What Do We Know?

SEEKING EFFECTIVE MATH AND SCIENCE INSTRUCTION

THE URBAN INSTITUTE

GE Foundation

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As requested by the GE Foundation, the main goal of this review was to identify mathematics and science curricula as well as professional development models at the middle and high school levels that had been deemed *effective* based on their success in *increasing student achievement*. Because of its emphasis on student achievement, this approach differs from that typically used at the local level and that adopted by other recent studies conducted to find "effective" curricula and professional development models.

Historically, curriculum choice at the local level has often been made by a committee that decides which curriculum to adopt based on considerations only peripherally related to student achievement—such as state-imposed standards, recommendations of others, cost, and presentations by publishers' representatives. Choice of professional development models follows a similar pattern. Indeed, there has been very little else available to guide school districts in their curriculum selection process, since for most curricula and textbooks the only data at hand are publishers' figures on the number of adoptions. That has been changing. There is a growing movement to assess the effectiveness of math and science curricula through various methodologies, including content analyses, comparative studies, case studies, and synthesis studies.[1] And while there have been several studies of the effectiveness of professional development practices, very few have measured the effects of these practices on student achievement.

The focus of this review, reflecting the GE Foundation's interests, was to identify current math and science curricula and professional development at the middle and high school levels that showed evidence of positive impact on student achievement. Our goal was to come up with enough math and science curricula with relatively credible evaluations to provide some choice to districts and schools that wanted guidance in selecting a curriculum and that wished to use effectiveness as a selection criterion.

Evaluation Study Selection Criteria Used

To be included, studies had to have

1. Rigorous methodological design including comparison groups;
2. Measures of impact on student outcomes that included, but were not limited to, test scores; and
3. Comparative data with experimental or quasi-experimental design preferred.

As can be seen from the criteria above, we chose increases in student achievement as the measure of effectiveness.[2] We limited our review to evaluations that compared student achievement outcomes elicited by the curriculum being studied with student achievement outcomes of another curriculum. Where data were available, we also took into account the content validity of the assessments used as well as the statistical significance and the effect size of the differences reported. Our review made a special effort to identify eligible studies that disaggregated results by performance of student subgroups. Our review of evaluation studies of professional development was similarly limited to studies that used student achievement as the measure of effectiveness.

Professional Development: What We Found

We identified 18 evaluation studies of professional development models that used

student achievement outcomes as measures of effectiveness. Features of these studies can be found in a full report of this review.[3] We found that

- **Providing professional development for teachers of standards-based science curricula is effective in increasing student achievement**. There is evidence from the research that standards-based science programs that provide professional development to teachers produce higher student achievement outcomes than those that do not.
- **Professional development that is tied to curriculum, to knowledge of subject matter, and/or to how students learn the subject is more effective in terms of improving student achievement than is professional development that focuses only on teaching behaviors**. A number of studies have concluded that the content of professional development—*what is taught*—is more important than its format—*how it is taught*—and that content should be linked to subject matter knowledge, a specific curriculum, or the process of student learning. For example, some professional development focuses on training teachers to model specific pedagogical approaches and skills using generic lesson formats. The goal of these efforts is to get teachers to change the way they teach, expecting that this will increase student achievement. More effective professional development focuses on increasing teacher knowledge of the subject matter, on a specific curriculum, or on the student learning process. The goal of these types of efforts is to change teacher knowledge, expecting that this will, in turn, both change teacher behavior and increase student achievement.
- **The amount of professional development provided is an important factor in influencing both change in the teaching behavior of teachers and change in the classroom environment**. One study found that behavioral change was only evident after teachers had received a minimum of 80 hours of intensive professional development; change in the classroom environment was achieved after 160 hours.[4] It is important to note that at the individual level, teacher preparation in the content area was an important factor in influencing effectiveness.
- **Some widely held beliefs about what constitutes effective professional development are not supported by research linked to student achievement**.
  - *Myth: Professional development should be distributed over the school year.* While professional development in science seems to benefit from distributed time, the same effect has not been found for math.
  - *Myth: More is better.* There is no evidence to support the belief that more contact time over and above 80 hours and 160 hours results in changes in teaching behavior or classroom environment, respectively.
  - *Myth: Classroom visits are necessary*. Visits to classrooms for consultation or coaching as part of professional development do not necessarily result in greater student achievement.
  - *Myth: Schoolwide programs are more effective*. Providing services to whole schools rather than individuals may not be the most important element of professional development that leads to increased student achievement.

Mathematics and Science Curricula: What We Found

Mathematics Curricula

Our review netted 89 middle and high school curricula, including eight mathematics curricula that were developed as part of whole school reform efforts. A total of 156 studies of student mathematics achievement with comparison group data were found for 18 of the curricula (20 percent of the total number of curricula originally identified). A list of the 18 mathematics curricula, together with overviews of the curricula and their impact studies, appears in Appendix A.

The following findings relate to methodology:

- **Most middle and high school mathematics curricula do not have studies of student achievement with comparison groups that can be found through literature or web searches**. Only three of the studies found specified the curriculum to which the target curriculum was being compared. The rest compared their curriculum to some unnamed curriculum, making comparisons across curricula impossible.
- **If students are going to be judged on the results of an external test, the mathematics curriculum selected should cover the areas and skills that are included on that test (i.e., the test and curriculum should be aligned)**. As would be expected, students tend to score higher on tests focusing on the content and skills covered in their curriculum. The content and skills covered in traditional math curricula tend to reflect the content and skills covered in most standardized and statewide tests. Alternatively, the content and skills covered in standards-based curricula tend to better reflect that which is covered in standards-based tests. (For more on this issue, see the text box, "Interpreting the Results.")

The following findings relate to outcomes and impacts:

- **Studies of six of the curricula found that students who use the curriculum being tested scored higher than comparison students on both a majority of standardized and/or state tests used *and* on a majority of the curriculum-based tests used**. These curricula were Cognitive Tutor, Connected Mathematics (CMP), Interactive Mathematics Program (IMP), Prentice Hall: Tools for Success, Saxon Math: An Incremental Development, and University of Chicago School Mathematics Project. Because students using these curricula scored higher on both types of tests, it is reasonable to assume that the effectiveness of each curriculum is not an effect of the type of test used.
- **It is difficult to determine any differential effect of these math curricula on girls and boys**. Very few of the curricula had studies that met our criteria and disaggregated their findings by sex. Among those that did, the results were inconsistent.
- **With the exception of Connected Mathematics, too few results per curriculum were broken out by race/ethnicity to allow us to draw general conclusions regarding racial/ethnic effects. Connected Mathematics, however, appeared to reduce racial/ethnic gaps**.

Science Curricula

We identified 80 science curricula at the middle and high school levels.[5]

Similar to the mathematics curriculum, we found seven science curricula that had been developed specifically as a part of whole school reform. A total of 45 studies of student achievement in science were found that met our criteria, covering 21 (or 26 percent) of the total science curricula identified. The 21 curricula are listed in Table 2, which together with brief descriptions of these curricula and the results of impact studies, is provided in Appendix B.

The following findings relate to methodology:

- **As with mathematics curricula, most middle and high school curricula do not have evaluation studies of student achievement with comparison groups that can be found through published literature or web searches**. However, in contrast to the mathematics curricula in Table 1 in Appendix A (many of which had been the subjects of multiple studies), most of the science curricula in Table 2 in Appendix B had only one evaluation or study, usually unpublished works available through the developer.

The following findings relate to outcomes and impacts:

- **Science curricula based on the inquiry approach are consistently more effective than traditional science curricula as measured by student achievement**. The preponderance of evidence provided by meta-analyses and evaluations of individual curricula seems to confirm that inquiry-based science curricula produce larger effects on student achievement than do the more "traditional" science curricula.[6]
- **It is difficult to determine the effect of these science curricula on different subgroups of students—such as girls, minority group members, and urban students**. Very few of the curricula had studies that met our criteria and disaggregated their findings by sex, language minority status, or urban location. Surprisingly, none of the studies reported data disaggregated by race/ethnicity.
- **Most science curricula include a professional development component**. Inclusion of a professional development component as a part

Interpreting the Results: Validity of Tests Used To Measure Student Achievement

The evaluation studies for mathematics and science curricula on our lists used a variety of assessments—some standardized, some state-mandated, some self-developed, and some developed by others specifically for standards-based curricula. In the case of mathematics curriculum studies, the content and skills covered by most standardized achievement tests tend to reflect more closely the content and skills covered by traditional mathematics curriculum than those covered by standards-based curriculum, causing them to have better "content validity" for traditional curriculum. Many researchers of standards-based curriculum are aware of this and develop their own student achievement tests that more accurately test the skills and content of standards-based curriculum.

