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Full Length Research Paper

Improving Equity through a Science Enrichment Program

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We examined the impact of science enrichment activities on African American female students' achievement and attitude towards science. Seventeen students participated in the study. Attitudes were measured using a pre and post attitudinal survey, whereas achievement was measured using test scores from their biology class over a six-week period. Pre- and post measures indicated a significant increase in achievement and attitudes for the students who participated in the study.

Keywords: females, African American, minorities, science activities

Introduction

The increase in the number of baby boomers retiring in the next decade, combined with a greater demand in new technologies, are expected to lead to a shortage of skilled workers in STEM-related careers (Science, Technology, Engineering and Mathematics) (Pantic, 2007; Tornatzky, Macias, Jenkins & Solis, 2006). To offset this shortage, and for the US to stay technologically competitive, a greater number of US students must enroll in math and science courses and choose STEM-related majors. However, international studies consistently show US students lagging behind students in other industrialized countries in their achievement in math and science (Cavanagh, 2007; Ravitch & Cortese, 2009; Schleicher, 2009), whereas within the US schools achievement gaps persist between minority and non-minority students (Chapin, 2005; Magnuson & Waldfogel, 2008). Furthermore, it appears that the disparities in educational opportunities that exist in the US may play an important role in our low performance in international studies (Cavanagh, 2007). Therefore, the economic and technological future of our country depends, to a great extent, on how far we go to achieve educational equity in our schools.

Theoretical Framework

The achievement gap between minority and non-minority students has varied since the 1970s (Barton, 2005; Ferguson & Mehta, 2004; Haycock, 2001). For example, between 1970 and 1988 the achievement gap between White and African American students decreased by half and decreased by one third between Whites and Latinos (Barton, 2005; Haycock, 2001). Barton (2005) credited the increase in minority student achievement in the 80's to interventions related to Head Start and Title I legislation. However, in the early 1990's the student achievement gaps began widening again and by1999 only one in 100 African American and one in 50 Latino 17 year olds were able to comprehend specialized text, compare to one in 12 Whites. In mathematics similar patterns were found. By the end of high school, one in 100 African American and one in 30 Latino students were able to do multi-step problem solving, compared to one in 10 Whites. When examining high school completion rates the data showed that while about 90% of White 18-24 year olds and 94% of Asian students completed high school or a GED diploma, only 81% of African Americans and 63% Latinos achieved a similar level of education (Haycock, 2001). Nonetheless, recent data in math and reading scores from the National Assessment of Educational Progress Long-Term (NAEP-LTT) show that achievement gaps between minority and non-minority students have been again decreasing for the past 10 years (Magnuson & Waldfogel, 2008).

There are many reasons for the achievement gaps between minority and non-minority students. From very early in life many African American and Latino children face economic

inequalities which in turn result in differing life opportunities. Magnuson and Votruba-Drzal (2008), pointed out that in general African American children are more likely to live in poor and higher crime neighborhoods and have less access to quality health care. As a result, when these children begin school, they already score lower in variables related to school readiness. Chapin (2005) found wide racial and ethnic differences in children's general science and social studies knowledge in both kindergarten and first grade.

However, although researchers agree that home and neighborhood environments play a role in children's life experiences and opportunities, others suggested that school-related variables play a greater role in the lack of academic progress of many minority children (Aaronson, Barrow & Sander, 2007; Corcoran & Evans, 2008; Donlevy, 2006; Haycock, 2001). For example, Donlevy (2006) contended that the discrepancies in funding greatly contribute to the substandard quality of education that many minority and poor children receive. According to Donlevy, "schools serving mostly poor and minority students receive approximately $65,000 less per classroom or more than $1,000,000 less for a 400-student elementary school" (p. 1). Researchers (Aaronson et al., 2007; Corcoran & Evans, 2008; Haycock, 2001) have also uncovered other school-related variables responsible for the achievement gaps. For example, Corcoran and Evans (2008) found that teacher quality plays a key role in the achievement gaps between minority and non-minority students, particularly in math and science. Aaronson et al. (2007), also noted a strong relationship between teachers' content knowledge and student achievement.

Using classroom observations and interviews with students and teachers Haycock (2001) identified three major school-related variables: low student expectations, boring and meaningless curriculum and poorly prepared teachers. Haycock contended that "we expect so little of students in high-poverty schools that we give them As for work that would earn them Cs or Ds anywhere else" (p. 5). Similarly, Barton (2005) identified six school factors responsible for the achievement gaps: (a) the rigor of the curriculum; (b) the adequacy of teacher preparation in the subject matter; (c) the amount of teachers' experience; (d) the class size; (e) the availability of technology-assisted instruction; and (f) the safety within the school. Findings such as these led Ferguson and Mehta (2004) to call for research that focuses on improving what happens in classrooms.

