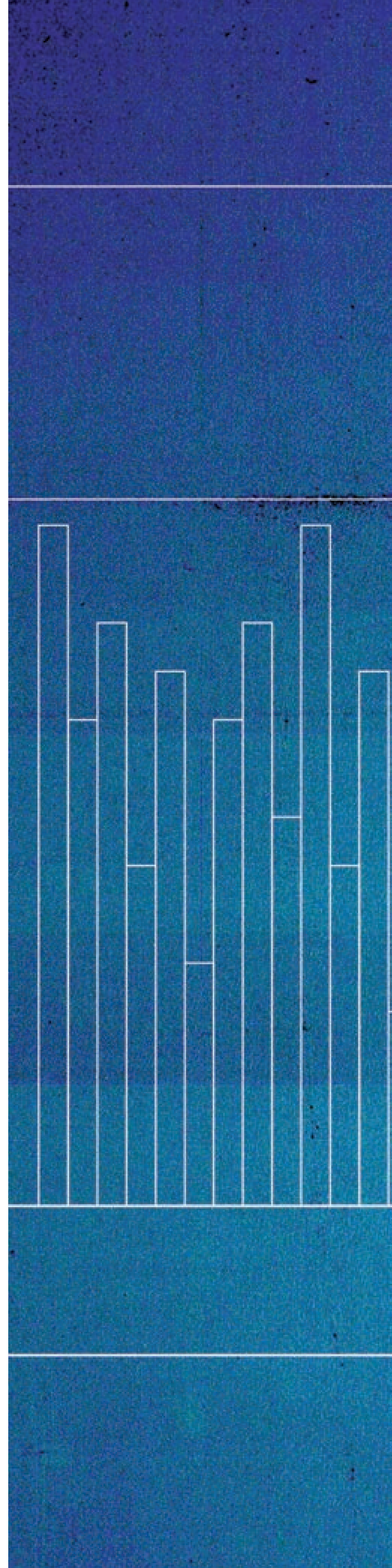
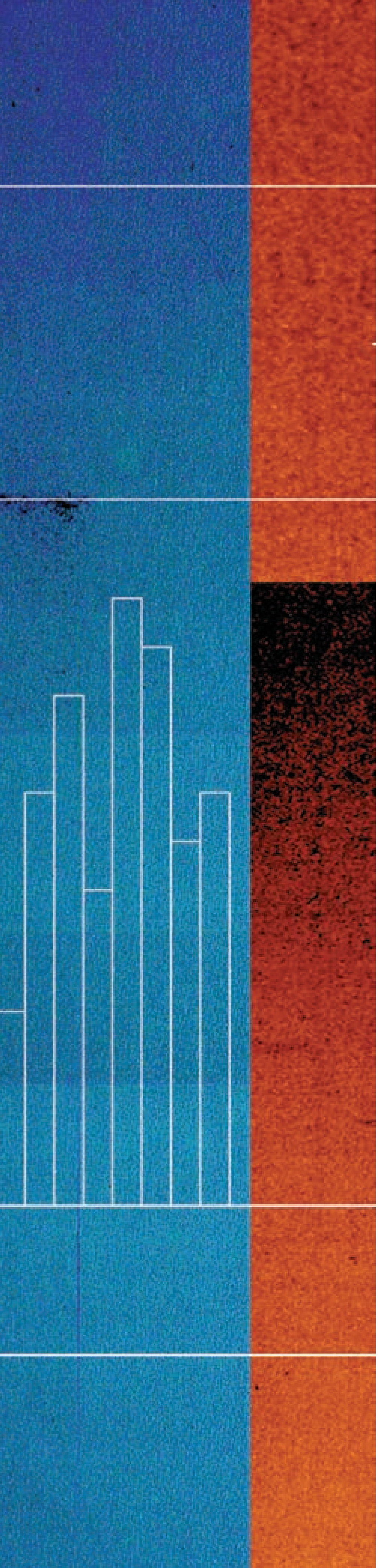
Research

Behind the Difference that Gets Results

Theoretical and Empirical Support for Saxon Math

SAXON MATH™





Theoretical and Empirical Support for SAXON MATH™

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Foundational Research

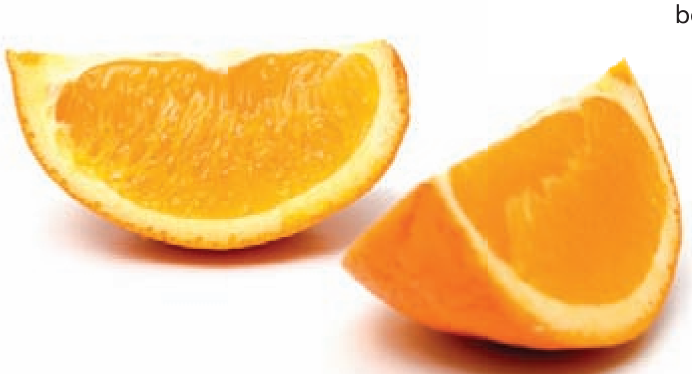
A well-articulated curriculum challenges students to learn increasingly more sophisticated mathematical ideas as they continue their studies. John Saxon, founder of Saxon Publishers, had a similar philosophy in mind when in the early 1980s he developed his theory-based distributed approach to mathematics instruction, practice, and assessment. Saxon's approach has evolved to include a K–12 textbook series with a comprehensive approach to mathematics.