If students taking one curriculum score higher than others on both types of test, there is no question of interpretation. Beyond that, however, judgments of efficacy must take into account the content validity of the tests in order to determine which type of curriculum is more effective. Although science curriculum studies face a similar dilemma, several studies comparing the results of standardized tests with those of other forms of assessment have found very small differences. The issue of content validity, therefore, seems to be less of a concern in judging the effectiveness of science curricula.

of the curriculum is far more common in science than in mathematics because science curricula tend to be more discretionary and variable than mathematics curricula. Science curriculum developers, therefore, may feel the need to provide more guidance to teachers about the appropriate instructional approaches to be used for specific curricula.

What Can We Conclude from Our Review?

The major conclusions of our review that should be most useful to those wishing to invest in sustainable school reform in science and mathematics can be summarized as follows:

- **Effective mathematics curricula in middle and high school may be either traditional or integrative (standards-based).**
- **Effective science curricula in middle and high school should be inquiry-based rather than traditional.**
- **Effective professional development programs are those that focus on content rather than format and that have the following features:**
  - Content tied to curriculum, knowledge of subject matter, and/or how students learn a subject;
  - A minimum of 80 contact hours to effect changes in teachers' instructional behaviors; and
  - A minimum of 160 contact hours to effect changes in the classroom environment.

How to Use This Review

Choice of a curriculum in mathematics and science involves deciding what aspects of these subjects are important to address and emphasize in schools—this choice thus determines what students will learn. Once a decision is made, selection should be guided by how effective a particular curriculum is for the student population to be taught. The National Research Council report, *On Evaluating Curricular Effectiveness: Judging the Quality of K–12 Mathematics Evaluations (2004)* describes the value of this knowledge to the decision-making process:

> Clearly, knowing how effective a particular curriculum is, and for whom and under what conditions it is effective, represents a valuable and irreplaceable source of information to decisionmakers, whether they are classroom teachers, parents, district curriculum specialists, school boards, state adoption boards, curriculum writers and evaluators, or national policymakers. Evaluation studies can provide that information but only if those evaluations meet standards of quality (p.1).[7]

This review of math and science curricula has tried to simplify for schools and districts the complex, time-consuming process of determining curriculum effectiveness by identifying programs that have what we consider to be credible evaluations. We have also distilled the findings of achievement-based research on professional development to a handful of principles that reflect effective practice. Once schools and districts have decided on a curriculum and an appropriate assessment tool, they might wish to collect their own impact data to evaluate how well the curriculum they choose is working with their own students.[8] It is the responsibility of the school and district community to ensure that the content that they want students to learn is embodied in the curriculum, that the curriculum is effective for this purpose, and that appropriate measures are used to assess whether students are indeed learning what the community wants them to learn. It is an enormous task and an enormous responsibility. We hope that our review can provide some guidance and assistance in the process.

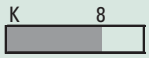
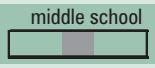
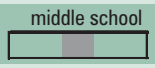
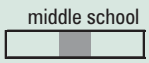
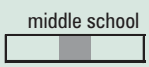
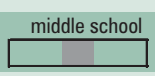
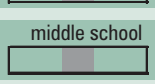
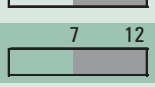
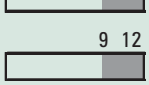
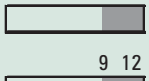
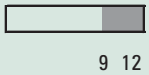
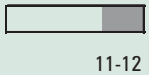
Endnotes

1. The majority of these efforts have been undertaken by AAAS, the National Research Council (NRC), and the U.S. Department of Education. The AAAS study used content analysis, the NRC study did not rate specific curricular math programs, and the U.S. Department of Education study reviewed middle school math programs only.
2. As determined by quantifiably measurable outcomes, such as test scores.
3. The full report, on which this summary report is based and which contains references and a bibliography of all studies described in this report, can be found on the Urban Institute web site, http://www.urban.org.
4. "Teacher behavior" in this context refers to teachers' use of specific pedagogical approaches in instruction, such as inquiry-based teaching practices. "Change in the classroom environment" refers to teacher facilitation of an investigative classroom culture through seating arrangements to stimulate discussion, use of cooperative learning groups, encouraging students to explain concepts to one another, and other such practices.
5. Of the 80 science curricula identified, 59 had no evaluations or had evaluations that did not meet our criteria, or evaluations were out of print, or we did not receive a response from the developers.
6. As measured by both standardized tests and tests developed for standards-based curricula in both meta-analyses and evaluations of individual curricula.
7. Jere Confrey and Vicki Stohl, eds. 2004. *On Evaluating Curricular Effectiveness: Judging the Quality of K–12 Mathematics Evaluations.* Committee for a Review of the Evaluation Data on the Effectiveness of NSF-Supported and Commercially Generated Mathematics Curriculum Materials. National Research Council. Washington, DC: National Academy Press.
8. For those schools and districts that already have programs that they feel are effective but are not included in Tables 1 and 2, we suggest that they collect their own effectiveness data via evaluation studies that adhere to the criteria established in this review. They may wish to contract with an evaluator for this purpose.

Appendix A
DETAILED FINDINGS OF THE REVIEW OF MATH CURRICULA

This appendix provides a list of the mathematics curricula included in our review, together with a description of each curriculum and its related evaluation studies. Table 1 lists the mathematics curricula identified as having evaluation studies that met our criteria.

TABLE 1. Math Curricula with Studies

Grades Covered	Curriculum Name		Subject Matter
	Edison Schools		Mathematics
	Direct Instruction		Mathematics
	Cognitive Tutor	*[sex, race/ethnicity]	Mathematics
	Connected Mathematics (CMP)	*[sex, race/ethnicity]	Mathematics
	Integrated Mathematics, Science, and Technology (IMaST)		Mathematics
	Mathematics in Context (MiC)	*[race/ethnicity]	Mathematics
	MATHThematics		Mathematics
	Prentice Hall: Tools for Success		Mathematics
	Saxon Math: An Incremental Development		Mathematics
	Mathematics with Meaning	*[sex, race/ethnicity]	Mathematics
	University of Chicago School Mathematics Project (UCSMP)		Mathematics
	College Preparatory Mathematics (CPM)		Mathematics
	Contemporary Mathematics in Context: A Unified Approach (Core-Plus Mathematics Project CPMP)		Mathematics
	Interactive Mathematics Program (IMP)	*[sex]	Mathematics
	Math Connections	*[sex, race/ethnicity]	Mathematics
	Mathematics: Modeling Our World (MMOW/ARISE)		Mathematics
	Systemic Initiative for Montana Mathematics and Science (SIMMS)		Mathematics
	Advanced Placement (AP) Calculus		Calculus

Note: Shaded curricula are those for which we have found the strongest evidence of effectiveness, that is, quantitative evidence that their use in instruction elicits higher achievement/performance in students than other curricula to which they are compared on both standardized and/or state tests and on curriculum developed tests. There are several curricula for which this evidence of effectiveness has not been collected but which might also qualify as effective should appropriate studies be conducted. An omission from this list of many curricula signifies merely that these curricula have not yet provided quantitative evidence of effectiveness that meets our criteria.
*An asterisk marks curricula for which effectiveness data are provided for subgroups of students, indicated in brackets. (See full report on the web for discussion of research findings by subgroup.)

A Description of the Mathematics Curricula and Evaluation Studies Found

In addition to a description of each curriculum, these overviews (presented in alphabetical order) include the type of student achievement measure used, the number and direction of the results, and, if available, the size of any differences between groups. If the results were broken out by sex and/or race and ethnicity, this too is indicated.