Thompson and O'Quinn (2001) suggested that academic achievement of African American students would increase if they were taught by able, well-prepared, experienced teachers and that minority students need a positive personal experience in school. Glassman and Roelle (2007) described the impact that systemic changes had on the achievement of African American male students in a suburban school in New York State. They found that increased teacher expectations, personalized instruction, smaller classes, strengthening of relationships between students and teachers, and increased faculty's cultural competence, greatly increased the success of their African American male students. Similarly, Miles and Matkins (2004) discovered that African American student achievement in science increased when students were exposed to meaningful science experiences. These experiences may include mentoring, tutoring, Saturday science academy, and hands-on lab experiences.

The literature presented here appears to indicate that the achievement gap between minority and non-minority students tends to be cyclical and influenced by national trends related to resource allocation. The current budget cuts that many schools in large urban areas are experiencing will most likely once again have a negative impact on the education of many minority students. However, the literature also indicates that programs at the local level can have a positive impact on the lives of the students they serve, when such programs implement approaches that lead to meaningful learning. In our study some of these approaches, role models and inquiry-based science activities, were implemented in an after-school program with a group of African American female students enrolled in a 9th grade biology class. The following research question guided the study:

- What impact will enrichment activities have on participating female students' achievement and attitudes toward science?

Method

A pre-experimental design, single-group, pre-test/post-test was used in this study (McMillan & Schumacher, 2010). After school enrichment activities related to a biology class were implemented with a group of female students in grades 9 and 10. The enrichment activities included after school tutoring, inquiry-based activities, role models and mentoring. The biology teacher implemented the activities.

Setting and Participants

The study took place during the 2007-08 school year in a 9-12 public high school located in an urban area outside the city of Atlanta. There were 2,155 students enrolled in the school, 48% of them White, 46% African American, 4.9% Hispanic and 1.1% multi-racial. Of the students, 30% came from an economically disadvantaged area. The school had met Adequately Yearly Progress (AYP) for the 2006-2007 school year. Seventeen female students chose to participate in the study and all of them were African American. Since this was an after-school program, participation was voluntary.

Data Sources and Analysis

Test scores were used to measure changes in student achievement, while a survey administered before and after the enrichment program was used to measure changes in student attitudes toward science. The 20-item survey asked students to rate their opinion on various statements about science using a 5-point Likert scale. Descriptive and inferential statistics were

used to find statistically significant differences in student achievement and attitude as a result of participating in the enrichment activities. Statistical significance was determined at $p < 0.05$. Cohen's measure of effect size (*d)* for comparing two means was also determined (Cohen, 1988).

Qualitative data in the form of student comments made during the program's activities were recorded verbatim and later analyzed using techniques of naturalistic inquiry (Lincoln & Guba, 1985; Miles & Huberman, 1994). As data were read several times, individual segments of data were coded and similar codes grouped into categories.

Program Characteristics

The program was implemented after regular school hours and had the following components:

Role models. Once a week the students learned about a different female scientist and their contributions to science. Dr. Mae Jemison, an African American Astronaut, was one such role model discussed during the program.

Inquiry-based activities. Students participated in many hands-on laboratory activities and projects related to concepts covered in class. These activities were delivered in the form of an inquiry-based approach know as the learning cycle (Marek, & Cavallo, 1997). In this approach students first explored the topic through hands-on activities to help them "discover" the concept they were investigating. Their exploration was followed by whole class discussions and then applications of the concept to solidify understanding. For example, students explored the concept of osmosis using gummy bears and gel electrophoresis to learn about DNA. Students also participated in one-on-one tutoring as well as in small group discussions of concepts covered in class.

Results

Pre- and post-test comparisons indicated a significant gain in student achievement ($p = 0.01$) and attitudes toward science ($p < 0.05$). Furthermore, Cohen's measure of effect size for both achievement ($d = 0.9$) and attitudes ($d = 4.8$) were high. Please refer to Tables 1 and 2 below.

Student Achievement

In this study, achievement was measured using a regular biology test given at the end of a unit of study. Analyses of the data indicated a significant difference ($p = 0.01$) in achievement when comparing students' biology test scores before and after the implementation of enrichment activities (See Table 1).

Student Attitudes Toward Science

As results in Table 2 indicate, the science enrichment activities had a significant positive impact on the students' attitudes toward science, with the *t*-test resulting in a *p*-value of less than 0.05.