Effective concept development involves incremental skill instruction, distributed throughout a school year.

Because smaller pieces of information are easier to teach and easier to learn, the ***Saxon Math*** series was developed by breaking down complex concepts into related increments. The instruction, practice, and assessment of those increments were systematically distributed across each grade level. Practice is continual, and assessment is cumulative. The Saxon approach differs from most programs in that it distributes instruction, practice, and assessment throughout the lessons and school year instead of massing these elements. In a massed approach, instruction, practice, and assessment of a skill or concept occur within a short period of time and are clustered within a single chapter or unit. In the ***Saxon Math*** program, as students encounter new increments of instruction, they also continually review previously introduced math concepts. Frequent assessments of new and old concepts are encountered throughout the lessons, ensuring that students truly integrate and retain critical math skills.

Theoretical Framework for *Saxon Math*

Saxon's instructional approach to teaching mathematics is supported by Gagne's (1962, 1965) cumulative-learning theory and Anderson's (1983) ACT theory. Gagne's theory of cumulative learning is based on the premise that intellectual skills can be broken down into simpler skills, which can in turn be divided into even simpler skills. Research has shown that intellectual skill objectives are arranged into a pattern that reveals prerequisite relationships among them (Gagne & Briggs, 1974). Thus, lower level skills must be mastered before higher level skills can in turn be mastered. Anderson's ACT theory explains the development of expertise through three stages: cognitive, associative, and autonomous. During the cognitive stage, learners rehearse and memorize facts related to a particular domain or skill that guide them in problem



solving. Within the associative stage, learners are able to detect errors and misunderstandings through continual practice and feedback. By the time learners have reached the autonomous stage, they have practiced a skill to the extent that it becomes automated, thus reducing the amount of working memory needed to perform the skill and leading to expertise with that skill.

Incremental Instruction, Distributed Across the Level

Research also suggests there is value in a teaching method that uses small, easily digestible chunks of information within its lessons (Ausubel, 1969; Brophy & Everston, 1976). Studies by Rosenshine and Stevens (1986) and Brophy and Everston (1976) demonstrated the importance of using incremental steps when teaching new information. Effective concept development involves incremental skill instruction distributed throughout a school year.

Continual Practice, Distributed Across the Level

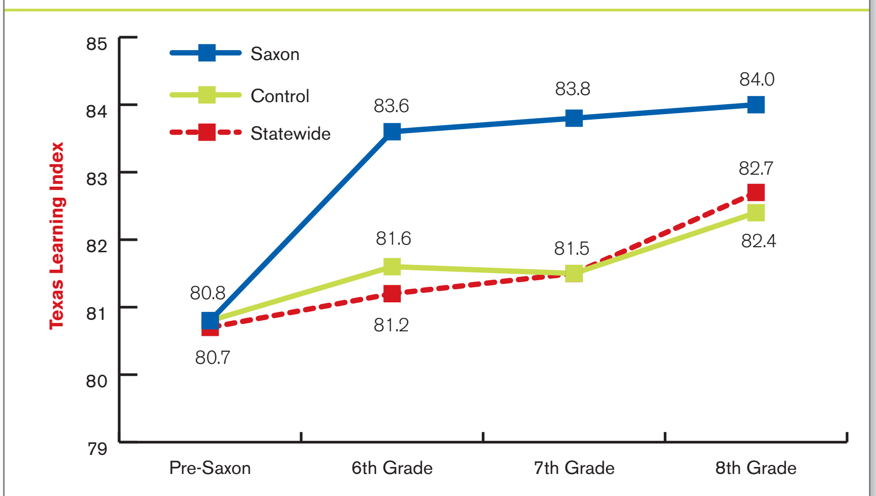
Foundational research has also shown that distributed instruction results in greater student achievement (English, Wellburn, & Killian, 1934) and leads to a higher level of recall (Glenberg, 1979; Hintzman, 1974) than does massed instruction. Distributed instruction with incremental practice and review has been found effective at all grade levels in a variety of subjects, including mathematics, science, and reading comprehension (Dempster, 1988; English et al., 1934; Hintzman, 1974; Reynolds & Glasser, 1964). Research studies have shown that students who are taught with a mathematics curriculum that uses continual practice and review demonstrate greater math achievement and skill acquisition than do students who are taught with a mass approach (Good & Grouws, 1979; Hardesty, 1986; MacDonald, 1984; Mayfield & Chase, 2002; Ornstein, 1990; Usnick, 1991). Dempster (1991) noted that the benefits of review have been validated by research since the early part of the 20th century, and numerous studies suggest that when review is incorporated into the learning process, both the quantity and quality of what is learned is improved. Studies in cognitive science also support continual practice, because it develops computational automaticity–it increases retrieval speed, reduces time required for recognition, and decreases interference (Klapp, Boches, Trabert, & Logan, 1991; Pirolli & Anderson, 1985; Thorndike, 1921).

