudes and beliefs towards African American students who were from different (often lower) social and economic status. Furthermore, Ladson-Billings (1994) reports that teachers who did not share their students' racial, cultural, or linguistic backgrounds possessed positive attitudes and beliefs regarding the capabilities of African American students. Nevertheless, because many African American teachers share African American students' racial and critical cultural backgrounds (e.g. low expectations from teachers), they are more likely than white teachers to possess positive attitudes and beliefs regarding the intellectual capabilities of African American students. African American teachers' positive attitudes and expectations towards African American students inspire them to teach these students for success. Further, African American teachers' positive

attitudes and high expectations towards their African American students inspire them to perform better academically.

Like the studies in science education, the studies on African American teachers also suffered from several limitations albeit of different types. For example, Foster's (1990) research did not address the validity and reliability of her findings. However, traditionally, historical researchers have not explicitly revealed how they ensured the validity and reliability of their methodology and findings. Recent trends in oral history have been to provide evidence of reliability and validity of results. Foster's work was published prior to this trend. Moreover, with the exception of Foster (1990), the studies on African American teachers do not provide specific pedagogical strategies within disciplinary areas including science.

Overall, a review of the literature on conceptual change teaching in professional development and the pedagogy and perspectives of African American teachers revealed that the two bodies of research do not inform one another. Closer inspection of African American science teachers' perspectives and practices is necessary to uncover how variables such as the ethnicity and culture of the teacher may influence the science performance of African American students in urban schools. Hence, as mentioned previously, this study focuses on addressing African American science teachers' conceptual change and practice after participating in a professional development program based on the conceptual change model of teaching. Specifically, unlike many of the studies on African American teacher, this study provides observation data that supports

or contradicts teachers' perceptions about their practice thereby increasing the reliability and validity of the results presented.

Methodology

This qualitative case study explored the influence of a science education professional development program on African American science teachers' conceptual change and practice. Data were collected from three sources in four different stages. The three sources of data were interviews, observations, and document analysis. Data were collected via pre-observation interviews, classroom observations, post-observations interviews, and post-analysis interviews. Each teacher participated in one 30 minute pre-observation structured interview, one 45 minutes to an hour post-observation semi-structured interview, and one 30 minutes to 45 minutes post-analysis interview. Overall, 21 interviews were conducted each lasting between 30 minutes and one hour.

Also, each teacher's science instruction was observed four times. Each observation lasted between 45 minutes and an hour and a half. In all, 28 science lessons were observed for inclusion of conceptual change teaching strategies. Finally, four documents were analyzed. They were teachers' lesson plans, student worksheets, annual reports regarding the implementation of professional development activities and the program evaluator's reports. Following is chart displaying the relationship between data sources and research questions.

Research Questions	Data Sources
How do African American teachers describe the influence of a science education professional development program on their teaching of science to	<ul style="list-style-type: none">• Structured interviews• Semi-structured interviews• Post-analysis interviews

African American students?	
How do African American teachers describe their beliefs about conceptual change teaching after participating in the professional development program?	<ul style="list-style-type: none"> • Semi-Structured interviews • Post-analysis interviews
Is there a relationship between self-reported changes in conceptual change teaching practices and actual classroom practices?	<ul style="list-style-type: none"> • Classroom observations • Document analysis
Is there a relationship between reported changes in conceptual change teaching practices and the content of the professional development institutes?	<ul style="list-style-type: none"> • Structured interviews • Semi-structured interviews • Post-analysis interviews • Classroom observations

The Participants

Purposeful sampling was used to select the teachers for this study (Guba & Lincoln, 1989). Teachers with various levels of science content knowledge, years of teaching experience, and leadership experience beyond the initial lead science teacher position participated in this study. Specifically, the following criteria were used to select teachers: a) ethnicity, b) number of years teaching, c) leadership position in the program, d) number of years in the professional development program, e) number of years as a lead science teacher in the program. Twenty-four teachers were eligible to participate in this study. After applying the selection criteria and upon agreement to participate, the science perspectives and practices of 7 African American women were documented. The teachers in this study taught mostly African American students between first and fifth grade for 12 or more years.

