

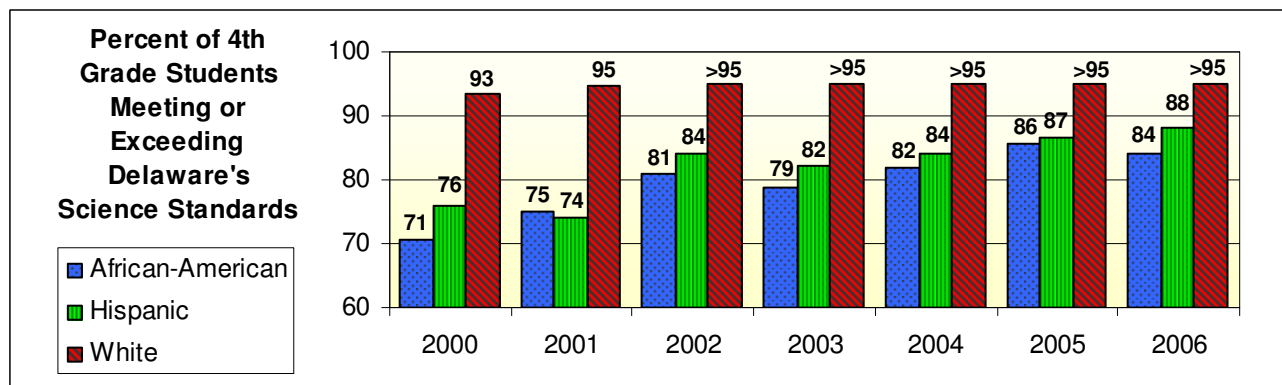
Studies of Student Achievement in Science

Through its programs and services, the National Science Resources Center (NSRC) provides school districts and states with tools and resources for initiating and sustaining effective science education programs. Using the NSRC model for science education reform, these states and school districts implement research- and standards-based science instructional materials, provide professional development for their teachers, and continually assess student progress. Further, they develop a system-wide support structure that provides science materials to the classroom and builds support from school district administration and the community.

School districts in places as diverse as California, Delaware, Pennsylvania, and Wisconsin have successfully implemented science education programs following the NSRC model. These programs have led to significant, documented improvement in student achievement. The following case studies, quasi-experiments, randomized-control studies, and meta-analyses provide evidence for the effectiveness of inquiry-based science programs at improving the learning and teaching of science.

Case Studies of Science Education Reform with inquiry-based instruction

Delaware. Although a small state, Delaware is an excellent example of the NSRC’s impact on science education reform. Its size is comparable to one of the nation’s larger school systems. The statewide student body is economically and ethnically diverse: 44% are members of minority groups and 34% are in poverty. In 1996, Delaware began a statewide science education reform program that included a partnership with the NSRC. The reform work began in elementary schools and has gradually moved to the middle and high school levels during the past decade. Between 1997 and 2001 every school district in Delaware attended an NSRC Science Education Strategic Planning Institute, resulting in the development of five-year strategic plans for reforming districts’ K-8 science education programs. These plans were based on “The NSRC Science Education Reform Model.” Using this model, the state developed a comprehensive technical assistance infrastructure to support the districts’ implementation of research-based instructional programs. This infrastructure included sustained professional development programs for teachers and state tests that aligned with state standards and research-based instructional materials. Results of state tests during the past six years provide evidence that Delaware is closing the achievement gap, beginning in grade four. At grade four the percentage of students meeting the statewide science standards increased from 80% in 2000 to 90% in 2005 for all ethnic groups. African-American and Hispanic students’ performance increased from 73% in 2000 to 87% in 2005, a gain of 15%. Additional data for grades six and eight can be found on the Delaware State Education Web site illustrating the continued progress Delaware is making in closing the gap for its students.