The types of measures used in the impact studies are broken into five categories:

- Standardized achievement tests (i.e., PSAT, SAT, SAT-9, and Iowa Test of Basic Skills)
- State-mandated achievement tests (i.e., FCAS, MEAP, and MCAS)
- Standards-based, curriculum-driven measures (i.e., Balanced Assessment, Problem Situation Test)
- Teacher-based measures (i.e., GPA, school tests, and mathematics courses taken)
- Percent passing different mathematics courses

In the charts that follow within this appendix, results were tracked rather than the number of studies. Multiple grades and multiple measures were counted as multiple results and broken out as such. For example, a study that looked at the impact of different subsets of a curriculum for sixth, seventh, and eighth grades was counted as three results. Cohort studies that tracked students across multiple grades were counted as one result. Also counted as one result were findings from different sites within the same study using the same measure. If a majority of sites had changes favoring the tested curriculum, the result was indicated as positive. If the majority of sites did not differ from the comparison, the result was indicated as no change. If a majority of sites had changes favoring the comparison curriculum, the result was indicated as negative.

Note: Most impact studies for math curricula reported the statistical significance of their results. Only differences that have reached the conservative minimum acceptable statistical significance level of .05 were included in the results reported for each study. If differences *are* statistically significant, then there is another measure, called an effect size, which shows how big the difference is. In our description of the study results, we provide effect sizes where available, although very few studies reported these results. Effect sizes greater than .4 are considered large; between .2 and .4 are considered moderate; and less than .2 are considered small.

Advanced Placement (AP) Calculus

The AP Calculus curriculum includes two courses: AP Calculus AB, which is comparable to one semester of college-level calculus, and AP Calculus BC, which is comparable to two semesters of college-level calculus. Both courses include elementary functions, limits and continuity, and differential and integral calculus, with Calculus BC covering these topics more extensively than Calculus AB. Prerequisites include knowledge of analytic geometry and elementary functions in addition to college preparatory algebra, geometry, and trigonometry. Enrolled students are expected to take the Advanced Placement examination in Calculus AB or BC.

Contact

College Board Headquarters
45 Columbus Avenue
New York, NY 10023-6992
Tel: 212-713-8066
Web site: http://apcentral.collegeboard.com/article/0,3045,151-165-0-2178,00.html

Results

Five results were found from studies on the effect of AP Calculus courses. These studies compared college mathematics performance of students who took AP Calculus with other students who did not.

Type of measure	Number of results	Results	Effect size
Teacher-based measures/GPA	3	AP students scored higher in two results; there were no differences in one result.	No effect size reported
Pass rates/ courses taken	2	AP students scored higher in one result, and there were no differences in one result.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Cognitive Tutor

The Cognitive Tutor (CT), from Carnegie Learning, includes full curricula in Algebra I, Geometry, Algebra II, an Integrated Math Series, and Quantitative Literacy Through Algebra. Each curriculum combines software-based, individualized computer lessons with collaborative, real-world problem-solving activities. Students spend about 40 percent of their class time using the software and the remainder of their time engaged in classroom problem-solving activities.

Contact

Carnegie Learning, Inc.
1200 Penn Avenue
Suite 150
Pittsburgh, PA 15222
Tel: 888-851-7094
E-mail: info@carnegielearning.com

Results

Twenty-one results from studies on the effect of CT were found, all of which focused on Algebra I at the middle and high school level.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	8	CT students scored higher in all eight results.	Moderate effect size in one result
Statewide tests	5	CT students scored higher in three results; there were no differences in two results.	No effect size reported
Curriculum-driven, skill-specific tests	7	CT students scored higher in seven results.	Large effect sizes in two results
Passing rates	1	CT students had higher passing rates.	No effect size reported

Two results looked at sex differences; in one result, CT boys' scores were higher than comparison boys. There were no differences between boys in one result, and there were no differences for the girls' scores in either result. Two results reported differences by race and ethnicity. In one result, African-American CT students had higher scores than comparison African-American students, and there were no differences for Hispanic students. In the second result, Hispanic CT students scored higher than comparison Hispanic students.

College Preparatory Mathematics (CPM)

The CPM series offers a four-year integrated curriculum where mathematics topics are revisited and built upon through the years. Problem-solving strategies are emphasized as a vehicle for learning mathematics, and student study teams are an integral part of the learning process. Based on the belief that concept mastery requires time, the curriculum spirals through practice of the main course concepts throughout each year and emphasizes students' supportive group work. The program sees the teacher's role as a guide.

Contact

CPM Business Office
1233 Noonan Drive
Sacramento, CA 95822
Tel: 916-681-3611
Web site: http://www.cpm.org

Results

Six results from studies on the effect of CPM were found, one of which focused on algebra and five of which focused on grade 9–11 math.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	5	There were no differences in all five results.	No effect size reported
Teacher-developed measure	1	There were no differences.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Connected Mathematics (CMP)

The Connected Mathematics (CMP) curriculum is composed of eight models, each focusing on one important area of mathematics and emphasizing previously learned content. Connected Mathematics is designed to develop students' knowledge and understanding of mathematics through attention to connections between mathematical ideas and their applications in the world outside school; among the core ideas in mathematics; among the strands in a modern mathematics curriculum; and between the planned teaching-learning activities and the special aptitudes and interests of middle school students.

Contact

Pearson Education
P.O. Box 2500
Lebanon, IN 46052-3009
Tel: 800-848-9500
Web site: http://www.phschool.com/math/

Results

Thirty-four results from comparison studies looking at the effect of CMP were found focusing on middle grade mathematics.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	11	CMP students scored higher for six results; they scored lower for one result; and there were no differences for four results.	No effect size reported

(*continued*)

Type of measure	Number of results	Results	Effect size
Statewide tests	16	CMP students scored higher for 14 results; there were no differences for two results.	No effect size reported
Curriculum-driven, skill-specific tests	6	CMP students scored higher for all six results.	Large effect sizes were found for one result.
Teacher-based measure	1	CMP students scored higher in one result.	No effect size reported

Seven results were broken out by race/ethnicity and two by sex. No significant sex differences were found. African-American CMP students were found to score higher than African-American comparison students in six results, while Hispanic CMP students scored higher than Hispanic comparison students in four results; in a fifth result, there were no differences. African-American and Hispanic CMP students showed greater gains than others in two results, while African Americans alone showed greater gains in one result. In one result, Native-American CMP student performance decreased.

Contemporary Mathematics in Context: A Unified Approach (Core PLUS Mathematics CPMP)

Core-Plus Mathematics consists of a single core sequence for both college-bound and employment-bound students during the first three years of high school. A flexible fourth year course can be used to prepare students for college mathematics.

Contact

Core-Plus Mathematics Project
Department of Mathematics
Western Michigan University
Kalamazoo, MI 49008-5248
Tel: 866-407-CPMP (2767)
E-mail: cpmp@wmich.edu

Results

Fifty-six results from comparison studies on the effect of CPMP were found focusing on high school math.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	43	In 19 of the results, CPMP students scored higher; in 24 results, there were no differences.	No effect size reported
Statewide tests	5	Students scored higher in all five results.	No effect size reported
Curriculum-driven, skill-specific tests	2	Students scored higher in both results.	No effect size reported
Teacher-based measure/GPA	6	CPMP students scored higher in one result, no differently in another, and lower in four results.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Direct Instruction

In Direct Instruction (DI), each program is fully scripted, from what the teacher says and anticipated student responses, to correctional procedures. Each skill is broken down into its component parts, and then each component of the skill is taught to mastery. Afterward, the skills are combined within a larger context where they may be utilized across settings, resulting in generalized fluency. The DI mathematics curriculum covers grades K–8, but focuses primarily on grades K–6. The mathematics curriculum covers 19 different topics ranging from addition and subtraction to money, mathematics study skills (graphs, charts, maps, and statistics), and geometry.

Contact

The McGraw-Hill Companies
P.O. Box 182604
Columbus, OH 43272
Tel: 888-772-4543
Web site: http://www.sraonline.com/index.php/home/curriculumsolutions/di/connectingmath/114

Results

Nine results from comparison studies on the effect of DI were found which focus on seventh and eighth grade math.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	6	DI students scored higher for four results; they scored lower for two results.	No effect size reported
State test	3	In all three results, DI students scored higher.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Edison Schools

Founded in 1992, Edison Schools is focused on raising student achievement through research-based school design, aligned assessment systems, interactive professional development, integrated use of technology, and other program features, including a longer school day and school year. The math curriculum for grades 6–8 includes applied arithmetic, prealgebra, and pregeometry, using a spiral curriculum approach to teach concepts and ideas. The mathematics in grades 9–10 provides three years of high school math in two years' time, using an integrated application-based approach to algebra, geometry, and trigonometry with additional emphasis on probability, statistics, and discrete mathematics. Grades 11 and 12 incorporate advanced mathematical modeling, Calculus and Statistics, Algebra 2, and Precalculus, as well as AP Statistics and Calculus.