Data Analysis

The transcribed interviews and observations were analyzed using the coding methods outlined by Miles and Huberman (1994). To start, a general start list of codes from the research literature on conceptual change teaching was generated. This start list of codes was modified and refined as data were analyzed. Codes that emerged from the data were added. The coded interviews and observations were mailed to the teachers for clarification. Also, another graduate student cross-checked the codes. Code checking was done to ensure (a) the definitions of the codes agreed with what was being coded, (b) all important and or relevant data had been coded, and (c) each unit of data were described by one and only one code (Merriam, 1998).

The second level codes or pattern codes for the observations and interviews originated from the first level codes. Second level coding allowed for a more in-depth understanding of themes and concepts involved in the study and for a synthesis of ways in which the themes interact and relate. As with the first level codes, a panel of experts with experience in coding, science education, and the pedagogy and perspectives of African American teachers checked pattern codes from a representative sample of interviews and observations.

Reliability

This study used the following strategies to address the issue of reliability of findings: (a) clear explanation of the researcher's biases, (b) an effective and accessible system of storage for the related data, and (c) a clear chain of evidence designed to outline the data collection process. Additionally, I

maintained a researcher's journal and kept detailed records of how decisions were made regarding changes in the interview guide. I also documented the circumstances and reasons for contacting each teacher.

I have several biases that may affect the reliability of the research. First, I was the professional development coordinator for the professional development program. In that role, on numerous occasions, I taught the participants in this study how to use hands-on inquiry science kits in their classrooms. Second, I assumed that since the teachers are African American women, they easily understood and implemented culturally appropriate strategies for African American students, and created positive rather than negative educational experiences for African American students. My assumptions were based on the fact that African American teachers, as African American students, may have had negative experiences in their schooling. Therefore, I assumed that African American teachers used culturally responsive practices to avoid creating negative educational experiences for their students. Finally, I am an African American woman who has pursued and successfully completed a graduate degree in analytical chemistry. I believed that I could have advanced further in the science field had I encountered more teachers at various grade levels who incorporated culturally appropriate strategies in their science teaching. To that end, I am committed to the type of science instruction culturally diverse students receive.

To address my biases and prohibit a falsely positive or falsely negative stance in the analysis, I employed the following measures. To account for my

close proximity, I maintained a researcher's journal where I recorded my personal thoughts about the teachers' science instruction. I also allowed three or more weeks to pass before analyzing data so that my personal feelings about the teachers' instruction dissipated. Finally, I looked for rival explanations to account for the teachers' pedagogy and where my first analysis of a case seemed to be overly reliant on negative data, I reviewed the material to look for data that were favorable towards the teachers. This additional aspect encouraged my objectivity.

Data were systematically catalogued and stored. Copies of the audiotaped interviews, hardcopies of transcribed verbatim interviews, and observation field notes were labeled and stored in an easily accessible location. Data acquired from the interviews and observations were audiotaped and transcribed verbatim. The interviewer's comments were typed in bold; the interviewee's statements were not. Additionally, in an effort to ensure accuracy, I proofread each transcribed interview by simultaneously listening to the recorded interview and reading the transcript. Finally, so the teachers could clarify any points, correct errors, or add pertinent information to the transcript, I mailed them a copy of the transcribed interviews to review.

Validity

This study employed the following strategies to address issues related to internal validity: (a) peer examination, and (b) triangulation. In an effort to ensure that the interview guide reflected valid qualitative design, the questions were reviewed by outside researchers with extensive knowledge of qualitative

research design and knowledge about science education professional development, conceptual change teaching, and African American teachers' instructional strategies. Furthermore, triangulation strengthened the reliability and internal validity (Merriam, 1998) for this study. In this case study, interview data were supported by classroom observation. Additionally, the data were supported by current literature on conceptual change teaching and the instructional strategies of African American teachers.