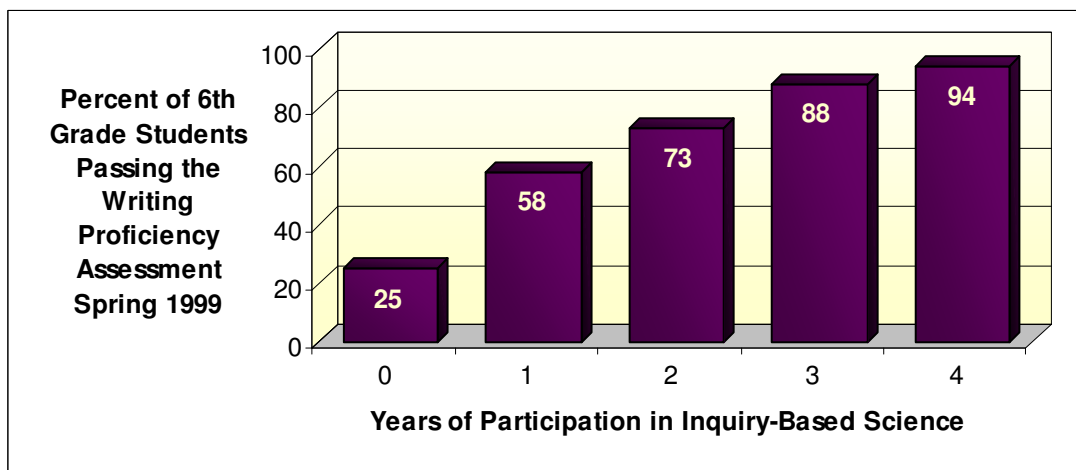
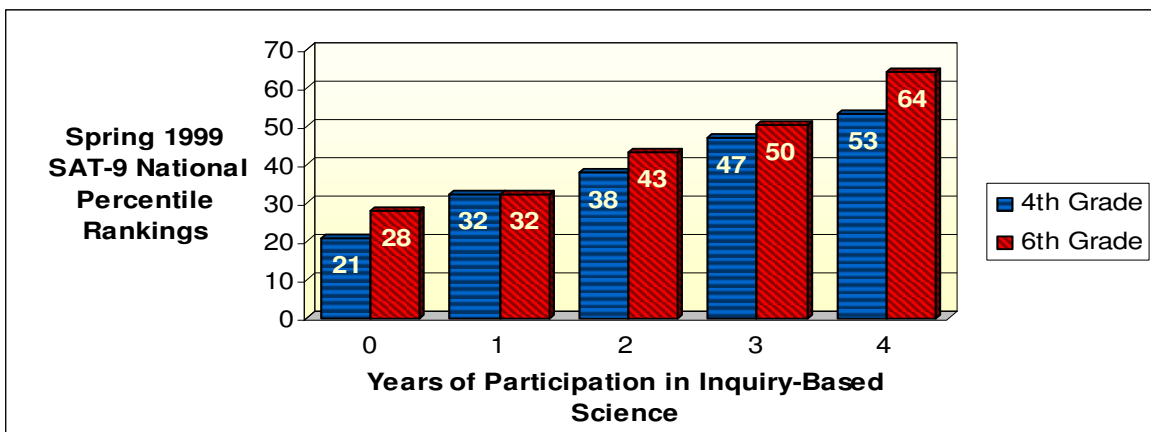
The Delaware Science Coalition. 2002. Delaware Smithsonian Project Report: Building on Success to Improve Our Children’s Future: 1995–2002 Update.

<http://www.doe.state.de.us/aab/NAEP%20Science%202006%20PR.pdf>

Fresno, California. Students receiving inquiry-based science instruction outperformed students receiving traditional science education in the same district. Additionally, an increase in the number of years of inquiry-based instruction correlated with an increase in standardized test scores in both science and reading.

<http://sustainability2002.terc.edu/invoke.cfm/page/143>

Imperial County, California. The science reform effort in this economically deprived rural community shows that an investment in science education provides an excellent return in other areas of the curriculum as well. Imperial County ranks highest in poverty of all 58 California counties with 66% of students receiving free/reduced lunches, and 47% of the students are English language learners. The El Centro Elementary School District implemented a reform effort following the NSRC model, including research-based instructional materials. Students in Imperial Valley public schools who have been taught using inquiry methods significantly outperform their classmates who have had traditional (textbook-based) science instruction. Stanford Achievement Test results indicate that the longer students are enrolled in research-based science programs, the better they perform on nationally normed science, writing, and mathematics tests.