Table 3 shows student responses to a selected group of items in the survey. Results show that after participating in the enrichment activities a greater percentage of students felt that they liked science, did well in science, planned to major in science and would like to pursue a science-related career. One of the highest point gains was connected to students' sense of self-efficacy in science represented by the statement "I do well in science classes." In addition, while on the pre-survey only 12% of the students said that biology was their favorite class, this number increased to 33% after participating in the enrichment activities.

Students also had an opportunity to comment on their experiences related to their participation in the science enrichment activities. Overall their responses indicated a favorable view of the program. Common comments included "I'm glad to be in the enrichment program; it's helping me understand science better." Other comments were related to students' enjoyment of the inquiry-based activities. "I never knew doing science could be so much fun," wrote one of them and "I enjoy doing learning cycles, they make me like science," responded another.

Student comments also indicated that some of the program components made a strong impact on the students' perceptions of science. For example, when they learned about one of the role models -- Dr. Mae Jemison, a Black female astronaut -- they were very interested. Many of them had never heard of her. One of them asked, "how come we didn't learn about her in science class?" Another student commented, "I didn't know there were Black astronauts let alone a woman." They took a fond interest in learning that Dr. Jemison was from Chicago and that she was a medical doctor as well as an astronaut.

The biology teacher who implemented the enrichment program also served as a role model to the young ladies. Also African American, she had decided to become a teacher after working for a few years as a biochemist in a Medical School. She shared with her students some of her experiences when working as a biochemist and the career path she had taken through college and graduate school. This in turn resulted in many student questions about science-related careers and the importance of doing well in science classes.

Discussion and Conclusion

As the results of this study indicate, the science enrichment activities in which the students participated had a positive impact on African American female students' achievement and attitudes toward science. Pre and post mean comparisons show a 10-point increase for both achievement and attitudes as well as large effect sizes for both measures (Cohen, 1988).

These results support those of Miles and Matkins (2004) who found that activities such as mentoring, tutoring, Saturday science academy, and hands-on lab experiences improved African American students' achievement in science. The results

of this study are also consistent with Nichols and Steffy's (1999) who noted that student self-efficacy increased when they experienced alternative learning environments. Similarly, Chang and Mao (1998) reported higher student achievement when middle-school students participated in inquiry-based activities.

Researchers have also purported a relationship between role models and student career aspirations (Fried & MacCleave, 2009; Hackett, Esposito & O'Halloran, 1989; Nauta, Epperson & Kahn, 1998). In the program described here, as students became familiar with the lives of female African American scientists their attitudes about science changed. They began considering the possibility of majoring in science and pursuing a science-related career.

Results such as these show that school-related variables are key to narrowing student achievement gaps. Yet, the current recession is once again negatively impacting the education of children in need, as schools cut programs and increase class size to meet budgetary cuts. Education was supposed to be the big equalizer after the passing of *Brown v. Board of Education* in 1954 and the subsequent Civil Rights Act of 1964, yet, half a century later, the educational experiences of many minority children continue to be inferior in quantity and quality when compared to those of the majority. Today as in the past, our large urban areas are segregated by race and socioeconomics and the schools in these areas mirror such segregation, with poor minority children attending, old, dilapidated schools with few resources. Yet, even though most minority students' educational experiences are drastically different from those of the majority, when measuring student achievement, those differences are not taken into consideration. Gaps in student achievement will continue to exist as long as there are gaps in the quality of their education.

References

Aaronson, D., Barrow, L., & Sander, W. (2007). Teachers and student achievement in the Chicago public high schools. *Journal of Labor Economics, 25*(1), 95-135.

Barton, P. E. (2005). Achievement gaps: Past and present. *Principal, 84*(4), 12-16.

Cavanagh, S. (2007). Poverty's effect on U.S. scores greater than for other Nations.
Education Week. 27(15), 1, 13.

Chang, C. Y., & Mao, S. L. (1998). *The effects of an inquiry-based instructional method on earth science students' achievement.* (Tech. Rep. No. EDO-SP-2003-02). San Diego, CA: Annual Meeting of the National Association for Research in Science Teaching. (ERIC Document Reproduction Service No. ED 418 858)

Chapin, J. R. (2006). Achievement gap in social studies and science starts early: Evidence from the early childhood longitudinal study (FN1). *The Social Studies, 97*(6), 231-8.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum.

Cohen, J. (1997). The earth is round (p < .05). In L. L. Harlow, S. A. Mulalk, & J. H.
Steiger (Eds.), *What if there were no significance tests?* (pp. 21-35). Mahwah, NJ: Erlbaum Press.

Corcoran, S. P., & Evans, W. N. (2008). The role of inequality in teacher quality. In K. Magnuson & J. Waldfogel (Eds.), *Steady Gains and Stalled Progress* (pp. 212-249). New York: Russell Sage Foundation.