External Validity

This study is not yet generalizable. However, to strengthen its use by other researchers, the following strategies were used (a) rich, thick description, (b) typicality, and (c) multisite design. The collection of rich data provides enough description so that readers will be able to determine how closely their situations match the research situation (Merriam, 1998). I address typicality by providing a detailed description of the participants and their classroom setting. In this study, I visited six elementary schools to collect data. Each school was comprised mostly of African American students; however, the schools were different in terms of school climate and instructional leadership.

Limitations

This study has a number of limitations. First, only African American teachers who participated in a science education professional development program were invited to share their perspectives and practice. Second, only African American teachers educating African American students attending elementary schools in urban districts were interviewed and observed. Third,

since the teachers' science pedagogy prior to their participation in the professional development program was not documented, I relied on the teachers' reflections of their practice to establish baseline data. Fourth, classroom observations were scheduled in advance. Thus, teachers had the opportunity to plan and implement four science lessons that may have looked differently if they had not been told the specific observation dates. Also, I was unable to verify that these lessons were representative of the instruction that occurred on the days when I was not present. Fifth, the interview data may not precisely reflect the teachers' perceptions during an hour and a half interview, especially to a researcher previously involved in their training. Last, the teachers in this study are atypical. The teachers received several awards and participated in the professional development program as lead science teachers for more than three years. They also volunteered to participate in this study. The atypical status of the teachers is a limitation and affects the generalizability of this study. Following are the results of the study.

Results

In this section, I discuss the results of this study. Science perspectives and practices of seven teachers from six different schools were analyzed to establish the context of the study. Pseudonyms are used to describe the schools and teachers. Table 2 below is an overview of the study participants and important context that help ground the findings.

Table 2

Study Participants

Teacher	Attended segregated schools	State	Attended Historically Black College	Years Teaching	Years in Professional Development Program	Continue to Facilitate Professional Development Sessions
Ms. Unicore	√	CA	x	19	5	Yes
Ms. Bedford	x	MA	√	17	4	Yes
Ms. Wiley	√	IL	x	27	4	Yes
Ms. Jacobs	x	NY	√	15	4	Yes
Ms. Pringle	√		√	12	4	No
Ms. Warner	√		√	27	5	Yes
Ms. Williams	√		√	25	5	Yes

√ = attended; x = did not attend

Specifically, five of the seven teachers attended all Black schools in various regions of the country. Teachers' age ranged from 39 to 57 and their years of teaching spanned from 12 to 27 years. Five of the seven teachers have Master of Science in Education degrees or higher. Except for one, all teachers have received the teacher of the year award at least once. Most of the teachers continued to participate in science education professional development.

Description of Schools

The following table depicts the school context in which the teachers taught.

Table 3

Description of Schools

Teacher in Case Study (pseudonym)	School (pseudonym)	School Enrollment	School Population by Ethnicity	% Students Eligible for Free/Reduced Lunch	School Population by Gender
Ms. Unicore	Ellis Grove Elementary	245	98% Black 1% White	93	51% male 49% female
Ms. Bedford	Harvey Elementary	578	99% Black No White	88	53% male 47% female
Ms. Jacobs	Calloway Elementary	739	96% Black 3% Hispanic	90	49% male 51% female
Ms. Wiley	Calloway Elementary	739	96% Black 3% Hispanic	90	49% male 51% female
Ms. Warner	Stillwater Elementary	334	100% Black	72	48% male 52% female
Ms. Pringle	Patton Elementary	492	76% Black 12% White	90	50% male 50% female

In general, these schools are in African American neighborhoods where the income level is below the national average. Generally, more than 80% of the population of students were eligible for free or reduced lunch. The schools varied in size from 245 to 739 students. All schools had student body populations that were close to a 50/50 ratio of males to females. The test scores were generally lower than other schools in the state.

After analyzing the school context, I used categories to answer the identified research questions. I used three categories to help answer research question one (How do African American teachers describe the influence of a science education professional development program on their teaching of science to African American students?). I asked teachers to describe their science teaching before the professional development program. Next, I asked them to share their dominant memories of the professional development experience. Finally, I asked the teachers to share their perceptions of educating African American students in science after the professional development program.