Contact

521 Fifth Avenue, 11th Floor
New York, NY 10175
Tel: 212-419-1600
Web site: http://www.edisonschools.com/

Results

Seventeen results from comparison studies on the effect of Edison Schools were found; fifteen focus on middle school math and two focus on high school math.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	8	For four results, Edison students scored higher; in the remaining four, there were no differences.	No effect size reported
State test	9	For two results, Edison students scored higher; for four results, Edison students scored lower; and for three results, there were no differences.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Integrated Mathematics, Science, and Technology (IMaST)

The Integrated Mathematics, Science, and Technology program provides integrated sixth, seventh, and eighth grade curricula that promote hands-on learning for students and teamwork among teachers from different disciplines. IMaST emphasizes learning based on constructivist theory and active student participation involving a hands-on approach comprising a wide variety of activities.

Contact

Ronjon Publishing, Inc.
1001 S. Mayhill Rd.
Denton, TX 76208
Tel: 800-262-3060
Web site:
http://www.ilstu.edu/depts/cemast/programs/imast.shtml

Results

One study was found looking at the effect of IMaST focusing on seventh and eighth grade students.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	1	IMaST students scored higher for the one result.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Interactive Mathematics Program (IMP)

This four year, problem-based curriculum incorporates traditional branches of mathematics (algebra, geometry, and trigonometry) with additional topics recommended by the NCTM Standards, such as statistics, probability, curve fitting, and matrix algebra. Students are encouraged to experiment, investigate, ask questions, make and test conjectures, reflect, and accurately communicate their ideas and conclusions. Although each unit has a specific mathematical focus, other topics are brought in as needed to solve the central problem. Ideas that are developed in one unit are usually revisited and deepened in one or more later units. Algebra and geometry are distributed throughout the four years.

Contact

Key Curriculum Press
1150 65th Street
Emeryville, CA 94608
Tel: 800-995-MATH (6824)
Web site: http://www.keypress.com/catalog/products/textbooks/Prod_IMP.html

Results

Twenty-two results from comparison studies were found on the effect of IMP, all focusing on high school.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	12	IMP students scored higher for eight results; there were no differences for four results.	No effect size reported
Pass rates or courses taken	5	In all five results, IMP students had higher passing rates and/or were more likely to take more mathematics courses.	No effect size reported
Curriculum-driven, skill-specific tests	3	IMP students scored higher for all three results.	Large effect sizes were found in the three results
Teacher-based measure	2	In both results, IMP students scored higher.	No effect size reported

Results were not reported by race or ethnicity. The one result reported by sex found IMP girls were slightly more apt to continue three or more years in math than IMP boys, while the reverse was the case for comparison students.

MATH Connections

MATH Connections (MC) is an integrated curriculum that blends ideas from traditionally separate mathematical fields (e.g., algebra, geometry, statistics, and discrete mathematics) in ways that blur the lines between them. This three year curriculum replaces the traditional Algebra I, Geometry, Algebra II sequence and is designed for all students in grades 9, 10, and 11, with honors students beginning the curriculum in grade 8.

Contact

750 Old Main Street
Suite 303
Rocky Hill, CT 06067-1567
Tel: 860-721-7010
Web site: http://www.mathconnections.com

Results

Fifteen results from comparison studies were found on the effect of MC, all of which focused on high school students.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	6	MC students scored higher for three results; for three results, there were were no differences.	No effect size reported
State test	8	MC students scored higher for all eight results.	There was a large effect size for three results.
Curriculum-driven, skill-specific test	1	No difference was found.	N/A

One result looked at sex, race, and ethnic differences and found no differences within MC students.

Mathematics in Context (MiC)

Mathematics in Context is a four-year middle school curriculum (grades 5–8) that encourages students to discover mathematical concepts and skills through engaging problems and meaningful contexts. Each year includes lessons in the four strands (numbers, algebra, geometry and statistics, and probability) that are interwoven through 10 units. For example, sample algebra units include Patterns and Symbols (grade 5), Expressions and Formulas (grade 6), Ups and Downs (grade 7), and Graphing Equations (grade 8).

Contact

Holt, Rinehart and Winston
Attn: Ms. Web1
10801 N. MoPac Expressway
Building 3
Austin, TX 78759
Tel: 800-HRW-9799 (800-479-9799)
Web sites: http://www.hrw.com
http://mic.britannica.com/mic/common/home.asp

Results

Twenty results from comparison studies were found on the effect of MiC, which focused on middle school students.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	17	In 15 results, MiC students scored higher; in two results, there were no differences.	In two results, a majority of classes showed at least moderate effect sizes.
State test	3	MiC students scored higher for all three results.	No effect size reported

One result was broken out by race. No statistically significant difference was found between African-American students using MiC and comparison students.

Mathematics: Modeling Our World (MMOW/ARISE)

In Mathematics: Modeling Our World (MMOW), students are taught to use a variety of resources to solve problems and to choose resources that meet the needs of a particular situation. As in real life, MMOW's problems do not necessarily have perfect solutions. MMOW works to strengthen the students' ability to solve problems by setting goals and thinking strategically about how to achieve these goals, solving problems through trial and error and/or process of elimination, using technology like calculators and computers, and working together to solve semi-structured problems and communicating the solutions.

Contact

W.H. Freeman and Company
41 Madison Avenue
New York, NY 10010
Tel: 800-446-8923
Web sites: http://www.whfreeman.com/highschool/contact_hs_rep.asp
http://www.comap.com/highschool/projects/mmow/introduction.htm

Results

Four results related to MMOW were found, one focusing on middle school students and three focusing on high school students.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	4	For three results, MMOW students scored higher; for one result, there were no differences.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Mathematics with Meaning

Mathematics with Meaning (MwM) is not a complete curricular program; rather, it is a combination of professional development, instructional strategies, and carefully planned materials designed to alter the pedagogy and content of middle school and high school mathematics courses in order to improve student achievement. The program consists of instructional units that teachers may use on a supplementary basis or as their entire instructional program. MwM takes a student-centered approach based on exploratory learning and problem solving, focusing on developing conceptual understanding, connections, and communication with mathematical concepts through frequent group work and hands-on activities.

Contact

College Board
Dept CBO
P.O. Box 869010
Plano, TX 75074
Tel: 212-713-8260
Tel: 800-323-7155
E-mail: Collegeboardcustomerservice@pfsweb.com
Web site: http://www.collegeboard.com

Results

Eleven results from comparison studies on the effect of MwM were found; three focused on middle school math achievement and eight on high school math achievement.

Type of measure	Number of results	Results	Effect size
Statewide tests	11	In six results, there were no differences; in five results, MwM students scored higher.	No effect reported

Six results were broken out by sex, four by race. In the six results where sex differences were given, boys slightly outperformed girls. In four results where race/ethnic differences were given, achievement scores were significantly

lower for African-American students than other students in both MwM and comparison groups.

Middle Grades MATHThematics

Middle Grades MATHThematics (STEM) is a three-year curriculum designed for use in grades 6–8. Four unifying concepts—Proportional Reasoning, Multiple Representations, Patterns and Generalizations, and Modeling—are used across the three years with seven content strands: Number, Measurement, Geometry, Statistics, Probability, Algebra, and Discrete Mathematics.

Contact

McDougal Littell Customer Service Center
A Houghton Mifflin Company
1900 S. Batavia
Geneva IL 60134
Tel: 617-351-5326
Tel: 800-462-6595
Web sites: http://www.mcdougallittell.com/
http://www.classzone.com/math_middle.cfm

Results

Six results from comparison studies were found on the effect of STEM.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	2	In one result, STEM students scored higher; in the second, there were no differences.	No effect size reported
Statewide tests	2	In one result, STEM students scored higher; in the second, there were no differences.	No effect size reported
Curriculum-driven, skill-specific tests	2	In both results, STEM students scored higher.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Prentice Hall: Tools for Success

In Prentice Hall Math (PHM), various mathematical strands (such as number sense, algebra, geometry, measurement, data analysis, and problem solving) are integrated throughout the series to ensure that students are prepared for subsequent mathematics courses at the high school level. Each lesson includes a Think and Discuss section that presents the new material along with questions to get students actively thinking about and discussing important concepts. Textbooks in this curriculum include Work Together activities that allow students to work in groups, often doing hands-on activities to reinforce math topics.

