Research on Closing the Achievement Gap in Science

A recent literature review on student diversity and science education (Lee & Luykx, in press) discusses a number of issues that should be considered in addressing student achievement gaps in science. These can be grouped as follows:

Curriculum Materials and Instructional Strategies

Appropriate curricula, materials, and pedagogy can decrease science achievement gaps. The culture of Western science is foreign to many students. Most current classroom science materials are not culturally relevant to non-mainstream students and do not adequately represent cultural diversity. Science instruction may reinforce power structures that privilege mainstream students, and other students may actively resist the approaches being used. This is exacerbated by teacher expectations that are lower for non-mainstream students.

All students, including those from low income families, English language learners, and special needs backgrounds as well as those with limited science experience, can engage in scientific inquiry, reasoning, and argumentation. Science teachers must learn to base instruction on content drawn from students' everyday knowledge and scientific practices. Science assessments may become more valid and equitable by making them relevant to student and community knowledge and experiences so that students can demonstrate what they know. Certain assessment formats are more equitable than others.

Teacher Quality

Much of the variation in student achievement in science is attributable to teacher characteristics. Teachers need not come from the same racial/ethnic backgrounds as their students in order to teach effectively, but they must understand and respect their students' backgrounds. Science teachers must earn their students' respect before they can offer content information. Science teachers need to engage in reform-oriented practices themselves in order to be able to provide effective science instruction for their students.

Other Interventions

A variety of other interventions can affect science achievement. At the school level, restructuring efforts, such as reducing tracking, can narrow science achievement gaps. Family support, including homework supervision, learning materials and resources, and parent's educational background, influences children's achievement, attitudes, and aspirations in science.

At the district level, it is becoming more common to adopt a scaled-up validated science program. Unfortunately, scaling up focused reforms frequently compromises the conceptual rigor and fidelity of implementation, due to the demands and constraints imposed by local policies and institutional conditions, and by individual teacher practices. When science is part of

accountability measures, teachers may feel pressured to teach to the test, sometimes leading to unintended and harmful consequences.

Elementary (Grades K-2)

Including multiple stakeholders in planning and implementing a new science curriculum raised student achievement (Vasquez, Teferi, & Schicht, 2003).

Elementary (Grades K-2 and 3-5)

Children in a bilingual (Spanish and English) presentation of inquiry science materials developed conceptual understanding and scientific thinking abilities that are components of scientific literacy (Hampton & Rodriguez, 2001).

Male laboratory partners are less likely than females to engage in mutual activities. Males are more likely than females to tinker with materials and use them outside the scope of teacher directions. Teachers can increase girls' interactions with materials by overtly sanctioning exploration of their properties and functions. Working in pairs encourages discussion and collaboration, but having one's own set of materials encourages individual exploration (Jones et al., 2000).

Elementary (Grades 3-5)

An instructional intervention that combined instructional materials, teacher professional development workshops, and teachers' classroom practices significantly raised student achievement without creating a gender gap (Lee, Deaktor, Hart, Cuevas, & Enders, 2005).

Specific instruction in science inquiry practices raised all students' achievement, especially for low-achieving students and those from low-SES and limited English backgrounds (Cuevas, Lee, Hart, & Deaktor, 2005).

For many urban, African American youths, argumentative, active confrontational evaluations are a primary method of meaning-making in science (Southerland, Kittleson, Settlage, & Lanier, 2005).

Middle School (Grades 6-8)

Students receiving hands-on instruction did significantly better on short-answer and hands-on assessments, but not on multiple-choice tests, than those students receiving only textbook instruction. After receiving hands-on instruction, students were more likely than those students receiving only textbook instruction to correctly explain physical phenomena without resorting to common misconceptions. Although disabled students needed behavioral support in both types of instruction, they were able to master science concepts at an acceptable level through hands-on instruction. Hands-on assessment, although less efficient than written assessments, allowed disabled students to demonstrate understanding of science concepts without interference from language factors (McCarthy, 2005).

Special education students with severe emotional disturbances or learning disabilities improved their science achievement while integrated into general education science classes. There was no effect on general education students' achievement of including special education students in these classes (Cawley, Hayden, Cade, & Baker-Kroczynski, 2002).
All students' attitudes toward science were significantly related to their achievement. Boys' attitudes toward science were more positively related to achievement test scores than were girls' attitudes. African-American girls with high ratings of home support were more likely to have friends who also participated in science activities. Gender differences in African-American students' science achievement were less pronounced in classrooms led by teachers who had participated in the SSI professional development activities (Kahle, Meece, & Scantlebury, 2000).

Students had higher test scores when their teachers were female and when they used standards-based instructional practices. Classes taught by teachers who had been involved in Statewide Systemic Initiative (SSI) professional development scored higher on the *Discovery* Inquiry test than did students in matched classes whose teachers had not yet participated in this professional development (Kahle et al., 2000).

In one school district with low science achievement scores, performance in science was higher when there was implementation of an inquiry-based modular science curriculum which involved extensive student use of software modeling, visualization, and information searching tools. Achievement was also higher when teachers participated in a professional development program focusing on collaborative construction of understanding and adaptation of materials and practices. The impact of the inquiry-based, technology-infused science curriculum continued to grow as the program scaled up (Marx et al., 2004).

For white girls, teaching strategies that emphasized both increased achievement and improved attitude toward science raised achievement scores. For white boys, strategies emphasizing improved attitude had no effect on achievement (Mattern & Schau, 2002).