Most teachers stated that before the professional development program, they devoted between 30 minutes and 2.5 hours per week to science instruction. Five of the seven teachers reported conducting some hands-on science activities; however, the teachers indicated discomfort with this instructional technique and reported that most of the activities were not curricula focused. Overall, the teachers were not comfortable teaching science because of their lack of professional preparation and the limited emphasis on science in their respective work environments. Further, the teachers often were forced to purchase the science materials from their personal funds.

Additionally, prior to the professional development program, three teachers mentioned that their students' desks were arranged in rows. Four of seven teachers reported the use of cooperative groups prior to the professional development program. All teachers stated using paper and pencil assessments

to gauge students' understanding of science concepts. Five teachers expressed that they did not feel comfortable or prepared to teach science. One teacher said that she felt somewhat comfortable because she completed three science courses in college. Two participants, Ms. Wiley and Ms. Bedford were comfortable teaching science. During the interview, Ms. Wiley stated that she liked science in high school but did not feel encouraged to pursue science as a career especially when she arrived to college. With regard to the teachers' perceptions of the professional development experience, all teachers perceived the experience as positive. Most noted the camaraderie developed among their cohorts and the support from the professional developers. Specifically, Ms.

Unicore stated:

During the time we were trained and during the times we trained teachers, teachers were allowed to be dismissed from their classrooms so they had the full two days just to learn inquiry, classroom management, and [complete] the actual activities of the kit, [discuss] the importance of content, and [talk about] the importance of questioning. [Teachers] were in a more relaxed environment because it wasn't something that they had to do after work. It was obvious that the system appreciated it [professional development] and thought it was important. They valued the training...and we were treated like professionals.

Additionally, all teachers noted increases in their science pedagogical knowledge. For instance, Ms. Wiley stated:

I stopped telling children everything. I taught the children to ask questions. I had to learn to ask students what they thought. I asked more questions. [Subsequently] children started asking more questions.

In reference to the teachers' perspectives about educating African American students in science after the professional development program, all teachers had very definitive beliefs about how African American students should be taught science. For instance, the teachers reported that educators should expect that African American students will succeed academically, especially in science and that teachers should include cultural experiences to help students understand science content. Furthermore, the teachers in this study perceived that conceptual change instruction benefited African American students. The teachers reported that improvements in their science instruction stimulated their African American students' interest in science. Additionally, two teachers noted the improvement in some African American students' reading skills as a result of engaging in conceptual change instruction.

However, the African American teachers in this study did not perceive that the professional development experience altered their perspectives on educating African American students as they reported that they held these perspectives before the professional development program. For instance, Ms. Pringle said:

I do not think that children are given the same motivation and push [by others]. I give them the same materials and the same lessons, but when it

comes to that extra push and that extra motivation, I don't think that they get it from other groups (referring to white teachers). I think that our children sometimes need that because we older people have been through integration, we remember.

Ms. Pringle further reported:

I think often times, when science or any other lesson is presented by [another] group to our children, the emphasis is not the same emphasis placed on being successful...I know that with the African American teachers that I've worked with, including myself, you put that little extra spark like "You can do it." [We] motivate them and say, "Yes, you can do science..."

In sum, all the African American teachers in this study perceived that the professional development experience altered their perspectives and practices related to science teaching but not on educating African American students. Further, all teachers held similar perspectives regarding African American students' academic success. Different from other studies on African American teachers is their explicit belief that African American students can excel in science when given the appropriate motivation and instruction. The teachers in this study maintained that they held the reported perspectives about the academic ability of African American students prior to the professional development experience.

Research question two (How do African American teachers describe their beliefs about conceptual change teaching after participating in the professional

development program?) involved two facets. To help answer this question, I asked teachers to share what they learned after years of participating and facilitating professional development sessions. Additionally, I asked the teachers to describe their science teaching after the professional development program.

All teachers in this study believed that conceptual change teaching modeled in professional development sessions allowed them to feel comfortable and adequately prepared to teach science. Also, the teachers thought that their participation in professional development increased their science content knowledge. Teachers perceived that they incorporated several conceptual change strategies after attending professional development sessions. For instance, all teachers reported that they arranged students in groups, engaged students in hands-on activities, asked numerous questions and did not rely on the textbook as much as they did prior to the program.

