

Research on Closing the Achievement Gap in Mathematics

The key findings from the research articles contained in this review are organized according to grade level clusters. Several of the research articles presented here spanned all grade levels K-12, and results from them are listed as K-12 findings. This research highlights a number of themes (interventions, instructional strategies, and teacher quality) that transcend all levels. The themes are important considerations leading to effective means for improving mathematics achievement and for narrowing or closing the achievement gap.

Grades K-12

A meta-analysis was conducted to determine effect sizes for studies within certain categories of mathematics achievement. Significant findings included:

- Providing teacher and students with specific information on how each student is performing enhanced mathematics achievement consistently.
- Using peer tutors or guides enhanced mathematics achievement.
- Providing clear, specific feedback to parents of low achievers on their children's successes in mathematics was found to enhance achievement, although modestly.
- Principles of direct or explicit instruction can be useful in teaching mathematics concepts or procedures. (Baker, Gersten, & Dae-Sik, 2002)

Teacher credentials had a statistically significant effect on students' test scores: a 10 percent increase of the number of teachers with full credentials on a school staff increased math scores by over 1 point. The benefits of full credentialing generally accrued equally for all students without helping reduce the racial/ethnic achievement gap, and without helping one racial group at the cost of another. An increase of 10 points in the percent of minority teachers increased Hispanic and African American math scores by close to 1 point and decreased nonminority scores by close to 1 point. Higher levels of white teachers in classrooms had a negative impact on minorities, but a positive influence on nonminority students, in each group's math scores. Higher levels of African-American teachers had a negative impact on nonminority students but a positive one on minority student, in their math scores (Bali & Alvarez, 2003).

Elementary (Grades K-2 and 3-5)

Teachers' mathematical knowledge for teaching positively predicted student achievement gains in mathematics in both first and third grades (Hill, Rowan, & Ball, 2005).

In math, a 10-student decrease in class size increased Hispanic scores by close to 2 points. All else equal, class size held some promise in reducing the race gap for Hispanic students' scores without hurting other students (Bali & Alvarez, 2003).

Hispanic students did not differentially benefit from enrollment in GATE [Gifted and Talented Education], while African-American students experienced some benefits, especially in math. Participation in magnet schools was associated with lower scores for African Americans and nonminorities in mathematics. Although enrollment in GATE programs generally benefited all students, enrollment in magnet schools did not strongly benefit any group, nor benefit one group at the expense of another (Bali & Alvarez, 2003).

Academic emphasis of the school was systematically related to student achievement in urban elementary schools. Results suggested that schools with strong academic emphases positively effect achievement for poor and minority students (Goddard, Sweetland, & Hoy, 2000).

Schools that effectively implemented activities that encouraged parents to participate with their children in home learning activities reported improved percentages of students who were proficient in mathematics from one year to the next. Activities that supported mathematics learning included: (a) homework assignments that required students and parents to interact and talk about mathematics, and (b) mathematics materials and resources provided for families to use at home. The relationships between implementation of these activities and mathematics achievement were strong and positive even after accounting for the influential variables of schools' prior achievement or level of schooling (Sheldon & Epstein, 2005).

Elementary (Grades 3-5)

Effective school characteristics may be more important for African American students' academic resilience (success) than for White and Latino students. Greater engagement in academic activities, stronger sense of efficaciousness in mathematics, more positive outlook toward school, and higher self esteem are characteristics differentiating low-SES students who achieved resilient outcomes from those who did not (Borman & Overman, 2004).

Gender gaps were not distributed evenly across mathematical content strands. At each grade level, gaps were largest for measurement. There were consistent gaps favoring males across grade levels in number and operations, and a significant gap favoring males in algebra and functions at grade 4. No content strand had a gender gap favoring females. Gender disparities within racial/ethnic groups favored males for white and Hispanic, but no differences for African American students. Female students' attitudes and self concepts related to mathematics were more negative than males (McGraw, Lubienski, & Strutchens, 2006).

Specific practices that made the most differences in student achievement were in specific topic areas.

- African-American students appeared to be particularly weak in measurement and estimation.
- Latino students appeared to be particularly weak in issues around working with data.
- The bulk of class time for fourth grades was devoted to numbers and operations. Yet, emphasizing these most basic topics was of no benefit to any demographic group. Instead, teachers need to spend more time on the topics they now spend the least time on, including geometry, insofar as that topic seems to benefit fourth graders across the board. (Wenglinsky, 2003)

Middle School (Grades 6-8)

For students with mild to moderate learning disabilities in mathematics, enrolled in Grades 6, 7, and 8, the concrete-representational-abstract (CRA) group demonstrated better conceptual understanding of fraction equivalency than did the representational-abstract (RA) group. The CRA and RA treatment groups had significantly higher scores than did the comparison group on solving work problems with embedded fraction equivalencies (Butler, Miller, Crehan, Babbitt, & Pierce, 2003).

The strongest predictor for mathematics performance for white and Latino-American students was parental expectation. The strongest predictor for mathematics performance on the SAT-9 math scores for African-American students was the mother's attitude. For African-American students, the combined effect of mother's positive attitude towards mathematics, and high expectations regarding specific math capability may be significant factors in strengthening mathematics achievement. Among Latino Americans, family process factors tended to revolve around high expectations and mother's attitude toward mathematics in predicting math performance (Der-Karabetian, 2004).

