Scientists in the Making: Promoting African American Students' Interest in Science through Inquiry-based, Culturally Relevant Instruction

Jomo W. Mutegi
Indiana University, IUPUI

The low number of African Americans pursuing careers in the natural sciences has been (and continues to be) a concern for science educators. While science educators have sought to explain the science-career decisions of African Americans through research (Hager & Elton, 1971; Lewis, 2003; Lewis & Collins, 2001; Lewis & Connell, 2005; Lewis, Pitts, & Collins, 2002; Maple & Stage, 1991), we have also worked to increase African American representation in science through various intervention programs (Barisa & Holland, 1993; Carmichael & Sevenair, 1991; Hrabowski, 1999; Maton, Hrabowski, & Schmitt, 2000; Tobias, 1992). Unfortunately, the problem has been a resilient one and African Americans (comprising fewer than 2% of practicing, Ph.D.-holding scientists since 1977) continue to be underrepresented in science and science-related careers (National Science Board, 2000).

Many scholars see promise in the current reform movement as articulated in the National Science Education Standards (1996). Some researchers have found that standards-based teaching practices (particularly inquiry-based instruction) lead to improved attitudes, interest, and general achievement among African American students (Brownstein & Destino, 1994, 1995; Kahle & Damnjanovic, 1994; Kahle, Meece, & Scantlebury, 2000; Wandersee & Griffard, 1999). Khale, Meece, and Scantlebury (2000), for example, examined the science achievement and attitudes of a sample of African American, middle school students throughout Ohio. Their findings indicated that students whose teachers frequently used standards-based instruction exhibited more positive attitudes and achievement in science than their counterparts.

At the same time there is a substantial cadre of educators calling for reform in the pedagogy of African-American students (Cochran-Smith, 2001; Giddings, 2001; Howard, 2001; Hubbard & Mehan, 1999; Middleton, 2001; Mutegi, 2011; Shujaa, 1995). Foremost among these reformers are those advocating culturally relevant pedagogy (e.g. Ladson-Billings, 1994, 1995). In this article I describe the Carson Institute for Science Research and Learning (CISRAL), which is an after-school science workshop that enjoins principles of inquiry-based science instruction with culturally relevant teaching practices in order to increase African American students' interest in science and science-related careers.

Description of CISRAL

The Carson Institute for Science Research and Learning operates in a public, inner-city middle school as part of an after-school arts program. It is named for Dr. Benjamin Carson – the well-known Professor of Neurosurgery at The Johns Hopkins University School of Medicine. It is the result of collaboration between the University of Pittsburgh, Arsenal Middle School, and the St. Mary's Lawrenceville Arts Program (a community-based arts program for inner city children). CISRAL was one of several programs that comprised the after-school offerings. In addition to science, students were also able to study origami, ballet, sewing, entrepreneurship, and photography.

Participants

CISRAL was available to all students who attended Arsenal Middle School. Over 30 students expressed interest and attended throughout year-one. Approximately 69% were male and 31% were female. In addition, 20% of the students were sixth-graders, 70% were seventh-graders, and 10% were eight-graders. All students but one (97%) were African American; there was one Caucasian student. Students who attended CISRAL (as with all of the programs) did so voluntarily. And while staff encouraged consistent participation, there were a number of students whose attendance was sporadic. Of the 30 students participating, seven attended the program consistently throughout the entire school year.

CISRAL Activities

As stated, the objective of CISRAL was to draw on principles of inquiry-based science instruction and culturally relevant teaching practices to increase African American students' interest in science and science-related careers. To this end CISRAL was designed to represent a microcosm of the scientific community. Students who attended the Carson Institute were referred to as junior scientists, and their job was to engage in science research. Teachers at the Carson Institute were referred to as senior scientists. Their job was also to conduct science research acting as facilitators for junior scientists. Junior and senior scientists conducted research by raising research questions, designing investigations to answer those questions, and presenting the results to their peers.