Contact

Pearson Education
P.O. Box 2500
Lebanon, IN 46052-3009
Tel: 800-848-9500
Web site: http://www.phschool.com/math/

Results

Eleven results from comparison studies on the effect of PHM were found.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	8	PHM students scored higher in five results; in three results, there were no differences.	Moderate effect sizes in one result
Statewide tests	2	PHM students scored higher in both results.	No effect size reported
Curriculum-driven, skill-specific tests	1	PHM students scored higher in this result.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Saxon Math: An Incremental Development

Saxon Math (SM) is a K–12 curriculum that systematically distributes instruction, practice, and assessment throughout the academic year rather than concentrating concepts in a single unit or chapter. Each increment builds upon the foundation of earlier increments, to lead students toward a deeper understanding of mathematical concepts. Instruction of related concepts is spread throughout the grade level, ensuring that students have an opportunity to master each concept before they are introduced to the next one.

Contact

Saxon Publishers
2600 John Saxon Blvd.
Norman, OK 73071
Tel: 800-284-7019
E-mail: info@saxonpublishers.com

Results

A total of eight results from comparison studies were found on the impact of SM, focusing on both middle and high school.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	3	SM students scored higher in all three results.	No effect size reported
Statewide tests	3	SM students scored higher in all three results.	No effect size reported
Curriculum-driven, skill-specific tests	1	SM students scored higher in this result.	No effect size reported
Teacher-based measure/GPA	1	SM students scored higher in this result.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Systemic Initiative for Montana Mathematics and Science (SIMMS)

The SIMMS curriculum is divided into six levels, each consisting of one year of work. Level 1 is typically offered to ninth graders, followed by level 2 in grade 10. After completing level 2, students may choose between levels 3 and 4 and then proceed to either level 5 or 6 in the subsequent year. The sequence for potential math and science majors is 1-2-4-6. Levels 1 and 2 offer basic mathematical literacy.

Contact

Kendall/Hunt Publishing
4050 Westmark Drive
P.O. Box 1840
Dubuque, IA 52004-1840
Tel: 800-542-6657
Web sites: http://www.simms-im.com
http://www.montana.edu/~wwwsimms/

Results

Twelve results from comparison studies were found on the effect of SIMMS. Four results each focused on levels 1 and 2, and two each focused on levels 4 and 6.

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	6	No differences were found in the six results.	No effect size reported
Curriculum-driven, skill-specific tests	6	In one result, SIMMS students scored higher; no differences were found in the other five.	No effect size reported

Results were not reported by sex, race, or ethnicity.

University of Chicago School Mathematics Project (UCSMP)

The UCSMP secondary curriculum consists of six courses: Transitional Mathematics; Algebra; Geometry; Advanced Algebra; Functions, Statistics, and Trigonometry; and Pre-Calculus and Discrete Mathematics. Transitional Mathematics, which was originally designed for average to above average seventh graders (but can be started earlier or later), weaves together three more or less equal strands of major content: applied arithmetic, prealgebra, and elementary geometry. Algebra, geometry, and some discrete mathematics are integrated into all courses, as are statistics and probability.

Contact

UCSMP
5835 South Kimbark Avenue
Chicago, IL 60637
Tel: 773-702-1130
Web site: http://socialsciences.uchicago.edu/ucsmp/

Results

Fourteen results were found from comparison studies on the effect of UCSMP. The following UCSMP courses were covered: Transitional Mathematics (2), Algebra (2), Geometry (5), Advanced Algebra (4), and Pre-Calculus and Discrete Mathematics (1).

Type of measure	Number of results	Results	Effect size
Standardized achievement tests	5	In all five results, UCSMP students scored higher.	No effect size reported
Curriculum-driven, skill-specific tests	8	In all eight results, UCSMP students scored higher.	No effect size reported
Teacher-based measure/GPA	1	No differences were found.	No effect size reported

Results were not reported by sex, race, or ethnicity.

Appendix B
DETAILED FINDINGS OF THE REVIEW OF SCIENCE CURRICULA

This appendix provides a list of the science curricula included in our review, together with a description of each curriculum and its related evaluation studies. Table 2 below lists the science curricula that we identified as having evaluation studies that met our criteria.

TABLE 2. Science Curricula with Studies

Grades Covered	Curriculum Name		Subject Matter
K 12	Expeditionary Learning Outward Bound (ELOB)	*[LEP]	Whole School Reform
K 8	Full Option Science System (FOSS)	*[LEP]	Multi-Science
PK 8	Great Explorations in Math and Science (GEMS)		Math & Multi-Science
K 6	The Science Curriculum Improvement Study (SCIS)		Multi-Science
2 8	National Science Curriculum for High Ability Learners		Multi-Science
6 8	DESIGNS/DESIGNS II	*[sex]	Physical Science
6 8	Integrated Math, Science and Technology (IMaST)		Math, Science & Technology
6 8	Center for Learning Technologies in Urban Schools (LeTUS)	*[sex]	Multi-Science
6 8	Learning By Design (LBD)		Multi-Science
6 8	Science 2000/Science 2000+		Multi-Science
6 8	Science and Technology Concepts for Middle School (STC/MS)		Multi-Science
6 9	Event-Based Science (EBS)		Earth Science
7 8	Constructing Ideas in Physical Science (CIPS)	*[sex]	Physical Science
7 9	Foundational Approaches in Science Teaching (FAST)		Multi-Science
7 9	Global Lab Curriculum (GLC)		Multi-Science, Environmental Focus
7 9	Issues, Evidence and You (IEY)/SEPUP		Multi-Science
9 11	BSCS: An Inquiry Approach		Multi-Science
9 12	High Schools that Work (HSTW)		Whole School Reform
9 12	Modeling Instruction in High School Physics	*[sex]	Physics
9 12	World Watcher/Learning About the Environment (LATE)	*[urban]	Environmental Science
10 12	Physics Resources and Instructional Strategies for Motivating Students (PRISMS)		Physics

Note: Shaded curricula are those for which we have found the strongest evidence of effectiveness, that is, quantitative evidence that (1) their use in instruction elicits higher achievement/performance in students than other curricula to which they are compared on both standardized and/or state tests and on curriculum developed tests, or (2) they showed large effect sizes in terms of increasing student achievement. All science curricula listed in Table 2, however, have credible evaluations that show evidence of effectiveness. There are several curricula for which this evidence of effectiveness has not been collected but which might also qualify as effective should appropriate studies be conducted. An omission from this list of many curricula signifies merely that these curricula have not yet provided quantitative evidence of effectiveness that meets our criteria.
*An asterisk marks curricula for which effectiveness data are provided for subgroups of students, indicated in brackets. (See full report on the web for discussion of research findings by subgroup.)

A Description of the Science Curricula and Evaluation Studies Found

The attached descriptions of science curricula, which appear in alphabetical order, include the type of student achievement measure used, the number and direction of the results, and, if available, the size of any differences between groups. When known, effect sizes have been listed. Where results have been provided by race/ethnicity, sex, or other demographic characteristics, we have reported these. The absence of such notation means that no data were reported by subgroup. In the case of three curricula, descriptions of studies do not follow the normal format because results reported are not best described in that particular format.

Note: Almost all impact studies for science curricula reported the statistical significance of their results. Only differences that have reached the conservative minimum acceptable statistical significance level of .05 were included in the results reported for each study. If differences *are* statistically significant, then there is another measure, called an effect size, that shows how big the difference is. In our description of the study results, we provide effect sizes where available, although few studies reported these results. Effect sizes greater than .4 are considered large, between .2 and .4 are considered moderate, and less than .2 are considered small.

BSCS: An Inquiry Approach

This program introduces 9th, 10th, and 11th grade students to the core concepts in inquiry, the physical sciences, the life sciences, and the earth–space sciences as articulated in the National Science Education Standards. In addition, the curriculum engages students in integration across the disciplines in relevant contexts that explore the standards related to science in a personal and social perspective. This program provides high school students with an alternative to the traditional sequence of biology, chemistry, and physics. Included with this program is a professional development component designed to help teachers and school districts implement the materials.

Contact

Pamela Van Scotter
Director
The BSCS Center for Curriculum Development
BSCS 5415, Mark Dabling Blvd.
Colorado Springs, Colorado 80918
Web site: http://www.bscs.org/page.asp?id=curriculum_development|high_school_9-12|An_Inquiry_Approach

Results

Most of the evaluative work on this was of the materials, not student achievement; however, the results of a nationwide field test are summarized below.