Additionally, the teachers in this study expressed several school related factors that limited their ability to implement conceptual change strategies. Every teacher expressed the limits of preparing for standardized test in mathematics and language arts on their science instruction. Further, every teacher expressed the limitations of the structure of elementary schools on science teaching. Also, most teachers perceived that elementary school principals, who are unaware of the processes for constructing knowledge in science, unknowingly, inhibit science learning. However, although the school factors remained the same after the teachers' participation in the professional development program, all the teachers increased their science instruction after receiving more pedagogical and

content knowledge. This finding suggests that school constraints are important to consider and should be addressed to facilitate better science instruction. Yet, school constraints may not be the single variable that explains why teachers teach science less frequently. Indeed, the paucity of science instruction may also relate to teachers comfort level and content preparation.

Research question three related to the connection between perception and practice (Is there a relationship between self-reported changes in conceptual change teaching practices and actual classroom practices?) To determine the relationship between self-reports and actual practice, I observed in each teacher's classroom four times. Then I compared and contrasted the teachers' perspectives with their practice. As previously mentioned, the teachers perceived that they implemented hands-on activities, asked questions, reduced their reliance on the science textbook, allowed students to talk in cooperative groups, managed their classrooms during science and increased the amount of time towards science instruction. Classroom observations revealed that teachers implemented hands-on activities, allowed students to work in cooperative groups and asked several questions albeit most were recall questions. Also, I observed teachers using praise, terms of endearment and culturally specific analogies.

However, some classroom practices were inconsistent with teachers' self-reported practices. The teachers in this study stated that they implemented pedagogical strategies that I did not observe. Specifically, the teachers did not use alternative forms of assessment to evaluate students' science content knowledge nor did they allow students to discuss science concepts within their

groups. The teachers also stated that they no longer lectured about science content and that they no longer used the science textbook as the primary instructional tool to teach science. However, observation data revealed that teachers implemented teacher guided hands-on activities and five of the seven teachers relied heavily on the science textbook. Also, I observed several instructional strategies that were not mentioned by the teachers during any of the in-depth interviews. For instance, some teachers did not mention their use of culturally specific analogies, praise, or terms of endearment such as “darling” and “my babies” to interact with the students in their classrooms.

In sum, classroom observations revealed that teachers implemented strategies that they reported and strategies that they did not report. I also observed teachers implementing strategies that they said they eliminated from their practice. When the teachers’ actual classroom practice is juxtaposed onto their perceived practice, it is interesting to note that praise, terms of endearment, and culturally specific analogies were unrelated to the science education professional development curricula and that teachers were not conscious that they implemented these strategies.

Research question four (Is there a relationship between reported changes in conceptual change teaching practices and the content of the professional development institutes?) pertains to the relationship between reported changes in conceptual change practice and the content of the professional development curricula. To help answer this question, I examined the professional development

curricula in the annual reports. I then juxtaposed the professional development curricula onto teachers' perceptions and practices.

Interview data revealed that all teachers perceived that they implemented all components of the professional development curricula. Classroom observation data revealed that most teachers (86%) implemented conceptual change strategies like allowing students to make predictions, engaging students in hands-on science activities, and asking numerous questions. However, in the majority of the cases, the teachers did not implement the strategies to the same degree as the professional development facilitators. Limitations in teachers' implementation of certain conceptual change teaching strategies may stem from their limited science content knowledge as expressed by the teachers during the interviews.

Observation data also revealed that a wide range exists between implementation of specific conceptual change teaching strategies. For example, as illustrated in Table 4, 100% of the teachers implemented hands-on activities. In contrast, only 29% clarified science concepts. Ten percent of the teachers gave students repeated opportunities to reuse new knowledge and none of the teachers employed alternative assessment strategies to determine students' comprehension of science material.