Each semester began with a one- to two-week orientation in which senior scientists described expectations to students, instructed students in laboratory safety and use of laboratory equipment, and reinforced the model of learning promoted in CISRAL. The orientation concluded with senior scientists leading the entire group of students in conducting a research project, beginning with the identification of a research question and ending with the presentation of findings. Following the orientation junior scientists were permitted to begin the research process by conducting their own investigations.

During the fall semester, five students completed research projects from beginning to end. In one research project on magnetism a student identified and described various patterns of magnetic forces using magnets and iron filings. In a second project a student with an interest in black holes wrote an essay on what was known and unknown about black holes. The initial reaction of senior scientists was that this project did not fulfill the spirit of CISRAL since it did not involve “inquiry.” However, after careful consideration it was concluded that since the student was interested in the topic, and since not all scientific inquiry involved laboratory manipulation of materials the project was acceptable. As it turns out the student prepared an extremely insightful report. Other students conducted investigations of the effect of light on plant growth, the electromagnetic properties of everyday materials, and weather patterns related to tornadoes.

During the fall semester students expressed discomfort with the high level of autonomy required for completing the research projects. In response, spring semester projects were conducted in small research groups comprised of three to four junior and senior scientists. This format allowed greater collaboration and input from both junior and senior scientists. As a result of this change, spring semester projects tended to be more sophisticated than those of the first semester. One second semester research project dealt with electricity. The research group conducting this project used a battery as an energy source to test the conductivity of several solutions. They also used a light bulb as an indicator of whether a circuit was made complete by the various solutions. This research group suggested that, should this project be repeated, it would be better to use an ammeter rather than a light bulb in order to obtain more precise data.

Other projects included a study of the effect of temperature on the speed of sound, and a study of the degree to which soap could inhibit bacterial growth.

There were two forums through which students were required to share findings with their peers. First, biweekly colloquia were held in which all junior and senior scientists gave updates on their research projects. The format was informal, patterned after a round table discussion. These forums provided participants an opportunity to ask questions of one another, deepen their understanding of their own research, and gain insight into the work being conducted by others. Second, at the end of each semester, research seminars were held in which students from throughout the after-school program were invited to see formal presentations of the students' work. These forums provided the same benefits as the colloquia and served the added function of piquing the interest of students participating in other programs.

Central Features

Inquiry-based science instruction shares many features with culturally relevant teaching practices and as such they are an ideal fit. Two features that I will discuss in relation to CISRAL are ownership of knowledge and establishing a community of learners. In reference to inquiry and the ownership of knowledge, reform literature provides the following guidelines:

1. Learners are engaged by scientifically oriented questions.
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
3. Learners formulate explanations from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations. (National Research Council, 2000, p. 24-27)

It is clear from these guidelines that the perspective presented is one wherein the onus for constructing knowledge resides with the student. Accordingly, learners are engaged; learners give priority, develop, and evaluate; learners formulate; learners evaluate; and learners communicate and justify. Similarly, culturally relevant teaching emphasizes the students' role in knowledge construction, "...culturally relevant teaching attempts to help students understand and participate in knowledge-building." Further, knowledge is "continuously recreated, recycled and shared by teachers and students" (Ladson-Billings, 1994, p. 81). These commitments require a different approach from what is found in traditional instruction, where the teacher is the owner of knowledge and the onus is on him or her to "give" the "correct" answers to students.

CISRAL drew from this idea by encouraging junior scientists to explore and learn to find answers themselves. Senior scientists would often solicit the thoughts and opinions of junior scientists by constantly asking, "What do you think?" and "Why?" Moreover, they emphasized that there is not always a "right" answer when conducting investigations. One senior researcher was fond of saying that "There may not be a *right* answer, but the *best* answer is the one that you can justify and defend." The willingness to modify the program structure (specifically the formation of research teams) based on input from junior scientists is another way that CISRAL drew from this idea.