Cumulative Assessment, Distributed Across the Level

In terms of cumulative assessment, research has indicated that well-designed classroom testing programs that are routine rather than are an interruption (National Council of Teachers of Mathematics [NCTM], 2000) have a positive impact on later student achievement (Dempster, 1991). Dempster found that higher levels of achievement occur when testing is frequent and cumulative rather than infrequent or related only to content covered since the last test. Benefits are most noted when tests are an integral part of the instructional approach; administered regularly and frequently; and collected, scored, recorded, and returned to students promptly, thus preventing any misunderstanding from becoming ingrained. Furthermore, Cotton (2001) noted that students who are tested frequently and given feedback have more positive attitudes toward tests.

According to Fuchs (1995), assessments enhance instruction by monitoring student learning, evaluating instructional programs, and revealing remediation needs. In particular, cumulative assessment that is frequent and distributed has been found to be effective by a number of studies which have shown that students who are assessed frequently have higher test scores than do students who are assessed infrequently (Blair, 2000; Peckham & Roe, 1977; Rohm, Sparzo, & Bennett, 1986).

Figure 1.
Growth in TAAS Texas Learning Index by group (and statewide)



Efficacy Studies[1]

Historical Effectiveness of *Saxon Math:* Elementary and Middle School

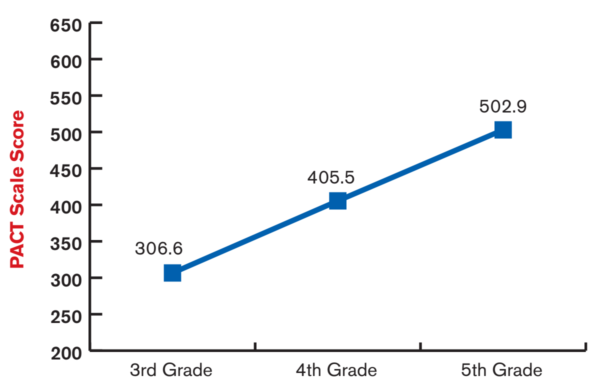
Since 2005, Harcourt Achieve has contracted with PRES Associates—an external, independent educational research firm—to conduct analyses using longitudinal state assessment data to document the effectiveness of Saxon's elementary and middle school math programs over time in several states, including South Carolina (Resendez, Sridharan, & Azin, 2007), California (Resendez & Azin, 2007), Georgia (Resendez & Manley, 2005), and Texas (Resendez, Fahmy, & Manley, 2005; Resendez, Sridharan, & Azin, 2006). Analyses were conducted during specified years on school and student-level achievement data that compared users of ***Saxon Math*** to those who used other math curricula during the same years.

[1] For further information on the evaluation reports cited in this section, please visit the Saxon Web site at www.SaxonMath.com

The findings across these studies are consistent: ***Saxon Math*** works. The longitudinal data from these states indicate that elementary and middle school students in Saxon schools have shown significant growth in math achievement over time. Furthermore, these gains are immediate and sustainable (see Figure 1). Teachers and schools see results quickly. ***Saxon Math*** has also been effective for those groups of students that typically struggle academically including English language learners, students classified as special education, economically disadvantaged students, and minorities.

The South Carolina study (Resendez et al., 2007) found that among Saxon schools in South Carolina there is significant growth in achievement on the statewide math assessment (Palmetto Achievement Challenge Test [PACT]) within both elementary and middle school grade levels (see Figures 2 and 3). Students using ***Saxon Math*** in South Carolina from 2002 to 2006 have shown growth year after year in math achievement. Additional findings from South Carolina suggest there are increasing trends in math performance among all subgroups in Saxon elementary and middle schools, especially among limited English proficient (LEP) students. Analyses found that LEP students showed accelerated rates of math performance over time; specifically, a closing of the achievement gap between Saxon LEP and non-LEP students was shown to exist between these groups. In addition, preliminary analyses, examining aggregated PACT scores only, showed that the average performance of both elementary and middle school Saxon students was significantly higher than the average performance of non-Saxon students.