Klentschy, Michael, Leslie Garrison, and Olga Maia Amaral. 1999. "Valle Imperial Project in Science (VIPS): Four-Year Comparison of Student Achievement Data, 1995-1999."

<http://www.carolina.com/stc/publications/evidence/vips.pdf>

Klentschy, Michael P., and Elizabeth Molina-De La Torre. 2004. "Students' Science Notebooks and the Inquiry Process," In *Crossing Borders in Literacy and Science Instruction: Perspectives on Theory and Practice*. NSTA Press, Arlington, VA.

Michigan. A small-scale study conducted in Michigan showed that students in school districts that used the STC curriculum performed better on the Michigan Educational Assessment Program (MEAP) for Science than those who did not. The study compared the results from 15 STC school districts in affluent, moderate, and poor districts (socioeconomic categories aggregated according to the percentage of students who qualify for free or reduced-price lunch) with the results from districts using a textbook approach to science education. Ten of the 15 STC districts, including two of the low-income districts, improved their scores of the MEAP at a greater rate than the state average.

<http://www.carolinacurriculum.com/stc/publications/evidence/michigan.pdf>

National Education Longitudinal Study. Data from 24,599 eighth-grade students in 1988 indicated that students who frequently engaged in hands-on science activities showed significantly higher levels of science achievement than those who did not.

Stohr-Hunt, P.M., (1996), An Analysis of Frequency of Hands-On Experience and Science Achievement, *Journal of Research in Science Teaching*, 33(1): 101-109.

Philadelphia, Pennsylvania. Students from three Philadelphia middle schools using inquiry-based instruction were followed from 4th to 7th grade, and compared to students in matched control schools. Standardized test scores were higher for students using the inquiry-based science programs, and the size of the gain correlated with the number of years in the science program.

Ruby, A. 2006. Improving science achievement at high-poverty urban middle schools. *Science Education*, 90(6): 1005-1027.

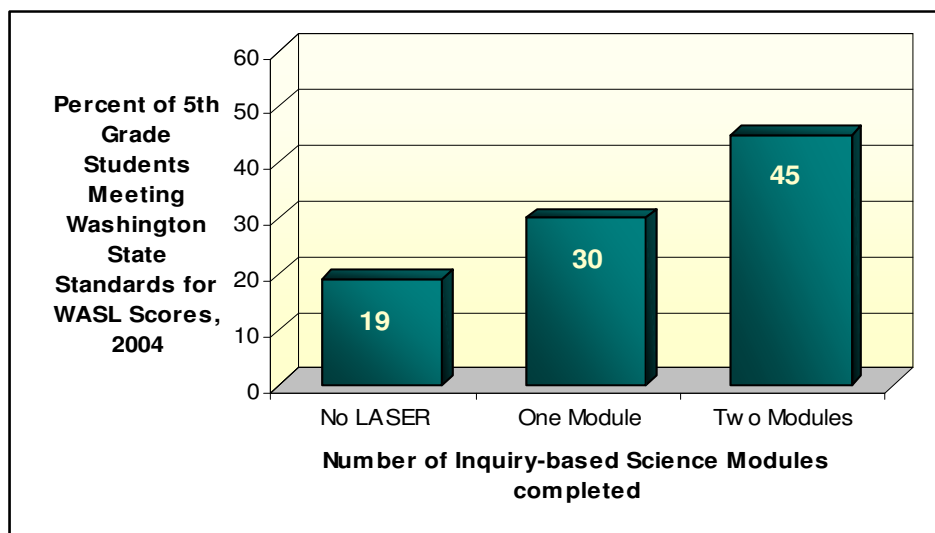
Southwestern Pennsylvania. Under the leadership of Pittsburgh-based ASSET Inc., a nonprofit educational leadership group, more than 50 school districts in western Pennsylvania have followed the NSRC model for science education reform, emphasizing the use of research-based instructional materials and professional development. Results from the Trends in International Mathematics and Science Study (TIMSS) show that students in these 50 districts outperformed their peers in the United States and internationally. They also performed on par with students from the highest scoring nations in the TIMSS study. This progress convinced Pennsylvania governor Ed Rendell to launch an initiative to support the implementation of this approach to science learning and teaching in all school districts in the rest of the state. The NSRC is a partner with ASSET in this effort.