Type of measure	Number of results	Results	Effect size
Content test, unknown if self-designed or state-issued	1	Average student gains at both 9th and 10th grade levels were between 20 and 25 percent.	No effect size reported

Note: Statistical significance levels were not reported.

The field test was conducted across 10 states and included students in urban, suburban, and rural schools. However, data regarding specific demographic groups was not provided.

Center for Learning Technologies in Urban Schools (LeTUS)

LeTUS, developed by researchers at the University of Michigan and Detroit public school teachers, includes project-based curriculum materials that build from district, state, and national standards to support the development of integrated science understanding for middle school students. The materials support students' science learning through engaging them in inquiry about real world problems, providing them with multiple opportunities to work with concepts, and integrating the use of learning technologies in instruction. LeTUS is focused on learning about and developing a new machine to construct large buildings and bridges, an area that has been identified as of interest to young urban students.

Contact

Joseph Krajcik
School of Education
University of Michigan
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Ann Arbor, MI 48109-1259
Tel: 734-647-0597
Fax: 734-615-5245
E-mail: krajcik@umich.edu

Results

Two evaluations of the LeTUS program were found, one that utilized skill-specific instruments and one that used statewide achievement test scores to measure effectiveness.

Type of measure	Number of results	Results	Effect size
Curriculum-driven,skill-specific tests	1	Significant content and process gains that increased with program revision and scale-up	Large effect size for content achievement and more moderate effects for process skills.

(*continued*)

Type of measure	Number of results	Results	Effect size
Statewide tests	1	Students who completed at least one LeTUS unit in seventh or eighth grade outperformed peers in all content and process categories measured by the test.	Moderate effect size for all three content areas and both process areas. Moderate effects in increas- test passing rates.
Program-designed measures	1	Sixth graders showed significant overall improvement on pre- and post-test measures over a four-year period.	Large effect size for achievement gains pre- and post-test

The study looking at differences by sex indicated that participation in at least one LeTUS unit is associated with an apparent reduction in boy-girl achievement differences on statewide examinations.

Constructing Ideas in Physical Science (CIPS)

Constructing Ideas in Physical Science (CIPS) is an inquiry-based, yearlong physical science course that attempts to engage seventh or eighth grade middle school students in constructing meaningful understanding of physical science concepts. The CIPS course is based on the themes of interactions and energy transfers between objects. CIPS has five units. Each unit consists of two or three cycles of activities designed to help students develop physics and chemistry concepts.

Contact

CIPS Project
6475 Alvarado Road, Suite 206
San Diego, CA 92120
Fax: 619-594-1581
E-mail: cips@public.sdsu.edu
Web site: http://cipsproject.sdsu.edu

Publisher:
It's About Time, Inc.
Tel: 888-698-TIME (8463)

Results

Type of measure	Number of results	Results	Effect size
Multiple-choice content items	1	CIPS students scored higher than non-CIPS comparisons after controlling for prior knowledge, student demographics, and weeks of instruction in Physical Science.	Small
Multiple-choice process items			Small
Open-ended content items			Moderate

CIPS participation did not appear to have closed either sex (male/female) or racial (white/Asian versus non-Asian minority) achievement gaps on either multiple-choice content or process questions or open-ended content items.

DESIGNS/DESIGNS II

Project DESIGNS (Doable Engineering Science Investigations Geared for Non-science Students), developed by the Harvard-Smithsonian Center for Astrophysics, includes design-based activity modules for use in physical science and technology education courses in grades 5–9. The project's six topics cover chemistry, static forces, electricity and magnetism, potential and kinetic energy, energy transfer, and force, work, power, and torque. Designs II resulted from a follow-up effort to develop a full-year middle school (grades 7–9) physical science course based on the modules. Project pedagogy was derived from the constructivist model of learning and takes into account students' personal theories. The project's goal was to open science concepts to students through activities involving the design, construction, and optimization of simple devices.

Contact

Program overview:
Web site: http://cfa-www.harvard.edu/sed/resources/designsinfo.html

Publisher:
Kendall/Hunt
Tel: 800-542-6657
Web site: http://www.kendallhunt.com/index.cfm?PID=219&PGI=152

Results

Type of measure	Number of results	Results	Effect size
Self-designed test to measure process skills	1	Designs II students gained over control students.	Large
Self-designed tests to measure conceptual knowledge	1 (same as above)	Students with initially lower scores gain more.	Large

Analysis by sex for conceptual knowledge shows no significant difference in gains.

Event-Based Science (EBS)

The Event-Based Science (EBS) series is a module-based program designed for students in grades 6–9, with a focus on current events. The series has 18 modules designed to last four to six weeks, each focusing on different themes and concepts across the domains of earth, life, and physical

sciences. The modules may be sequenced over all middle school grade levels and combined with other instructional materials in order to build a comprehensive middle school science program. One or two modules typically are used in a year, with teachers selecting particular units based on the district's science standards, the local curriculum program, the interests of the student population, and their own background knowledge in specific topics. EBS is not a "stand alone" curriculum. By design, teachers and students supplement each module with additional data about a specific event from various resources included as part of the materials, or suggested by the program.

Contact

Russ Wright, Project Director
Montgomery County Public Schools
850 Hungerford Drive
Rockville, MD 20850
Tel: 301-806-7252
Fax: 301-279-3153
E-mail: russ@eventbasedscience.com
Web site: http://www.mcps.k12.md.us/departments/eventscience/

Results

One interim study of the impact of EBS was found. This study measures the first three years of the EBS project. The report of the final findings from the six-year project is not yet available.

Type of measure	Number of results	Results	Effect size
Curriculum-driven, skills-specific, multiple-choice test	1	In two of the three tested years, EBS students outperformed the control group, after controlling for prior science performance.	Small
Science attitudes survey		EBS students displayed more positive attitudes about science than the control group.	Small
Task-based performance assessment rubric		EBS students outperformed the control group, controlling for prior science performance.	Moderate

Expeditionary Learning Outward Bound (ELOB)

As a whole school reform effort, Expeditionary Learning Outward Bound (ELOB), K–12, organizes curriculum, instruction, assessment, school culture, and school structures around producing high quality student work in learning expeditions. These expeditions are long-term, in-depth investigations of themes or topics designed to engage students both in and beyond the classroom through projects, fieldwork, and service. Learning expeditions are designed with clear learning goals aligned with district and state standards. Ongoing assessment is woven throughout each learning expedition.

Contact

Expeditionary Learning
100 Mystery Point Road
Garrison, NY 10524
Tel: 845-424-4000
E-mail: info@elob.org
Web site: http://www.elob.org/

Results

Only one study of many found for ELOB looked at science achievement. Two schools are included in this study, but only one includes data for science.

Type of measure	Number of results	Results	Effect size
Standardized tests	1	ELOB students showed steady gains in science.	No effect size reported

One of the schools in the study experienced an increase of about 22 percent in immigrant students (who were limited English proficient) over the five years accounted for in the evaluation. The school showed consistent gains in all subject areas. This same school also has a high number of students qualifying for free and reduced price lunch. The evaluation concludes that ELOB, in this instance, is "particularly successful with a challenging, normally low-achieving population."

Foundational Approaches in Science Teaching (FAST)

Foundational Approaches in Science Teaching (FAST) is a three-volume, comprehensive curriculum program based on a constructivist philosophy of learning in which students construct their own knowledge through experiential, hands-on learning. Investigations help students build on existing knowledge and reinforce conceptual understanding throughout their work. The continual reinforcement and return to concepts allows students to achieve a deep understanding of the material and to arrive at that understanding at different points in the curriculum. FAST puts the teacher in the role of "director of research." The program emphasizes an instructional strategy that is based on the teacher's question development practices and other techniques that encourage students to think critically. It is heavily laboratory-based, with most concepts taught through laboratory experiences where students develop skills in measurement and lab procedures.