Figure 2.
Elementary Saxon Students' PACT Match Performance
(Growth from 3rd–5th grade)



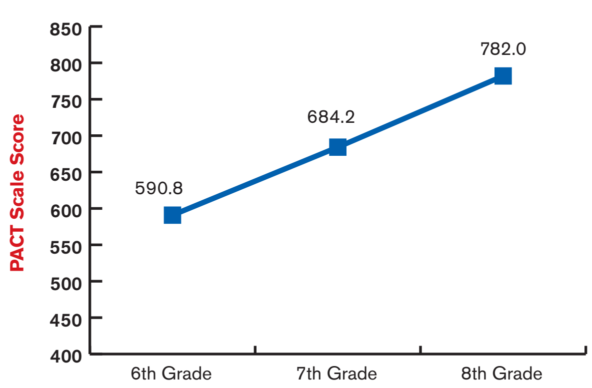
Experimental Studies of *Saxon Math:* Elementary and Middle School

A number of experimental and quasi-experimental evaluations of the ***Saxon Math*** program (K–8) have also been conducted through independent research organizations, including universities and school-district evaluation departments.

Elementary School

In 2006, Harcourt Achieve contracted with Edvantia, an independent research and evaluation firm, to examine the effectiveness of Saxon elementary math programs in a nationwide, large-scale study (Good, Bickel, & Howley, 2006). The evaluation was conducted by matching existing Saxon schools with demographically similar schools using other math

Figure 3.
Middle School Saxon Students' PACT Match Performance
(Growth from 6th–8th grade)



programs and examining student-level achievement in math after 1 year of implementation. Student achievement was measured using the *Stanford Achievement Test, Ninth Edition* (SAT 9) in kindergarten, first, second, and third grades.

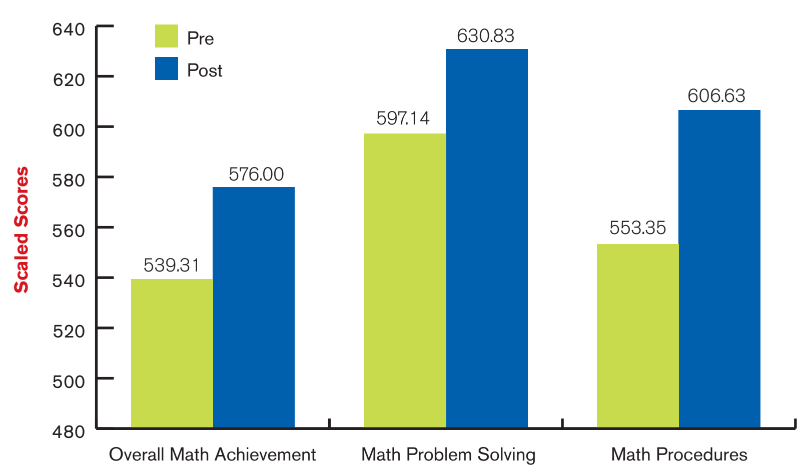
The Saxon approach differs from most programs in that it distributes instruction, practice, and assessment… throughout the lessons and school year.

Results indicated that, overall and for each grade level, Saxon students made significant gains on all three SAT 9 math achievement measures *(overall math achievement, math problem solving, and math procedures)* over the course of the school year (see Figure 4). Students in subgroups that are typically regarded as academically, economically, or culturally disadvantaged who were in Saxon schools made significant gains on all three SAT 9 achievement measures. Specifically, significant gains in achievement were seen over time for English language learners, students who qualified for free or reduced-priced lunch, students who were classified as special education, and minority group members.

Two other large-scale, quasi-experimental studies on the effectiveness of ***Saxon Math*** were conducted during 2 school years (1992–1994) by the Planning, Research, and Evaluation Department of Oklahoma City Public Schools (Nguyen, 1994; Nguyen & Elam, 1993). During the first year of the evaluation, 1992–1993, researchers from the Oklahoma City Public Schools Research, Planning, and Evaluation Department examined student achievement from five Oklahoma City schools that had fully implemented the ***Saxon Math*** program in kindergarten through fifth grade (Nguyen & Elam, 1993). These five schools had been implementing ***Saxon Math*** for 2 years at the time of data collection, minimizing any negative effects due to implementing a newly acquired program.

Saxon students' achievement on the math subtests of the *Iowa Tests of Basic Skills* (ITBS) was compared to achievement from a matched-sample

Figure 4.
Average SAT 9 Math Achievement Growth for Saxon Students, Grades K–3



Note. Math Problem Solving and Math Procedures, Grades 2 and 3 only.
All differences significant at the 95% confidence interval.

of students selected to be the control group, who were in classrooms that used a Scott Foresman math text. Students were matched on grade level, gender, race, socioeconomic status (SES), and the year prior ITBS total math score. In general, students using the ***Saxon Math*** program scored significantly higher than the control group on five out of the nine subtests of the ITBS: Complete Composite, Total Mathematics, Mathematics Concepts, Problem Solving, and Reading Comprehension ($p < .05$ for all significant comparisons).