In sum, three of seven teachers (42%) implemented at least 70% of the conceptual change strategies. Two of seven teachers (29%) implemented at least 40% of the strategies and two of seven teachers (29%) implemented 30% of the conceptual change teaching strategies. Therefore, five of the seven (71%)

teachers implemented at least 40% of the conceptual change teaching strategies. The data are consistent with the research literature on professional development, which suggests that most teachers rarely implement all strategies modeled or discussed in professional development sessions (e.g. Little, 1993; Showers, 1983; Sparks & Hirsh, 1997; Terehoff, 2002). However, in the professional development program, since the teachers received over 240 hours of professional development based on the conceptual change model of teaching, the expectation was that they would implement greater than 50% of the conceptual change strategies. Only three of the seven teachers (42%) reached that standard.

Overall, this study revealed that the lead science teachers valued the science content and pedagogical knowledge they learned in the professional development program and they continued to value the traditional African American teaching beliefs they already held. The findings regarding teachers' implementation of conceptual change teaching strategies suggest that if teachers receive more content and pedagogical knowledge in professional development programs, then they are more likely to incorporate more components of conceptual change teaching into their classroom teaching and to increase the amount of time they devote to science. Also, this study revealed that even when African American teachers experience professional development like the teachers in the literature, they do not implement the strategies in the same way as the professional development facilitators. Furthermore, professional development as currently discussed in the literature and implemented in

professional development institutes does not discuss the affective dimension to teaching as modeled by the teachers in this study. These teachers' interactions with African American students are unrelated to the professional development program in which they participated. All the teachers in this study have had over 12 years of experience working in all Black settings. This background may provide a better explanation for their perspectives and practices moreso than the science education professional development program.

Table 4

Summary of Conceptual Change Teaching Strategies Implemented

Conceptual change teaching strategy	Ms. Unicorn	Ms. Bedford	Ms. Wiley	Ms. Jacobs	Ms. Pringle	Ms. Warner	Ms. Williams
Elicit learners' predictions about science phenomena	√	√	√	√	x	√	√
Use laboratory activities to engage learners in science lessons	√	√	√	√	√	√	√
Encourage learners to clarify science concepts through class or group discussions	√	x	x	√	x	x	x
Give learners	x	x	x	√	x	x	x

Influence of science education professional development on African American teachers

multiple chances to use new knowledge							
Ask learners to clarify scientific explanations	√	x	x	√	x	x	√
Ask a range of questions	√	√	√	√	√	√	√
Model classroom management	√	x	x	√	x	x	√
Circulates around the classroom	√	√	x	√	√	√	√

Table 4

Summary of Conceptual Change Teaching Strategies Implemented

Explains science content to learners after completing activities	√	√	x	√	x	x	√
Employs a variety of assessments	x	x	x	x	x	x	x
% Implementation	80	50	30	90	20	40	80

√ = strategies implemented; x = strategies not implemented; % = percent implementation

Discussion

This study explored the influence of science education professional development on African American teachers' conceptual change and practice. The purpose of the study was to determine the perspectives and practices of exemplary African American science teachers following their participation in long term science education professional development.

The study revealed that the lead science teachers valued the science content and pedagogical knowledge learned in the professional development program and they continued to value the traditional African American teaching beliefs already held. Specifically, the results from this study indicate that teachers altered their science pedagogy to include several components of conceptual change teaching. The most frequently used pedagogical strategies involved allowing students to make predictions (n=6), engaging students in hands-on science activities (n=7), allowing students to work in cooperative groups (n=6),

and asking numerous questions during science instruction (n=7). This change is consistent with the literature on conceptual change teaching.

The findings regarding teachers' implementation of conceptual change teaching strategies suggest that if teachers receive more content and pedagogical knowledge in professional development, they are more likely to incorporate more components of conceptual change teaching into their classroom instruction and to increase the amount of time they devote to science. This research demonstrates that this finding may be as true for African American teachers as it is for the majority teachers who have usually been involved in research studies on conceptual change teaching.