Contact

Donald Young, CRDG Director
The University of Hawaii
The Curriculum Research & Development Group,
Science Section
1776 University Avenue, UHS Building 2, Room 202
Honolulu, HI 96822-2463
Tel: 808-956-4969
Fax: 808-956-6730
E-mail: crdg@hawaii.edu
Web site: http://www.hawaii.edu/crdg/FAST.pdf

Results

Type of measure	Number of results	Results	Effect size
Laboratory skills Process skills Knowledge skills	2 1 1	FAST students outperformed non-FAST comparison group.	No effect size reported
Statewide test scores	1	In one of two years tested, FAST students scored significantly higher than the state average, after controlling for student background.	No effect size reported
Standardized test scores	2	FAST students outperformed non-FAST students in one study. In the second, both FAST and non-FAST groups scored above national norms.	No effect size reported

Full Option Science System for Middle School (FOSS)

The Full Option Science System (FOSS) was developed by the Lawrence Hall of Science, University of California–Berkeley. Funded by the National Science Foundation, FOSS combines science content and process with a goal of increasing scientific literacy for students and instructional efficiency for teachers. The curriculum is organized into topical units, called courses, under each of three strands: Earth and Space Science, Life Science, and Physical Science and Technology. Each course is an in-depth unit requiring 9 to 12 weeks of instruction. The units have approximately 10 investigations, each with three to seven parts. The system advocates that students should learn important scientific concepts and develop the ability to think well if they are engaged in situations where they actively construct ideas through their own explorations, applications, and analyses.

Contact

FOSS Project
Lawrence Hall of Science, University of California
Berkeley, CA 94720
Phone: 510-642-8941
Fax: 510 642-7387
Email: foss@berkeley.edu
Web sites: http://www.lhsfoss.org/
http://www.delta-education.com/science/foss/index. shtml

Results

Two studies of FOSS materials met our criteria, though in each of these, use of FOSS was included as only one part of a larger curriculum or professional development intervention.

A 2003 evaluation of the NSF-sponsored Project Inquiry, a broad professional development intervention including the adoption and use of FOSS materials, revealed that fifth grade students of teachers trained in kit use performed significantly higher on both multiple-choice and constructed/open-ended response assessments than did the control group. Self-reported hours of teacher professional development were also positively associated with science achievement. The authors conclude that professional development is associated with better implementation of inquiry-based instruction and greater science topic coverage, which is in turn associated with science achievement.

A 2002 study of the use of multiple kit- and inquiry-based science materials (including FOSS) in fourth and sixth grade classes for English language learners revealed a positive relationship between years in the science program and standardized science test scores. This relationship remained after controlling for the students' increasing English language proficiency.

Global Lab Curriculum (GLC)

The Global Lab Curriculum (GLC) was a four-year project to create a science course emphasizing student collaborative inquiry. Organized around six units, GLC culminates in the design and conduct of original student investigations. The structure purposefully provides substantial guidance to students in initial investigations and gradually peels away the support to allow students to exercise acquired skills in designing and conducting their own collaborative experiments. GLC is also designed to capitalize on the Internet as both a communication and motivational tool that helps establish a cross-cultural science community.

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Results

Type of measure	Number of results	Results	Effect size
Self-designed tests	1	Students with low levels of prior knowledge benefit more from GLC than those with medium or high levels of prior knowledge.	No effect size reported

Great Explorations in Mathematics and Science (GEMS)

Great Explorations in Math and Science (GEMS) is a supplemental enrichment program for students from preschool through eighth grade. GEMS provides teachers with more than 70 teacher's guides, support documents, and pedagogical handbooks; professional development opportunities; an active web site; and a national support network of GEMS leaders and associates and over 45 regional sites. GEMS uses generally accessible materials that integrate science and mathematics. The program's units, presented as flexible enhancements or in curriculum sequence, are designed to help all teachers reach all students and feature clear, step-by-step teacher instructions. In addition to the specific standards-based learning goals and content, the program emphasizes cooperative learning and problem-solving, literature and language arts connections, and real world relevance. GEMS units feature an inquiry-based, guided-discovery, student-centered approach to learning. An assessment component is in place for the entire series.

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Results

Several studies of the GEMS units, which serve grades K–8, have been produced. Only one of these met our criteria and focused on the fourth through eighth grade astronomy unit Earth, Moon, and Stars.

Type of measure	Number of results	Results	Effect size
Content-specific, skills-driven test	3	Students receiving GEMS instruction had significantly higher pre–post gains than control groups without GEMS instruction.	No effect size reported

High Schools that Work (HSTW)

High Schools that Work (HSTW) is a whole-school, research- and assessment-based reform that offers a framework of goals and key practices for improving the academic, technical, and intellectual achievement of high school students. HSTW blends traditional college-preparatory content with quality technical and vocational studies. HSTW provides technical assistance and staff development focused on techniques and strategies such as teamwork, applied learning, and project-based instruction. The HSTW assessment is based on the National Assessment of Educational Progress (NAEP). The developer does not offer specific subject area programs, but consultants provide workshops customized to fit an individual school's needs.

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Results

Two studies were conducted using the same measure.

Type of measure	Number of results	Results	Effect size
HSTW assessment	1	Gains in achievement increase with the number of students in a school completing the HSTW curriculum.	No effect size reported
HSTW assessment	1	Over time, more students met achievement goals and completed program.	No effect size reported

Integrated Mathematics, Science, and Technology Curriculum (IMaST)

Integrated Mathematics, Science, and Technology Curriculum (IMaST) was developed by the Center for Mathematics, Science, and Technology at Illinois State University. IMaST is a standards-based, integrated curriculum for grades 6–8. IMaST integrates technology, science, and mathematics and includes connections to the language arts and social sciences, as well as readings that profile typical careers related to the curriculum content. The curriculum is based on the constructivist learning theory that allows concept development to take place in a structured venue.

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Results

Type of measure	Number of results	Results	Effect size
TIMMS sub-test	1	IMaST students outperform traditional peers, especially regarding science processes.	No effect size reported

Issues, Evidence, and You (IEY)/SEPUP

The University of California–Berkeley Lawrence Hall of Science developed the SEPUP IEY curriculum for middle school and junior high use with support from the National Science Foundation. Issues, Evidence, and You (IEY) focuses on environmental issues in a social context. The program builds upon earlier SEPUP modules and is designed to address students' increasing ability to think abstractly and builds upon students' need for peer interaction and support. The developer intended the curriculum to serve as the physical science component of an integrated science program (physical, life, and earth science) or as a year-long physical science program. The course consists of 65 activities or investigations presented in a conceptual sequence. The instructional times of the activities vary from one to three class periods. The curriculum can accompany Science and Life Issues (SALI), another SEPUP program now in the piloting phase. The program also integrates student assessment into the curriculum, providing teachers with a basis for understanding gaps in student knowledge of core scientific concepts and a plan for addressing such gaps as they are identified.

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Results

An assessment of the pilot implementation of IEY was conducted as an experimental study using pre- and post-tests of student knowledge for two groups: one taught using IEY and another using the traditional science curriculum. The study spanned 15 multi-school sites in 12 states, covering 26 classrooms and a total of 830 students. Student achievement was measured by the assessments from the IEY program, which consisted of multiple choice and short answer items.

Type of measure	Number of results	Results	Effect size
Curriculum-driven, skill-specific tests	1	IEY students experienced an increase in ability to present an evidence-based line of reasoning, while comparison classes did not experience significant improvement in this skill.	Moderate

Learning by Design (LBD)

Developed by Georgia Tech's EduTech Institute, Learning by Design (LBD) is an approach to science learning in which middle school students learn as a result of collaboratively engaging in design activities and reflecting appropriately on their experiences. Scaffolding is a key component of LBD; interventions combine teacher facilitation, paper-and-pencil design diaries and other paper prompts, and software tools and prompts. LBD has units in both physical and earth science.

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Results

Type of measure	Number of results	Results	Effect size
Self-designed test incorporating some standardized test items (NAEP, TIMSS)	1	LBD gains in content learning higher than comparison students. Typical LBD students do as well or better than honors-level non-LBD students.	No effect size reported
Performance assessments	2	Typical LBD students score higher than typical companion group students in applying collaborative science skills and practices. Typical LBD student's performance was on par with non-LBD honors students, and LBD honors students outperformed non-LBD honors students.	No effect size reported

Modeling Instruction in High School Physics

Modeling Instruction in High School Physics is grounded in the thesis that scientific activity centers on modeling: the construction, validation, and application of conceptual models to understand and organize the physical world. The program uses computer models and modeling to develop the content and pedagogical knowledge of high school physics teachers and train them to be leaders in science teaching reform and technology infusion. The program relies heavily on professional development workshops to equip teachers with a teaching methodology. Teachers are trained to develop student abilities to make sense of physical experience, understand scientific claims, articulate coherent opinions of their own, and evaluate evidence in support of justified belief. For example, students analyze systems using graphical models, mathematical models, and pictorial diagrams called system schema.