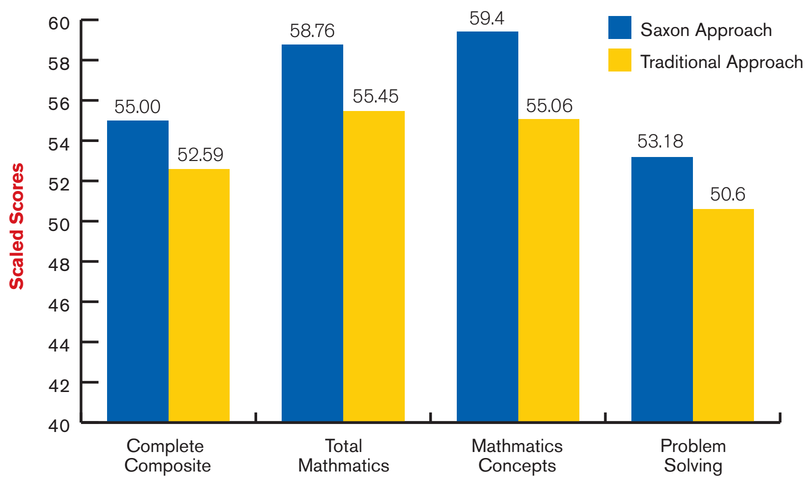
Student achievement was also examined by grade level. Grades 3, 4, and 5 from the five Saxon schools and a matched control sample from non-Saxon schools were chosen for comparison. Saxon students had higher achievement on 23 out of the 27 grade-level comparisons on the ITBS subtests. Eleven of these differences were significant in favor of the Saxon group ($p < .05$). A specific pattern of results within grade levels was not found, but generally the Saxon group outperformed the control group on the majority of the grade-level subtest comparisons.

To further evaluate the effectiveness of ***Saxon Math*** at the elementary level, a second study was conducted by the Oklahoma City Public Schools, Planning, Research, and Evaluation Department to examine student achievement in math in Oklahoma City schools (Nguyen, 1994).This study was conducted with five elementary schools in Oklahoma City that had completely integrated the Saxon program in all grade levels. A matched sample of the students using the Scott Foresman math text was selected to be the control group. These students were matched to students using the Saxon program on grade level, gender, race, SES, and the year prior ITBS total math score.

The ITBS scores from the 1993–1994 school year were collected and used to evaluate growth in mathematic skill over the implementation time for both groups.

On the posttest ITBS, the students using the ***Saxon Math*** product outscored the control group students on all subtests: Complete Composite, Total Math, Problem Solving, Reading Comprehension, Math Computation, Math Concepts, Science, and Social Studies. However, only the differences between groups on the Math Concepts, Science, and Social Studies tests were significant ($p < .05$). These results indicate that, collapsed across grade levels, students who used ***Saxon Math*** at these Oklahoma schools achieved greater gains in their knowledge of math concepts than did students who used the Scott Foresman program (see Figure 5).

Figure 5.
Iowa Test of Basic Skills Math Subtest Comparisons



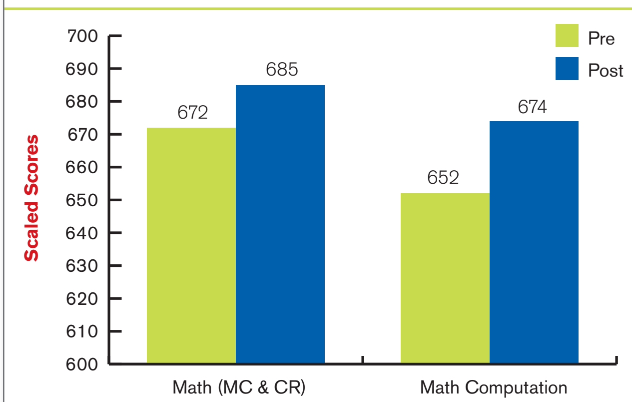
All differences significant at the 95% confidence interval.

Middle School

Harcourt Achieve contracted with PRES Associates in 2006 to conduct analyses of the effectiveness of the ***Saxon Math*** middle school programs in two Ohio school districts, using a randomized control trial design (Resendez & Azin, 2006). Sixth-, seventh-, and eighth-grade teachers in both districts were asked to use both ***Saxon Math*** and their districts' current math program. The use of ***Saxon Math*** was randomly assigned at the classroom level and exclusively taught in those classrooms. Math achievement was measured pre- and postimplementation using *TerraNova Math.* Data analyses found that those students using ***Saxon Math*** experienced significant gains on the *TerraNova* subtests (see Figure 6). Gains in performance were also found within all subgroups examined, including special education status, free and reduced-price lunch status, and minority status.