Poor Latino student achievement in science was not associated with perceptions that science was unimportant. Latino students did not receive less support for doing well in science classes than their non-Latino peers (Bouchey & Harter, 2005).

A team of researchers helped urban students achieve mastery on a number of science topics. However, they did not close the achievement gap on standardized tests. The extra time spent on instruction in depth led to coverage of only half the intended curriculum (Li, Klahr & Siler, in press).

High School (Grades 9-12)

In chemistry, teaching the particulate nature of matter had a differential gender effect. Female students, although having the same logical reasoning ability as male students, tended to score lower than male students on a test of previous chemistry knowledge. Girls who were taught the particulate nature of matter scored higher than girls who were not taught this fundamental

property of chemistry, and scored comparably on general chemistry tests to boys. This effect was maintained over time. Male students' achievement was unaffected by this instructional approach (Bunce & Gabel, 2002).

An inquiry approach that included eliciting student engagement, using appropriate laboratory techniques, problem solving, conducting extended studies, and scientific writing increased student achievement (Von Secker, 2002).

Restricting science instruction for lower track high school students to basic facts promotes learned helplessness. These students can learn to participate in scientific discourse (Yerrick, 2000).

Science content that failed to link with the everyday experiences of urban youth prevented them from becoming engaged in learning science (Proweller & Mitchener, 2004).

Placement in lower science tracks led to a cycle of poor performance for both Latino and non-Latino white students, with a greater effect on Latinos (Zuniga, Olson, & Winter, 2005).

References

Bouchey, H. A., & Harter, S. (2005). Reflected appraisals, academic self-perceptions, and math/science performance during early adolescence. *Journal of Educational Psychology, 97*(4), 673-686.

Bunce, D. M., & Gabel, D. (2002). Differential effects on the achievement of males and females of teaching the particulate nature of chemistry. *Journal of Research in Science Teaching, 39*(10), 911-927.

Cawley, J., Hayden, S., Cade, E., & Baker-Kroczynski, S. (2002). Including students with disabilities into the general education science classroom. *Exceptional Children, 68*(4), 423-435.

Cuevas, P., Lee, O., Hart, J., & Deaktor, R. (2005). Improving science inquiry with elementary students of diverse backgrounds. *Journal of Research in Science Teaching, 42*(3), 337-357.

Hampton, E., & Rodriguez, R. (2001, Fall). Inquiry science in bilingual classrooms. *Bilingual Research Journal, 25*(4), 417-434.

Jones, M. G., Brader-Araje, L., Carboni, L. W., Carter, G., Rua, M. J., Banilower, E., et al. (2000). Tool time: Gender and students' use of tools, control, and authority. *Journal of Research in Science Teaching, 37*(8), 760-783.

Kahle, J. B., Meece, J., & Scantlebury, K. (2000). Urban African-American middle school science students: Does standards-based teaching make a difference? *Journal of Research in Science Teaching, 37*(9), 1019-1041.

Lee, O., Deaktor, R., Hart, J. E., Cuevas, P., & Enders, C. (2005). An instructional intervention's impact on the science and literacy achievement of culturally and linguistically diverse elementary students. *Journal of Research in Science Teaching, 42*(8), 857-887.

Lee, O., & Luykx, A. (in press). Science education and student diversity: Race/ethnicity, language, culture, and socioeconomic status. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research in science education.* Mahwah, NJ: Lawrence Erlbaum Associates. Paper presented at Maryland Institute for Minority Achievement and Urban Education Second Annual Research Symposium, College Park.

Li, J., Klahr, D., & Siler, S. (in press). What lies beneath the science achievement gap? The challenges of aligning science instruction with standards and tests. *Science Educator, 15*(1), 1-28. Retrieved March 2, 2006, from http://www.psy.cmu.edu/lessonplans/What%20 Lies%20Beneath%20Achievement%20Gap.pdf

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & et al. (2004). Inquiry-based science in the middle grades: Assessment of learning in urban systemic reform. *Journal of Research in Science Teaching, 41*(10), 1063-1080.

Mattern, N., & Schau, C. (2002). Gender differences in science attitude-achievement relationships over time among White middle-school students. *Journal of Research in Science Teaching, 39*(4), 324-340.

McCarthy, C. B. (2005). Effects of thematic-based, hands-on science teaching versus a textbook approach for students with disabilities. *Journal of Research in Science Teaching, 42*(3), 245-263.

Proweller, A., & Mitchener, C. P. (2004). Building teacher identity with urban youth: voices of beginning middle school science teachers in an alternative certification program. *Journal of Research in Science Teaching, 41*(10), 1044-1062.

Southerland, S., Kittleson, J., Settlage, J., & Lanier, K. (2005). Individual and group meaning-making in an urban third grade classroom: Red fog, cold cans, and seeping vapor. *Journal of Research in Science Teaching, 42*(9), 1032-1061.

Vasquez, J. A., Teferi, M., & Schicht, W. W. (2003, Spring). Science in the city: Consistently improved achievement in elementary school science results from careful planning and stakeholder inclusion. *Science Educator.* Bi-annual newsletter published by National Science Education Leadership Association, Raleigh, NC.

Von Secker, C. (2002, January). Effects of inquiry-based teacher practices on science excellence and equity. *The Journal of Educational Research, 95,* 151-160.

Yerrick, R. K. (2000). Lower track science students' argumentation and open inquiry instruction. *Journal of Research in Science Teaching, 37*(8), 807-838.

Zuniga, K., Olson, J. K., & Winter, M. (2005). Science education for rural Latino/a students: course placement and success in science. *Journal of Research in Science Teaching, 42*(4), 376-402.