Of course, the implementation of the strategies in this research is mitigated by several factors. For example, the teachers implemented the strategies to varying degrees; however, they do not implement the strategies in the same way as the professional development demonstrations; they do not always practice what they report themselves to be doing; and their comfort level is not always improved after the professional development. The limitations in teachers' implementation of conceptual change teaching strategies appear to stem from their level of science content knowledge and from the structure of elementary schools, which includes a lack of emphasis on science education. The limitations of implementation described in this study are consistent with the literature on the influence of professional development on teachers' practice. Of importance to note, in this study, is the observation that the implementation of strategies was most effectively accomplished when the teacher was one who

continued to participate in professional development as a lead teacher. The correlation between changed pedagogy and curricular emphasis may indicate that teachers are more apt to change if they have sustained experiences in professional development.

However, not surprising given the nature of the professional development curriculum, the professional development program did not influence the teachers' general pedagogical beliefs about teaching African American students. Although the professional development program did provide sessions on equity and contributions of African Americans in science, with the exception of the sessions facilitated by the cultural anthropologist in residence, the sessions did not focus on issues related to teaching specific ethnic groups. Consequently, teachers entering the program held the same beliefs about African American students throughout the program. These beliefs appear to be culturally grounded. In particular, they share the following traits consistent with other African American teachers as identified in the multicultural education literature. For instance, like teachers in Foster (1990), Ladson-Billings (1994) and Stanford (1998) studies, the African American teachers in this study also perceived that African American students are capable of achieving academically but need supportive relationships with teachers who enable them to succeed in spite of adverse circumstances at home and school. Like teachers in Walker's (1996) study, the pedagogy of teachers in this study stem from their prior experiences in segregated schools. These experiences allowed the teachers in this study to support African

American students in ways that other teachers may not especially given the defacto (or dejure) segregation that exists in many urban schools today.

Similar to teachers in Foster's study, the teachers in this study took an interest in the African American students in their classes that extended beyond pedagogical strategies (insert Donna's comment about leaving their community in results section. Insert Pat's comment about forecasting the students' future).

These African American teachers reported that they are trying to prepare students to function in the larger society once they leave school.

Like teachers in Irvine's study, the African American teachers in this study maintained high expectations for the African American students they taught. They especially had expectations that their students would become more interested in and ultimately pursue science careers after their participation in hands-on inquiry based science instruction. Further, the African American teachers in this study used their knowledge of students to teach and develop personal relationships with their students. The knowledge and relationships were beneficial in helping teachers make analogies between students' culture and science content.

This study also suggests that knowledge of African American culture may be better understood by teachers who have had extensive opportunities to be part of the African American community. For example, five of seven teachers attended Historically Black Colleges, and one other teacher had an extensive background in African American history. All of these teachers were more adamant in their beliefs about what African American children needed especially

with regard to science education. In contrast, the teacher who spoke less about this connection attended a white state university in the Northern part of the United States. She did not speak extensively to the needs of urban African American students. She never mentioned teaching to prepare African American students for a better future.

In conclusion, the pedagogical strategies of the African American science teachers in this study extend the literature on conceptual change teaching by including more of the affective dimension of teaching. This study is unlike earlier science education studies that examined the influence of professional development on teaching and focused predominately on the cognitive domain of science instruction (e.g. Kahle, Meece, & Scantlebury, 2000; Neale, Smith, and Johnson, 1990; Radford, 1998). The analysis of teachers' perspectives and practices reveal that a blended African American model of teaching with standards based science instruction can possibly foster motivation and potential evidence of success in science for African American students. However, if teachers are not consistently cognizant of the duration of teacher guided strategies, then the blended model could potentially foster dependence and reliance, which contradicts standards of science achievement.

This study complements the current science education literature by revealing that despite ethnicity, teachers progress through a similar continuum when attempting to alter their science instruction. Specifically, as noted by Roychoudhury and Kahle (1999) and Wise, Spiegel, and Bruning (1999), following professional development, teachers in this study returned to their classrooms and implemented inquiry based strategies albeit and expectedly not at the level of expertise as the professional developers. Similarly, like the teachers in Radford's (1998) study, the teachers in this study implemented hands-on activities, arranged students in cooperative groups, and asked numerous questions. Teachers also altered their perspectives about science teaching and learning. Also, like the pedagogical strategies of other teachers identified in the science education literature, the teachers in this study demonstrated difficulty in asking critical analysis questions and engaging students in discourse related to the science content under investigation. In sum, with respect to pedagogical strategies, the results of this study reinforce the data reported in the science education literature.