The more time students spend on homework and doing real-world problems, the better the school performed on the National Assessment of Educational Progress (NAEP). The more testing that occurred in the school, the worse students performed on the National Assessment of Educational Progress (NAEP). For African Americans, time-on-task in math class reduced the achievement gap. For Latinos, working on projects reduced the achievement gap (Wenglinsky, 2004).

At every math achievement stanine, students who learned through multisensory algebra outperformed their peers who learned math through traditional abstract instruction. Increasing student interactions in class and allowing students to experiment and examine algebra concepts may allow students of all levels to develop and remember procedural steps more accurately (Witzel, 2005).

High School (Grades 9-12)

Hispanic and African-American students were not more likely to participate in special education or high school vocations tracks, after controlling for background characteristics. However, African Americans and Hispanics were less likely to participate in the GATE program (Bali & Alvarez, 2003).

The effect of prior attitude on later attitude and the effect of prior achievement on later achievement were significant across Grades 7-12. However, the stability effects were stronger in the case of achievement than in the case of attitude. Prior achievement significantly predicted later attitude across Grades 7-12. Prior attitude, by contrast, did not meaningfully predict later achievement. Researchers concluded that achievement demonstrated priority over attitude in the entire secondary school (Ma & Xu, 2004).

The teacher practice and concern variables that were significantly and positively associated with growth in student achievement are the following:

- Completion of a professional development workshop focused on preparing to teach the course effectively. A year of teaching a pilot version of the same course does not appear to be an adequate substitute.
- A spirit of cooperation with other teachers of the curriculum and confidence in skills to manage a class taught in this manner.
- Use of more group and pair work and less teacher presentation and whole-group discussion when completing the investigations.
- Minimal class time spent on nonacademic activities.
- Use of a variety of assessment methods including individual student interviews.

- High expectations on homework as evidenced by assigning extending problems frequently and to all students.
- High expectations on grading as evidenced by giving more weight to academic factors like quizzes and tests and less to attendance, attitude, and effort.
- Use of instructional and assessment materials as provided by the curriculum with minimal replacing or revising to make them more skill-oriented and less open-ended.
- A high observer rating of teaching based on the criteria for effective reform teaching. (Schoen, Cebulla, Finn, & Fi, 2003)

Middle school achievement, current student characteristics, and measures of opportunity to learn were related significantly to high school mathematics achievement. The effect of being in a remedial track was substantial because they fail to adequately prepare students for the annual achievement testing (Wang & Goldschmidt, 2003).

References

- Baker, S., Gersten, R., & Dae-Sik, L. (2002, September). A synthesis of empirical research on teaching mathematics to low-achieving students. *Elementary School Journal*, 103(1), 51-73.
- Bali, V. A., & Alvarez, R. M. (2003, September). Schools and educational outcomes: What causes the “race gap” in student test scores? *Social Science Quarterly*, 84(3), 585-587.
- Borman, G. D., & Overman, L. T. (2004, January). Academic resilience in mathematics among poor and minority students. *The Elementary School Journal*, 104(3), 177-195.
- Butler, F. M., Miller, S. P., Crehan, K., Babbitt, B., & Pierce, T. (2003). Fraction instruction for students with mathematics disabilities: Comparing the two teaching sequences. *Learning Disabilities Research & Practice*, 18(2), 99-111.
- Der-Karabetian, A. (2004). Perceived process factors and mathematics performance among Latino, African and European American middle school students. *Educational Research Quarterly*. 29(1), 38-47.
- Goddard, R. D., Sweetland, S. R., & Hoy, W. K. (2000, December). Academic emphasis of urban elementary schools and student achievement in reading and mathematics: A multilevel analysis. *Educational Administration Quarterly* (Supplement), 36(5), 683-703.
- Hill, H. C., Rowan, B., & Ball, D. L. (2005, Summer). Effects of teachers’ mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, 42(2), 371-406.
- Ma, X., & Xu, J. (2004, May). Determining the causal ordering between attitude toward mathematics and achievement in mathematics. *American Journal of Education*, 110, 256-280.

- McGraw, R., Lubienski, S. T., & Strutchens, M. E. (2006, March). A closer look at gender in NAEP mathematics achievement and affect data: Intersections with achievement, race/ethnicity, and socioeconomic status. *Journal of Research in Mathematics Education*, 37(2), 129-150.
- Schoen, H. L., Cebulla, J. J., Finn, K. F., & Fi, C. (2003). Teacher variables that relate to student achievement when using a standards-based curriculum. *Journal for Research in Mathematics Education*, 34(3), 228-259.
- Sheldon, S. B., & Epstein, J. L. (2005, March/April). Involvement counts: Family and community partnerships and mathematics achievement. *Journal of Educational Research*, 98(4), 196-206.
- Wang, J., & Goldschmidt, P. (2003, September). Importance of middle school mathematics on high school students' mathematics achievement. *The Journal of Educational Research*, 97(1), 3-19.
- Wenglinsky, H. (2003, November). Closing the racial achievement gap: The role of reforming instructional practices. *Education Policy Analysis Archives*, 12(64). Retrieved March 15, 2005, from <http://epaa.asu.edu/epaa/v12n64/>
- Wenglinsky, H. (2004, November). The link between instructional practice and the racial gap in middle schools. *Research in Middle Level Education Online*, 28(1). Retrieved March 2, 2006, from <http://www.nmsa.org/Publications/RMLEOnline/tabid/101/Default.aspx>
- Witzel, B. S. (2005). Using CRA to teach algebra to students with math difficulties in inclusive settings. *Learning Disabilities: A Contemporary Journal*, 3(2), 49-60.