Raghavan, Kalyani, Shira Cohen-Regev, and Shelley A. Strobel. 2001. "Student Outcomes in a Local Systemic Change Project." In *School Science and Mathematics Journal*, volume 101, number 8, Dec. 2001.

Davison, Reeny, and Kalyani Raghavan. 2000. "Impact of ASSET Inc. on Student Learning: Report on Results of the Systemic Reform of Education in Southwestern Pennsylvania from 1995–2000.

<http://lsc-net.terc.edu/do.cfm/paper/7034/show>.

Washington State. During its eight-year partnership with the NSRC, the Washington State LASER has established a strong alliance with the Washington State Department of Education, corporations, and nonprofit organizations. It has increased the number of school districts implementing research-based science education programs from a few pilot districts to districts that serve 75% of the state's student population. Statewide data show significant improvement in student learning in schools that have fully implemented the NSRC reform model, with a strong emphasis on teacher professional development. As a result of the progress shown in the state, Washington Governor Christine Gregoire has supported a measure that would increase funding for mathematics and science education in Washington schools by almost \$200 million.



www.carolinacurriculum.com/pdf/westvalley_results.pdf

ALL ACROSS THE UNITED STATES. The attitude towards teaching sciences used to be that the memorization of facts and high exam scores were more important to students than whether or not they actually liked science. Fortunately, that view is changing. Research has shown that despite the important role that knowledge plays in science, an appreciation of and affinity for the subject as a whole is much more important for students to learn while in school. Scientific knowledge is most useful to those pursuing a career in the subject. However, students do not have a firm grasp on what they want to do professionally until college or high school. As a result, making students cram facts is not only pointless, but drives them away from both scientific literacy and appreciation. After analyzing reports from classrooms across the country, this study concludes that in order for students as a whole to become scientifically knowledgeable adults, they must first have an appreciation for the subject and understand the need for scientific literacy in everyday life—from making medical decisions to political ones. Furthermore, the most effective approach to increasing appreciation for sciences is through the proper implementation of the inquiry method.

Ornstein, Avi. "The Frequency of Hands-On Experimentation and Student Attitudes Towards Science: A Statistically Significant Relation." *Journal of Science Education and Technology* 15.3 (2006):285-296.

Quasi-experiments testing the effectiveness of inquiry-based science education

Green Bay, Wisconsin. The Einstein Project in Green Bay, Wisconsin, is a collaborative effort among schools, businesses, and communities in northeastern Wisconsin. It is dedicated to improving the quality of mathematics, science, and technology education using kit-based curriculum materials and is based on the principles of the NSRC. The Einstein Project commissioned the St. Norbert College Survey Center (SNC) to evaluate the effectiveness of Science and Technology for Children curriculum units on student achievement versus a textbook approach to science class. The SNC found that the Einstein students performed better than non-Einstein students on a wide range of assessments. In addition, "Einstein Project students did significantly better than non-Einstein students when asked to perform a task, investigate, classify, arrange, draw and label, describe, or explain a scientific phenomenon."

http://www.einsteinproject.org/?page_id=35&parent_page_id=24

Detroit, MI. In a three-year study with nearly 8,000 children, the Detroit Public School system implemented a new inquiry-based science curriculum for the middle school students in order to test whether these students could improve their academic achievement despite the poor, urban setting. Throughout the three-year study, the students' performance increased dramatically as they were exposed more and more to inquiry-learning. Thus, the

setting—even if it is in a poor, urban, minority community—does not diminish student achievement as significantly when the proper instructional method is utilized.