The perspectives and practices of the African American teachers in this study parallels the perspectives and practices of African American teachers documented in the multicultural education literature. Specifically, like the teachers in Foster's (1997) study, the teachers in this study perceived that they are preparing students to navigate a society that may not readily embrace them. Additionally, like teachers described by Dilworth (1990), the teachers in this study

mentioned that they bring an inherent understanding of the background, attitudes, and experiences of their students.

The results of this study advance both bodies of literature (science education and multicultural education) in that it shows the necessity for the two bodies of literature to inform one another. Specifically, this study shows that exemplary African American teachers engaged in science professional development already possess positive attitudes towards the academic capabilities of African American students. These perspectives serve as a backdrop for desiring to enhance their pedagogical skills in an area of acknowledged limitation. The African American teachers in this study wanted to enhance their skills to provide high quality science instruction for African American students. Following these teachers' additional training in science, they continued to perceive that their students would be successful academically and now in science given that they had undergone additional science professional development. The classroom observations revealed that these teachers created an environment where students would be successful in science regardless of their cultural backgrounds and experiences. Some teachers' use of culturally specific analogies revealed their desire to help students connect to the content beyond the examples highlighted in their textbook. Also, the teachers' use of terms of endearment are not reported in either the science education or multicultural education literature. The teachers in this study used these terms of endearment subconsciously as an indication that they have a concern for their

students that supercedes the traditional teacher student relationship reported in the science education literature.

Finally, most teachers reported that following professional development sessions, their students performed better during science. Teachers noted that some of the students who previously performed poorly in reading increased their reading skills, comprehension and scores. The students' science achievement on standardized science scores was not measure; however, teachers reported marked improvements in students' interest and classroom performance in science. This study suggests that like other studies in science education, professional development does have an influence on African American teachers' conceptual change and practice. Not reported in many studies in science education is the influence that African American teachers' perspectives and practices can have on shaping the type science education professional development experiences all teachers of low-income African American students may receive.

This study suggests that more replication studies are needed to determine the generalizability of the data presented. Additionally, more research is needed on the following. First, science educators need to consider the influence of science education professional development on the science pedagogy of teachers in urban school districts. Science educators also need replication studies as this study represents only seven teachers in an urban district. Additionally, future research should consider the impact of continuous long-term professional development. Comparative studies of White science teachers of

African American students with Black science teachers of African American students are necessary. Particularly, data by Ladson-Billings (1994) suggest that exemplary White teachers of African American students have similar behaviors as teachers in this study. Finally, more science achievement studies of elementary students in classrooms of culturally responsive and scientifically competent teachers are needed that link teachers' perceptions of African American students and practices with African American students to academic achievement, specifically in science.

This study also has implications for teacher training programs and schools. Results suggest that science educators should consider providing teachers with extensive science content backgrounds and educating teachers on how to bridge specific content with pedagogical strategies. Teacher preparation programs should also provide teachers with cultural knowledge with the intent of extending their science pedagogical strategies. This thrust in science education development is important because most teachers of science are not African American. Thus, the cultural knowledge the teachers in this study were able to bring to fruition is a result of their previous experiences and is not knowledge that most teachers, particularly white teachers possess.

Finally, schools need to engage in conversations on the significance of culturally responsive pedagogy as the means for undergirding pedagogical practice, especially in science. Heretofore, science instruction has operated with little attention to the affective needs of African American students. Arguably, this study demonstrates that students need both the conceptual change strategies

and the motivation and praise that characterized the behavior of the teachers in this study. Well-trained teachers in conceptual change instruction should extend conversations focusing on African American students' low performance in science to conversations around teachers implementing strategies that increase students' achievement in the discipline. This study should serve as the necessary impetus for these conversations.

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