While CISRAL activities promote mutually shared knowledge, recognition is also important to knowledge creators. Senior scientists were watchful for opportunities to defer to junior scientists who had exhibited expertise in a given area and also to underscore the accomplishments of scientists throughout history where appropriate. The following vignette provides an example:

> During one group discussion a senior researcher began explaining that experiments do not always proceed as planned. Remembering an incident from the previous semester she asked Tameka to share her own experience. Tameka then described how she had become frustrated that her science experiment was not yielding any discernable results. She was growing plants in different environments and decided to take them home over the holiday to continue her project. During that period her younger sibling knocked over some of the plants. Initially, Tameka thought that she would have to quit attending CISRAL because she had "messed up her experiment." One of the senior researchers encouraged her to bring in her toppled plants. As it turns out they were together able to identify some differences in the plants.

This experience gave Tameka a degree of expertise in acceptable experimental procedures that she was able to share.

A second feature of CISRAL is that it represented a community of learners. Science education reform literature emphasizes the importance of community among learners of science. Accordingly, "Community-centered environments require students to articulate their ideas, challenge those of others, and negotiate deeper meaning along with other learners. Such environments encourage people to learn from one another" (National Research Council, 2000 p. 122). This emphasis is also a trait of culturally relevant teaching. Ladson-Billings (1994) points out that, "Encouraging a community of learners means helping the students work against the norm of competitive individualism. The teachers believe that the students have to care, not only about their own achievement but also about their classmates' achievement" (p. 69). CISRAL drew from this idea through the biweekly colloquia, research seminars, and the collaborative research teams. These forums were ideal venues through which junior scientists could speak equally as colleagues and learn to give and accept constructive criticism.

Lessons Learned

One of the greatest challenges faced by CISRAL staff was the low percentage of students who had consistent attendance. Exit interviews with CISRAL students indicate that the most significant factor inhibiting student participation was the high degree of self-sufficiency expected of students. As mentioned, students were expected to raise research questions, design means of answering those questions and present findings to their peers. Although they had guidance, students reported that this task was daunting. There was a sense of uncertainty about what they should do when engaging in the research process, and there was a feeling of isolation when conducting the research. One male student made the following comment:

> It would be better if we covered a general area in a specific time, like a week or two weeks or something. One group could talk about bacteria. Then one group could talk about citric acid. Then another group could do different kinds of bases or computers. Then the next week you could go to different things like rotate. And everybody could present at the end of the week.

A female student added,

> When you work individually there's lots of different things going on at different times and you have to switch over to something else. But if you do everything in a group then you have

different opinions that everybody can give on the same topic. And it's more fun working with more people.

The insight of these students represents a general sentiment of those interviewed and also illustrates that the inquiry-based science instruction originally planned did not take into account students' preparedness for this type of instruction. Consequently, some students did not feel part of CISRAL to the degree that they would attend regularly. Previous research concerning new initiatives or reform efforts has found that in order to be successful, all participants (teachers, students, parents, and administrators) must buy into the new initiative or reform (e.g. Doherty, 1993; Perreault & Isaacson, 1996). The experiences of year-one confirmed the importance of not only matching science education reform with contemporary methods of teaching African American children, but also matching those reforms with the students they are intended to serve. As the science education community (a) moves to extend our emphasis on inquiry-based instruction and (b) continues to advocate for culturally responsive pedagogy the experience of CISRAL provides an encouraging peek at the opportunities available to us. These need not be incompatible ends. Instead they serve as firm guideposts towards which we can move as we work to make science a more integral part of our students' lives.

References

Barisa, M. T., & Holland, C. (1993, November). *The graduate achievement program: A description of the first year of a summer enrichment program in math and science for minority undergraduate students.* Paper presented at the Mid-South Educational Research Association, New Orleans, LA.

Brownstein, E. M., & Destino, T. (1994). *Scenes from a science classroom: An enrichment program experience.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Brownstein, E. M., & Destino, T. (1995). Science enrichment outreach. *Science Teacher, 62*(2), 28-33. Carmichael, J. W., & Sevenair, J. P. (1991). Preparing minorities for science careers. *Issues in Science and Technology, 7*(3), 55-60.