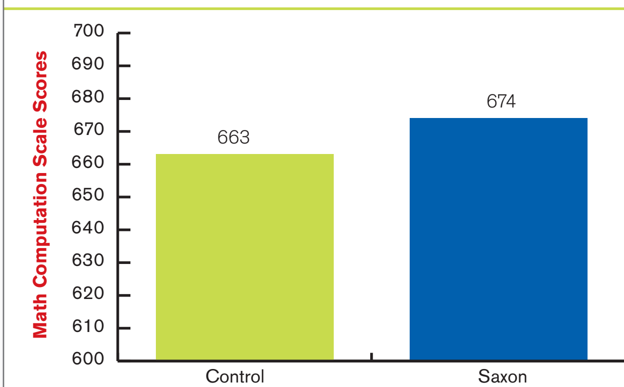
Further analysis of posttest performance found that students using ***Saxon Math*** performed significantly better than students using other math programs on the Math Computation subtest of the *TerraNova*. ***Saxon Math*** students had higher posttest scores than did students using other programs on almost half of the measured objects on the *TerraNova* (see Figure 7). Despite that teachers were using both a new program and a program they were already familiar with, those teachers using the ***Saxon Math*** program reported that they were significantly more likely to feel they had support from the ***Saxon Math*** program compared to their districts' current program. Teachers also felt that ***Saxon Math*** was an effective math program for their students and were satisfied with their students' progress.

Figure 6.
Saxon Math students' *TerraNova* performance at pre- and post testing



MC = mulitple choice, CR = constructed response

Figure 7.
Math Computation postest scores of *Saxon Math* and control students



Note: These are adjusted posttest scores after controlling for initial pretest, minority status, attendance, grade, special education, class size, free/reduced-price lunch, and school.

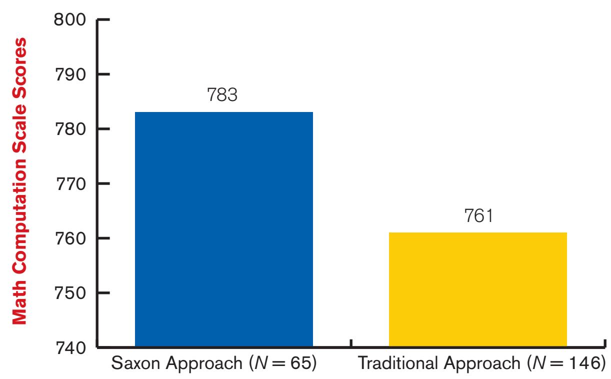
Several other examinations of the effectiveness of ***Saxon Math*** at the sixth-grade level have found superior performance for the Saxon approach than for programs based on the traditional unit-based approach. Specifically, Rentschler (1994) found that after controlling for pretest differences, Saxon students significantly outperformed a matched-sample of students using a traditional unit-based program on the Mathematics Computation subtest of the *California Test of Basic Skills* (see Figure 8). Similarly, Lafferty (1994) reported that sixth-grade students using the Saxon program scored significantly higher scores on the *Metropolitan Achievement Test, Seventh Edition* than did students in traditional-approach classrooms after controlling for pretest differences (see Figure 9). Furthermore, Lafferty found that the Saxon students had significantly less math anxiety at the end of the year than did the students in traditional-approach classrooms.

Eighth Grade

Multiple investigations of the Saxon methodology have also be conducted at the eighth-grade level to examine the effectiveness of the ***Saxon Algebra I*** and ***Algebra ½*** programs. Results of a 9-week study of ***Algebra I*** conducted by Clay (1998) found that ***Saxon Math*** was effective at increasing math achievement scores on teacher-created criterion-referenced math tests and helped students overcome an initial math deficiency to bring about greater gains in math achievement than did a control group using a traditional program.

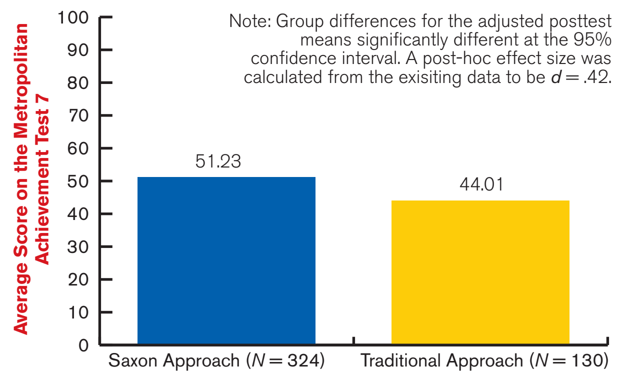
Crawford and Raia (1986) examined the effectiveness of ***Saxon Algebra ½*** with eighth-grade students in five different middle schools. Achievement on the *California Achievement Test* (CAT) for students in Saxon classrooms

