Effective Programs for Elementary Science: A Best-Evidence Synthesis

Educator's Summary
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Which science programs have been proven to help elementary students to succeed? To find out, this review summarizes evidence on three types of programs designed to improve the science achievement of students in grades K–6:

- **Inquiry-oriented programs without science kits**, such as Increasing Conceptual Challenge, Science IDEAS, and Collaborative Concept Mapping. These programs help teachers learn and use generic processes, such as cooperative learning, concept development, and science-reading integration, in their daily science teaching.

- **Inquiry-oriented programs with science kits**, such as Insights, FOSS, STC, SCALE, and Teaching SMART. The theory of action in science kit programs is that implementing hands-on activities helps to build deep learning about the scientific process and core concepts of elementary science.

- **Technology programs**, such as BrainPOP, The Voyage of the Mimi, and web-based labs. Technologies utilized in these approaches include computer-assisted instruction and class-focused technology (such as video and interactive whiteboard technologies).

Review Methods

A literature search of articles written between 1980 and 2011 was carried out to find studies that met the following criteria:

- The studies compared children taught in classes using a given science program or practice with those in control classes using an alternative program or standard methods.

- The program or practice had to be one that could, in principle, be used in ordinary science classes (i.e., it did not depend on conditions unique to the experiment).

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- Random assignment or matching with appropriate adjustments for any pretest differences (e.g., analyses of covariance) had to be used. Studies without control groups, such as pre-post comparisons and comparisons to "expected" scores, were excluded.
- Pretest data had to be provided, unless studies used random assignment of at least 30 units (individuals, classes, or schools) and there were no indications of initial inequality.
- The dependent measures included quantitative measures of science performance that were not excessively aligned with the experimental (but not control) treatment.
- A minimum study duration of 4 weeks was required (see full report for rationale).
- Studies had to have at least two teachers and 15 students in each treatment group.

Key Findings

A major finding of this review is the fact that there are very few rigorous experimental evaluations of elementary science programs. After an exhaustive search involving examination of 327 published and unpublished articles, only 17 studies met the inclusion criteria. In light of the small number of qualifying studies, it must be acknowledged that any conclusions about the findings of these studies can only be tentative.

Inquiry-oriented programs without science kits. Eight qualifying studies found significant positive effects of inquiry-oriented professional development on conventional measures of science achievement, with a sample size-weighted mean effect size of +0.30. These studies provided extensive professional development in effective science teaching, emphasizing conceptual challenge, cooperative learning, science-reading integration, teaching scientific vocabulary, and use of an inquiry learning cycle.

Inquiry-oriented programs with science kits. A surprising finding from the largest and best-designed of the studies is the limited achievement impact of programs that provide teachers with kits to help them make regular use of hands-on, inquiry-oriented activities. The weighted overall mean effect size across four qualifying studies of science kit programs was only +0.02.

Technology programs. Five qualifying studies of technology applications all show significant promise (ES=+0.37). These approaches were characterized by the use of video or computer graphics to illustrate scientific processes; active inquiry using technology tools; integration of technology, teaching, and group work among students; and efforts to make science content motivating and relevant to students.

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Conclusion

The evidence from studies that met the inclusion criteria supports a view that improving outcomes in elementary science depends on improving teachers' skills in presenting lessons, engaging and motivating students, and integrating science and reading. Technology applications that help teachers teach more compelling lessons and that use video to reinforce lessons also have promise.

Far more research and development are needed to identify effective and replicable approaches to improving science achievement for elementary students. Science education needs to move beyond brief and artificial pilot tests of exciting new methods and technologies. Approaches need to be tested in real schools over extended periods of time, with valid and comprehensive measures of achievement. Science education researchers should use the tools of science to evaluate and progressively improve the programs and practices needed to help elementary teachers build a scientifically literate society.

Full Report

Slavin, R.E., Lake, C., Hanley, P., & Thurston, A. (2012, May). *Effective Programs for Elementary Science: A Best-Evidence Synthesis*. Baltimore, MD: Johns Hopkins University, Center for Research and Reform in Education.

The full report can be downloaded at www.bestevidence.org/science/elem/elem_science.htm

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