Cochran-Smith, M. (2001). Multicultural education--Solution or problem for American schools? *Journal of Teacher Education*, *52*(2), 91-93.

Doherty, C. L. (1993). *A case study of constraints to teacher change.* M.S. Thesis, Florida State University, Tallahassee, FL.

Giddings, G. J. (2001). Infusion of Afrocentric content into the school curriculum: Toward an effective movement. *Journal of Black Studies, 31*(4), 462-482.

Hager, P. C., & Elton, C. F. (1971). The vocational interests of Black males. *Journal of Vocational Behavior*, *1*, 153-158.

Howard, T. C. (2001). Powerful pedagogy for African American students: A case of four teachers. *Urban Education, 36*(2), 179-202.

Hrabowski, F. A. I. (1999). Creating a climate for success. *Presidency, 2*(1), 34-39.

Hubbard, L., & Mehan, H. (1999). Race and reform: Educational "Niche picking" in a hostile environment. *Journal of Negro Education, 68*(2), 213-226.

Kahle, J. B., & Damnjanovic, A. (1994). The effect of inquiry activities on elementary students' enjoyment ease, and confidence in doing science: An analysis by sex and race. *Journal of Women and Minorities in Science and Engineering, 1*(1), 17-28.

Kahle, J. B., Meece, J., & Scantlebury, K. (2000). Urban African-American middle school science students: does standards-based teaching make a difference? [Feature]. *Journal of Research in Science Teaching, 37*(9), 1019-1041. doi: 10.1002/1098-2736(200011)37:91019::aid-tea93.0.co;2-j

Ladson-Billings, G. (1994). *The dreamkeepers: Successful teachers of African American children*. San Francisco: Jossey-Bass Publishers.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-491.

Lewis, B. F. (2003). A critique of literature on the underrepresentation of African Americans in science: Directions for future research. *Journal of Women and Minorities in Science and Engineering, 9*, 361-373.

Lewis, B. F., & Collins, A. (2001). Interpretive investigation of the science-related career decisions of three African-American college students. *Journal of Research in Science Teaching, 38*(5), 599-621.

Lewis, B. F., & Connell, S. (2005). African American students' career considerations and reasons for enrolling in advanced science courses. *Negro Educational Review, 56*, 221-231.

Lewis, B. F., Pitts, V. R., & Collins, A. C. (2002). A descriptive study of pre-service teachers' perceptions of African American students' ability to achieve in mathematics and science. *Negro Educational Review, 53*, 31-42.

Maple, S. A., & Stage, F. K. (1991). Influences on the choice of math/science major by gender and ethnicity. *American Educational Research Journal, 28*(1), 37-60.

Maton, K. I., Hrabowski, F. A. I., & Schmitt, C. L. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff Scholars Program. *Journal of Research in Science Teaching, 37*(7), 629-654.

Middleton, J. A. (2001). A role for the African American church in urban school reform. *Urban Education, 36*(3), 426-437.

Mutegi, J. W. (2011). The inadequacies of –science for all|| and the necessity and nature of a socially transformative curriculum approach for African American science education. *Journal of Research in Science Teaching, 48*, 301-316.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

National Science Board. (2000). Science and engineering indicators 2000. Washington, DC: U.S. Government Printing Office.

Perreault, G., & Isaacson, N. (1996). Learning from schools with restructured schedules. *The Clearing House, 69*, 265-267.

Shujaa, M. J. (1995). Cultural self meets cultural other in the African American experience: Teachers' responses to a curriculum content reform. *Theory into Practice, 34*(3), 194-201.

Tobias, R. (1992). Math and science education for African-American youth: A curriculum challenge. *NASSP-Bulletin, 76*(546), 42-48.

Wandersee, J. H., & Griffard, P. B. (1999). Challenges to meaningful learning in African-American females at an urban science high school. *International Journal of science education, 21*(6), 611-632.