Marx, Ronald, Phyllis C. Blumenfeld, Joseph Krajcik, Barry Fishman, Elliot Soloway, Robert Geier, and Revital Tali Tal. "Inquiry-Based Science in the Middle Grades: Assessment of Learning in Urban Systemic Reform." *Journal of Research in Science Teaching* 41.10 (2004): 1063-1080.

<http://www3.interscience.wiley.com/cgi-bin/abstract/109745711/ABSTRACT>

Independent Evaluation of an inquiry-based science curriculum by The Center for the Study of Testing, Evaluation, and Education Policy (CSTEPP). "Consistent, statistically significant differences provided evidence to support the contention that the four curriculum units were more effective in teaching the scientific concepts assessed than were the more traditional instructional approaches employed with the control groups. Students exposed to the STC/MS (*Science and Technology Concepts for Middle Schools*) curriculum also outperformed the nation and international groups. Together, this pattern of results suggests that all four of the curriculum units were very effective in teaching science and technology concepts to middle school students."

Pedulla, J., The Center for the Study of Testing, Evaluation, and Education Policy (CSTEPP), Boston College, Boston, MA, 2002 (available upon request from the NSRC)

Montgomery County, Maryland. Five schools were randomly selected to use an inquiry-based chemistry program, and were compared to five control schools. Students from the experimental schools performed significantly better on assessments than did the students from the control schools.

Lynch, S., Kuipers, J., Pyke, C., & Szesze, M. (2005). Examining the effects of a highly rated science curriculum unit on diverse populations: Results from a planning grant. *Journal of Research in Science Teaching*, 42(8): 912-946.

http://www.gwu.edu/~scale-up/scaleup_norc_jan15_04.doc

Rhode Island. A study of 399 5th graders indicated that students receiving inquiry-based instruction scored significantly higher than students receiving traditional forms of instruction, even though there were more minutes of science instruction in the traditional classrooms.

Young, B. J., & Lee, S. K. (2005). The effects of a kit-based science curriculum and intensive science professional development on elementary student science achievement. *Journal of Science Education and Technology*, 14, 5/6, 471-481.

NASA. In an effort to provide students with an opportunity to understand the work involved in engineering and technology for space exploration, NASA has established Explorer Schools across the country. At these schools, students learn sciences, technology, engineering, and mathematics (STEM) topics through inquiry instruction. This is a new initiative of NASA in an effort to both attract more students to careers in STEM while increasing science appreciation and comprehension within the general population. This is encouraging to adherents of the inquiry method because many have argued that inquiry cannot be used as an instructional mode outside of life sciences. Through these Explorer Schools, however, NASA has found that inquiry instruction is just as effective in the subjects of technology, engineering, and mathematics as it is in life sciences.

Loston, Adena, Peggy Steffen, and Steven McGee. "NASA Education: Using Inquiry in the Classroom so that Students See Learning in a Whole New Light." *Journal of Science Education and Technology* 14.2 (2005):147-156.