Donlevy, J. (2006). A new year's resolution for 2006: Closing the achievement gap. *International Journal of Instructional Media 33*(1), 1-3.

Ferguson, R. F., & Mehta, J. (2004). The 50th anniversary - an unfinished journey: The legacy of Brown and the narrowing of the achievement gap. *Phi Delta Kappan, 85*(9), 656-669.

Fried, T., & MacCleave, A. (2009). Influence of role models and mentors on female graduate students' choice of science as a career. *Alberta Journal of Educational Research. 55*(4), 482-496.

Glassman, P., & Roelle, R. J. (2007). Singling black boys to close the gaps. *School Administrator, 64*(10), 26-28, 30-31.

Hackett, G., Esposito, D., & O'Halloran, M. S. (1989). The relationship of role model influences to the career salience and educational and career plans of college women. *Journal of Vocational Behavior, 35*,164-180.

Haycock, K. (2001). Closing the achievement gap. *Educational Leadership, 58*(6).

Jencks, C., & Phillips, M. (1998). *The Black-White Achievement Gap*. Washington, D.C: The Brookings Institution Press.

Lincoln, Y. S., & Guba, E. (1985). *Naturalistic inquiry.* Beverly Hills, CA: Sage Publications.

Magnuson, K., & Waldfogel, J. (2008). *Steady gains and stalled progress.* New York, NY: Russell Sage Foundation.

Magnuson, K., & Votruba-Drzal, E. (2008). Enduring influences of childhood poverty. In S. Danziger & M. Cancian (Eds.). *Changing Poverty.* (pp. 153-179) New York, NY: Russell Sage.

Marek, E. A., & Cavallo, A. M. L., (1997). *The learning cycle: Elementary school science and beyond*. Portsmouth, NH: Heinemann.

McMillan, J. H, & Schumacker, S. (2010). *Research in education: Evidence-based inquiry* (7th Ed.). New York, NY: Pearson.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* Thousand Oaks, CA: Sage Publications.

Miles, R., & Matkins, J. J. (2004) Science achievement for African American students. *The Science Teacher 71*(2), 36-42.

Nauta, M. M., Epperson, D. L., & Kahn, J. H. (1998). A multiple-groups analysis of predictors of higher level

career aspirations among women in mathematics, science, and engineering majors. *Journal of Counseling Psychology, 45*, 483-496

Nichols, J. D., & Steffy, B. E. (1999). An evaluation of success in an alternative learning programme: Motivational impact versus completion rate. *Educational Review, 51*(3), 207-219.

Pantic, Z. (2007). STEM Sell. New England Journal of Higher Education. 22(1), 25-26.

Ravitch, D., & Cortese, A. (2009). Why we're behind: What top nations teach their students but we don't. *Education Digest: Essential Readings Condensed for Quick Review*. *75*(1), 35-38.

Parker, V., & Gerber, B. (2000). Effects of a science intervention program on middle-grade student achievement and attitudes. *School Science and Mathematics, 100*(5), 236-242.

Schleicher, A. K. R. (2009). From Finland to Kyrgyzstan: A changing landscape. *School Administrator*. *66*(3), 26-27.

Thompson, C. L., & O'Quinn, S. D. (2001) *Eliminating the Black-White achievement gap: A summary of research.* Greensboro, N.C: North Carolina Education Research Council (ERIC Document Reproduction Service No ED457250).

Tornatzky, L. G., Macias, E. E., Jenkins, D., & Solis, C. (2006). *Access and achievement: Building educational and career pathways for Latinos in advanced technology.* Report on a National Study of Latino Access to Postsecondary Education and Careers in Information. Technology. Los Angeles, CA. The Tomás Rivera Policy Institute. (ERIC Document Reproduction Service No ED502061).

Table 1
Comparison of Test Scores Pre- and Post-Treatment (N = 17)

Pre-Treatment *M*	Post-Treatment *M*	*t*	*d*	*p*
69.9	78.8	3.17	0.9	0.01

Table 2
Comparison of Student Attitudes Pre- and Post-Treatment

Pre-Treatment M	*Post-Treatment M*	*t*	*d*	*p*
57.8	*67.9*	*2.81*	*4.8*	*0.02*

Table 3
Percentage of Students Agreeing with Each Statement Before and After the Use of Science Enrichment Activities

Statement	Total Pre	Total Post	Point Gain
I like science.	33	38	5
Biology is my favorite class	12	33	11
I do well in science classes	23	30	7
I plan on majoring in a science related field	16	22	6
I would like to be an engineer, scientist or doctor	23	26	3