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Results

Four evaluations of the impact of Modeling Instruction on student achievement were found.

Type of measure	Number of results	Results	Effect size
Tests of alternate methods of physics instruction (Comparison of average classroom scores between teachers using Modeling Instruction, traditional methods, and reform methods)	2	Average pre–post test gains in Modeling Instruction classrooms were double those in traditional classrooms, and 10 percentage points higher than those in reform-method classrooms.	No effect size reported
Tests of alternate methods of physics instruction (Comparison of average classroom scores between teachers pre–Modeling Instruction training and the same teachers post-training)	2	Post-test scores after a teacher is trained in Modeling Instruction were between 6 and 10 percentage points higher than their classroom averages before training.	No effect size reported

Data from three studies show that male students consistently outperform female students.

National Science Curriculum for High Ability Learners

The National Science Curriculum for High Ability Learners Project is a supplemental program that has been implemented across grades 2–8 with a broad group of students within the average-to-gifted range of ability. The curriculum units employ problem-based learning for engaging students in the study of the concept of systems, specific science content, and the scientific research process. Students engage in a scientific research process that leads them to create their own experiments and design their own solutions to each unit's central problem. The units encourage in-depth study, and content areas cover a breadth of scientific subject matter drawn from the physical, life, and earth sciences. Each unit constitutes approximately 30 hours of instruction, with students typically receiving two units within an academic year. Major components of the program include a curriculum framework that contains goals and learning outcomes linked to individual lesson plans; embedded and post assessments that focus on science content, concept, and process learning; 25 lesson plans that address these goals and outcomes with relatively equal emphasis on each of the goals; and a real world problem that serves as the catalyst for subsequent learning in the unit.

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Results

Type of measure	Number of results	Results	Effect size
Open-ended assessment to test gifted science students	1	Students in National Science Curriculum (NSC) classrooms scored better on one unit tested when compared to students in non-NSC classrooms.	High
Open-ended assessment to test gifted science students	4	Same as above	High

Physics Resources and Instructional Strategies for Motivating Students (PRISMS)

The goal of Physics Resources and Instructional Strategies for Motivating Students (PRISMS) is to provide learning activities to promote understanding of physics principles in the context of experiences relating to the daily lives of secondary school students. PRISMS includes a guide with over 130 activities in the form of student instructions and teacher notes with background information on the activities. The program's resources include several videotapes from which students make observations and take data, and recommended software and interfacing for schools that have access to microcomputers. A complete student evaluation and testing program is included in a three- to four-diskette set. The instructional strategies blend exploratory activities, concept development, and application activities to stimulate problem-solving skills and the understanding of major physics concepts. The guide can be integrated with the use of any physics textbook and is designed to be individualized to meet the needs of each teacher. The guide also contains activities dealing with scientific, technological, and social issues as well as career information. The new version is called PRISMS PLUS.

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Results

Type of measure	Number of results	Results	Effect size
State assessment	2	PRISMS students have higher achievement gains than comparison students.	No effect size reported
Program-designed measures	1	PRISMS students' gains in reasoning and problem-solving skills were greater than those of comparison students.	No effect size reported

Science 2000/Science 2000+

Science 2000+ (previously known as Science 2000) is a multimedia, multiyear science curriculum for high schools that takes an integrated, thematic approach to the earth, life, and physical sciences. At each grade level, the yearlong course includes four nine-week units, connected by central themes and a storyline—a narrative that sets a real-world context for the science content. Each unit poses problems related to real-life scientific and social issues. Students address these problems by drawing information from CD-ROM-based resources (text, images, video, simulations) supplemented by laser disc, web references, and manipulative kits. Multimedia resources (text, images, and video) are cross-referenced and linked within the CD.

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Results

Type of measure	Number of results	Results	Effect size
Self-designed test instruments	1	All Science 2000 students showed gains in content knowledge from pre- to post-test.	No effect size reported

Study showed the curriculum to be effective in increasing the content knowledge of all students, regardless of gender, ethnicity, or language classification.

Science and Technology Concepts for Middle Schools (STC/MS)

Science and Technology Concepts for Middle Schools (STC/MS) is a modular program composed of 24 units. There are four units for each grade level, one each in the following strands: life science, earth science, physical science, and technology. Each STC unit generally has 16 lessons with hands-on investigations. Teachers can use the four modules to comprise the science curriculum for the entire school year or use one or two individual units as supplements to other curriculum pieces. Eight modules for grades 7 and 8 are currently under development. When completed, STC/MS will include eight units for science in grades 7 and 8. The instructional units will be balanced among life, earth, physical sciences, and technological design. The components are designed to be offered as two one-year courses (one unit from each of the scientific strands) or as four single semester courses.

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Results

In a 2001 study of four of the eight STC/MS modules, a post-test only design was used to compare the performance between groups receiving STC/MS instruction and those who received traditional instruction. The impact of the curriculum on student achievement in each particular content area was measured by multiple-choice and short-answer tests developed to measure concepts specific to each unit, including TIMMS and NAEP. When possible, test items were taken from previously existing assessments so that national and international comparisons were possible. In all four STC/MS curriculum units, students demonstrated significantly higher performance than control groups and national/international comparison groups. The quasi-experimental evaluation design, however, makes it difficult to control for prior knowledge or instruction of students in comparison groups.

The Science Curriculum Improvement Study (SCIS)

The Science Curriculum Improvement Study (SCIS) was developed at the Lawrence Hall of Science at the University of California between 1962 and 1974 for use in grades K–6. The goal of the program is the development of scientific literacy, defined as a combination of basic knowledge concerning the natural environment, investigating ability, and curiosity. The program consists of 12 units, one life and one physical science unit at each elementary grade level. About 10 major concepts are developed each year. The concepts are interrelated and are intended to provide a conceptual framework for the child's thinking. Opportunities are provided for developing science processes as well. The general instructional pattern is free exploration of new materials, the introduction of a new concept, and the application of the new concept in a range of new situations.

Contact

Note: Science Curriculum Improvement Study (SCIS) is now called SCIS 3+

Publisher:
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Results

A 1983 meta-analysis of 57 controlled studies of SCIS and two other activity-based science programs (ESS and SAPA) draws conclusions about the programs across process, content, and affective outcomes. Seventy percent of the studies were dissertations, and a conservative estimate of the combined students tested is 13,000 in over 900 classrooms. Seventy-nine percent of the studies had a quasi-experimental design. Forty-eight percent of the studies tested effects after more than one year of program use.

The overall effect of these three programs on all outcome areas was positive, though not dramatically so; thirty-two percent of comparison studies had statistically significant results favoring the treatment group, while 6 percent favored the nontreatment group. These results support an overall conclusion of a positive program effect. The mean effect size for all studies, with all outcomes weighted equally, was .35, or a 14 percentile point improvement over

non-activity-based instruction. The effects on measures of science process, intelligence, and creativity were positive. Small positive effects were observed in attitudes towards science. Contrary to a common worry about activity-based programs, content achievement was not negatively affected.

A second meta-analysis conducted in 1986 largely confirmed these results, emphasizing in particular the differences in attitude toward science and process skills (17 and 19 percentile point gains, respectively) among students who were taught with activity-based modules.

World Watcher/Learning about the Environment Curriculum (LATE)

The World Watcher/Learning about the Environment Curriculum (LATE) is a yearlong, inquiry-based, technology-supported environmental science curriculum for high school developed at Northwestern University. It is based on the Learning-for-Use model of learning that conceptualizes content and process learning as complementary and mutually facilitating, rather than at odds. LATE incorporates the use of scientific visualizations and is centered on three key issues: population growth and resource availability, electricity generation and energy demand, and managing water resources for agriculture and human consumption.

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Results

Type of measure	Number of results	Results	Effect size
Self-designed test	1	Gains at all grade levels and all populations (urban, suburban). Biggest differences in 10th grade.	Large (urban), moderate (suburban)

Urban students showed higher gains (5 points) than suburban students (3.5 points). Researchers caution not to interpret this result as greater effectiveness of the curriculum for the urban group. It is possible that a subgroup of a sample that scores below average on a test tends to do better on retests.

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