Figure 8.
Posttest Comparison of Math Computation Ability



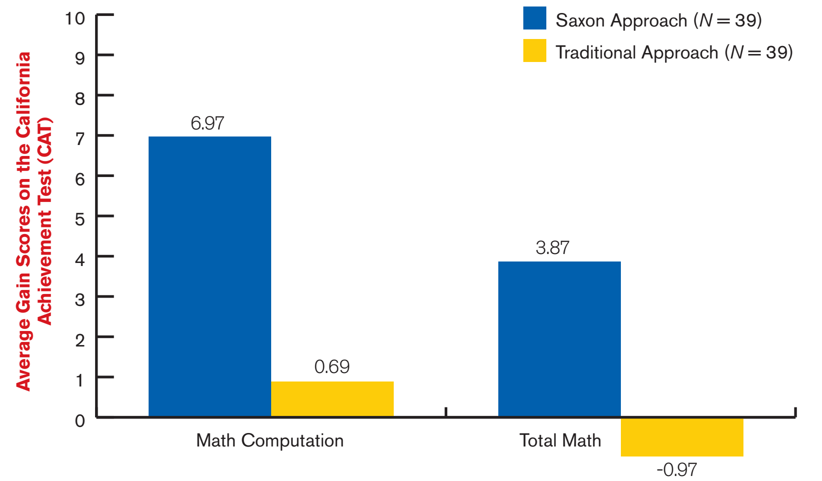
Note: Group differences for the adjusted posttest means significantly different at the 95% confidence interval.
A post-hoc effect size was calculated from the exisiting data to be $d = .73$.

Figure 9.
Mathematics Achievement Posttest Comparison for 6th Grade Students using *Saxon Math* Vs. a Control Group Math Product



…all these results provide a strong body of evidence to support the instructional effectiveness of the ***Saxon Math*** *programs.*

Figure 10.
Gain Scores on the California Achievement Test Math



Note: The average gain for the *Saxon Math* group on Math Computation and Total Math score was significaltly higher that the Control group at the 95% confidence interval. Post-hoc effect sizes were calculated from the exisitng data to be $d = .55$ for Math Computation and $d = .62$ for Total Math.

was compared to those students in classrooms using a more traditional approach to math instruction. After controlling for pretest differences, it was found that the results significantly favored the Saxon program. A second analysis matching students in the treatment and control groups by preimplementation achievement level found that Saxon students made significantly higher gains from pre to post on the CAT Math Computation subtest and the Total Math score than did control group students (see Figure 10). A final analysis examined achievement on only those objectives covered by both programs. The analysis found that the results were significantly different in favor of the Saxon group, indicating that the higher gains in achievement on the CAT for the ***Saxon Math*** students were not due to performance on objectives that were unique to the Saxon program.

Finally, in a recent evaluation of the ***Saxon Math*** program, Baldree (2003) found that eighth-grade students who used the ***Saxon Math*** program had significantly higher scores on the Computation and Concepts and Estimation subtests of the *Georgia Criterion Referenced Competency Test* than did a matched group of students who received pre-algebra instruction based on a constructivist-based model. Taken together, all these results provide a strong body of evidence to support the instructional effectiveness of the ***Saxon Math*** programs from kindergarten to eighth grade.

References

Anderson, J. (1983). *The architecture of cognition.* Cambridge, MA: Harvard University Press.

Ausubel, D. P. (1969). *Readings in school learning.* New York: Holt, Rinehart, and Winston.

Baldree, C. L. P. (2003). *The effectiveness of two mathematical instructional programs on the mathematics growth of eighth grade students.* Unpublished doctoral dissertation, University of Georgia, Athens, Georgia.

Blair, J. (2000). ETS study links effective teaching methods to test-score gains. *Education Week,* 20(8), 24.

Brophy, J., & Everston, C. (1976). *Learning from teaching: A developmental perspective.* Boston: Allyn and Bacon.

Clay, D. W. (1998). *A study to determine the effects of a non-traditional approach to algebra instruction on student achievement.* Unpublished master's thesis, Salem-Teikyo University, Salem, West Virginia.

Cotton, K. (2001). *Monitoring student learning in the classroom. Northwest Regional Educational Laboratory.* Retrieved October 8, 2002, from http://www.nwrel.org/scpd/sirs/2/cu4.html

Crawford, J. R., & Raia, F. (1986). *Executive summary: Analysis of eighth grade math texts and achievement.* Oklahoma City, OK: Oklahoma City Public Schools, Planning, Research, and Evaluation Department.

Dempster, F. (1988). The spacing effect: A case study in the failure to apply results to psychological research. *American Psychologist,* 43, 627–634.

Dempster, F. (1991, April). Synthesis of research on reviews and tests. *Educational Leadership,* 48, 71–76.

English, H. B., Wellburn, E. L., & Killian, C. D. (1934). Studies in substance memorization. *Journal of General Psychology*, 11, 233–260.

Fuchs, L. S. (1995). *Connecting performance assessment to instruction: A comparison of behavioral assessment, mastery learning, curriculum-based measurement, and performance assessment* (ERIC Digest E530). Reston, VA: ERIC Clearinghouse on Disabilities and Gifted Education. (ERIC Document Reproduction Service No. ED381984)

Gagne, R. M. (1962). The acquisition of knowledge*. Psychological Review,* 69, 355–365.