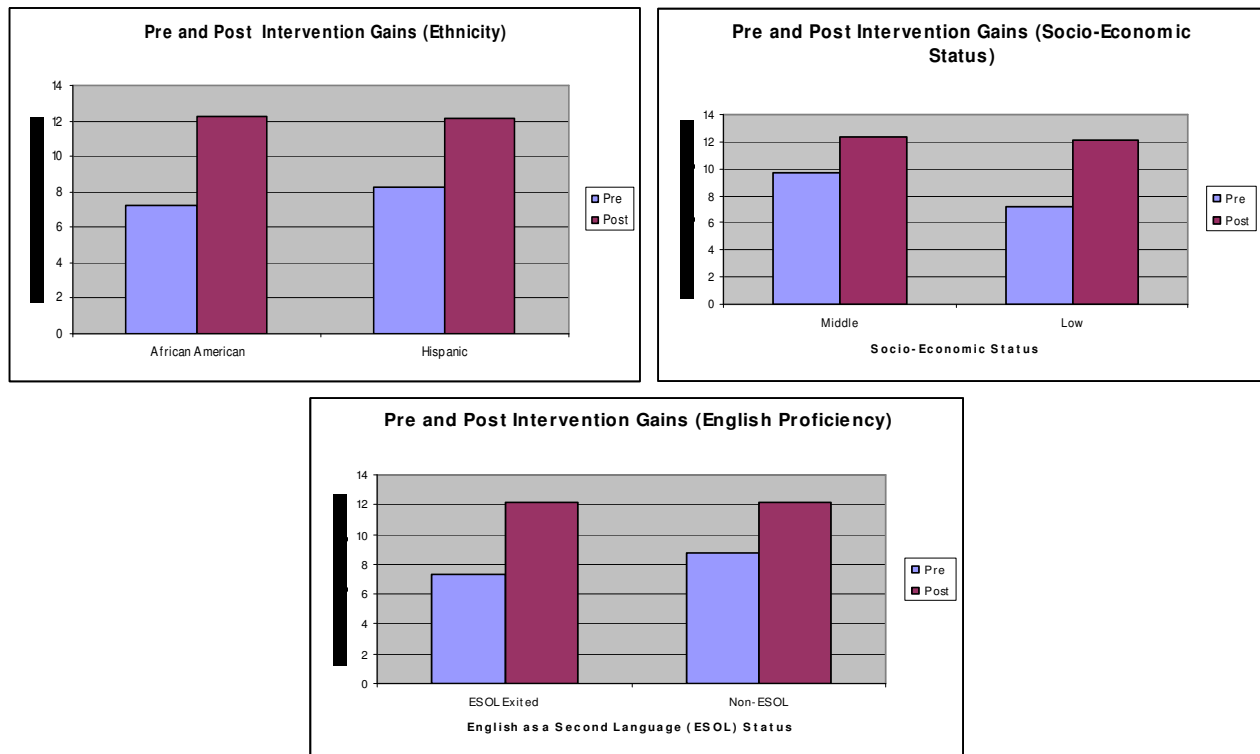
<http://www.springerlink.com/content/r7x77t518h7k6867/>

Southeastern United States. In the previous year, another group of researchers examined the effect that inquiry learning has on a diverse group of students to determine whether their achievement could be increased by a more interactive learning environment. Twenty-eight culturally, linguistically, and socioeconomically diverse

elementary-school students from six urban schools were monitored for their progress. Students who were predetermined to have lower achievement levels and are of a lower socioeconomic level increased their scores twice as much as those who were deemed “high-achievers.” Likewise, students who learned English as a second language had a greater increase in scores than those who did not. Overall, the third-grade students had a greater average increase in their score than the fourth-grade students, which further emphasizes the importance of using the inquiry method early on.

Cuevas, Peggy, Okhee Lee, Juliet Hart, and Rachael Deaktor. "Improving Science Inquiry with Elementary Students of Diverse Backgrounds." *Journal of Research in Science Teaching* 42.3 (2005):337-357.

<http://www.d.umn.edu/~bmunson/Courses/Educ5560/readings/Cuevas-InquiryDiversity.pdf>



Meta-analyses of Inquiry-Based Curricula

An analysis of 57 studies on the effectiveness of three activity-based curricula found a 14 percentile improvement exhibited by the students in the activity-based programs over students in traditional programs.

Bredderman, Ted, (1983), Effects of Activity-Based Elementary Science on Student Outcomes: A Quantitative Synthesis, *Review of Educational Research*, 53(4): 499-518.

A 1990 analysis of 81 studies comparing the effectiveness of hands-on science programs with that of traditional textbook-based classrooms found that the students receiving hands-on instruction scored 1.4 standard deviations higher than did the students in traditional elementary school classrooms.

Shamansky, J.A., Hedges, Larry V., Woodworth, George, (1990), A Reassessment of the Effects of Inquiry-Based Science Curricula of the 60's on Student Performance, *Journal of Research on Science Teaching*, 27(2): 127-144.

A study of 140 comparisons of inquiry-based science education and traditional teaching in middle and high schools found that inquiry-based instruction resulted in an average of a 13 percent increase in achievement scores over traditional instruction.

Wise, K.C., (1996), Strategies for Teaching Science: What Works? *The Clearing House*, July/August, 337-338.