Gagne, R. M. (1965). *The conditions of learning.* Austin, TX: Holt, Rinehart, and Winston.

Gagne, R. M., & Briggs, L. J. (1974). *Principles of instructional design.* Fort Worth, TX: HBJ College Publisher.

Glenberg, A. M. (1979). Component-levels theory of the effects of spacing of repetitions on recall and recognition. *Memory and Cognition,* 7, 95–112.

Good, K., Bickel, R., & Howley, C. (2006). *Saxon elementary math program effectiveness study: Final report.* Charleston, WV: Author.

Good, T. L., & Grouws, D. A. (1979). The Missouri mathematics effectiveness project. *Journal of Educational Psychology,* 71, 355–362.

Hardesty, B. (1986). Notes and asides. *National Review,* 37, 21–22.

Hintzman, D. L. (1974). Increasing your teaching effectiveness. In R. L. Solso (Ed.), *Theories in cognitive psychology: The Loyola symposium.* (pp. 77–99). Potomac, MD: Erlbaum.

Klapp, S. T., Boches, C. A., Trabert, M. L., & Logan, G. D. (1991). Automatizing alphabet arithmetic: II. Are there practice effects after automaticity is achieved? *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 17, 196–209.

Lafferty, J. F. (1994). *The links among mathematics text, students' achievement, and students' mathematics anxiety: A comparison of incremental development and traditional texts.* Unpublished doctoral dissertation, Widener University, Chester, Pennsylvania.

MacDonald, C. J. (1984). *A comparison of three methods of utilizing homework in a precalculus college algebra course.* Unpublished dissertation, Ohio State University, Columbus.

Mayfield, K. H., & Chase, P. N. (2002). The effects of cumulative practice on mathematics problem solving. *Journal of Applied Behavior Analysis,* 35, 105–123.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Nguyen, K. (1994). *The 1993–94 Saxon Mathematics program evaluation report.* Oklahoma City, OK: Oklahoma City Public Schools.

Nguyen, K., & Elam, P. (1993). *The 1992–93 Saxon Mathematics program evaluation report.* Oklahoma City, OK: Oklahoma City Public Schools.

Ornstein, A. C. (1990). Practice and drill: Implications for instruction. *National Association of Secondary School Principals,* 74, 112–117.

Peckham, P. D., & Roe, M. D. (1977). The effects of frequent testing. *Journal of Research and Development in Education,* 10, 40–50.

Pirolli, P. L., & Anderson, J. R. (1985). The role of practice in fact retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 11, 136–153.

Rentschler, R. V. (1994). The effects of Saxon's incremental review on computational skills and problem-solving achievement of sixth-grade students. *Dissertation Abstracts International,* 56 (02), 484A. (UMI No. 9518017)

Resendez, M., & Azin, M. (2006, November). *Saxon Middle School Math Randomized Control Trial.* Austin, TX: Harcourt.

Resendez, M. & Azin, M. (2007, January). *The relationship between using Saxon elementary and middle school math and student performance on California statewide assessments.* Austin, TX: Harcourt.

Resendez, M., Fahmy, A., & Manley, M. A. (2005, April). *The relationship between using Saxon middle school math and student performance on Texas statewide assessments.* Austin, TX: Harcourt.

Resendez, M., & Manley, M. A. (2005, December). *The relationship between using Saxon elementary and middle school math and student performance on Georgia statewide assessments.* Austin, TX: Harcourt.

Resendez, M., Sridharan, S., & Azin, M. (2006, June). *The relationship between using Saxon elementary school math and student performance on Texas statewide assessments.* Austin, TX: Harcourt.

Resendez, M., Sridharan, S., & Azin, M. (in press). *The relationship between using Saxon Math at the elementary and middle school levels and student performance on the South Carolina statewide assessment.* Jackson, WY: PRES Associates.

Reynolds, J. H., & Glasser, R. (1964). Effects of repetition and spaced review upon the retention of a complex learning task. *Journal of Educational Psychology,* 55, 297–308.

Rohm, R. A., Sparzo, F. J., & Bennett, C. M. (1986). College student performance under repeated testing and cumulative conditions: Report on five studies. *Journal of Educational Research,* 80, 99–104.

Rosenshine, B., & Stevens, R. (1986). *Teaching functions. In M.C. Wittrock (Ed.), Handbook of research on teaching: Vol. 3.* (pp. 376–391). New York: Macmillan.

Thorndike, E. L. (1921). The psychology of drill in arithmetic: The amount of practice. T*he Journal of Educational Psychology,* 12, 183–194.

Usnick, V. F. (1991). *It's not drill and practice, it's drill or practice. School Science and Mathematics,* 91, 344–347.

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