What Works Clearinghouse

Detailed Study Report

Reviewed Study:

Baker, J. J. (1997). *Effects of a generative instructional design strategy on learning mathematics and on attitudes towards achievement.* Unpublished doctoral dissertation, University of Minnesota.

WWC Study Reports are intended to support decision making; neither the What Works Clearinghouse (WWC) nor the U.S. Department of Education endorses any interventions. No single Study Report should be used as a basis for making policy decisions because (1) few studies are designed and implemented flawlessly and (2) all studies are tested on a limited number of participants, using a limited number of outcomes, at a limited number of times, so generalizing from one study to any context is very difficult. To highlight these issues, the WWC Study Reports describe in detail the specifics of each study, focusing primarily on studies that provide the best evidence of effects (randomized controlled trials). Systematic reviews of the evidence will be conducted to extend the results of the individual studies.

Brief version of the report (PDF)

Topic:	Curriculum-Based Interventions for Increasing K–12 Math Achievement—Middle School
Intervention:	The Expert Mathematician, Version 3.0
Study Design:	Randomized Controlled Trial
Study Rating:	
Date Released:	June 30, 2004

= Meets Evidence Standards = Meets Evidence Standards with Reservations = Does Not Meet Evidence Standards

The What Works Clearinghouse (www.whatworks.ed.gov) was established in 2002 by the U.S. Department of Education's Institute of Education Sciences to provide educators, policymakers, researchers, and the public with a central and trusted source of scientific evidence of what works in education. Please email all questions and comments to info@whatworks.ed.gov. The What Works Clearinghouse is administered by the U.S. Department of Education through a contract to a joint venture of the American Institutes for Research and the Campbell Collaboration.

WWC Study Ratings[a]
Baker (1997)

Causal Validity: Meets WWC Evidence Standards, a Randomized Controlled Trial with No Randomization, Attrition, or Disruption Problems

Participants were randomly assigned to the intervention and control groups. There was a significant difference between groups on the Objective by Strands pretest, but this was addressed by the study author. There was severe overall attrition, but it did not affect the initial equivalence of the groups analyzed. Other than the pretest, no extraneous events were identified that appeared to be confounded with the intervention's effect.

Other Study Characteristics	Study Rating	Study-Specific Information
Intervention Fidelity	●●	The intervention is well defined and implemented and meets the definition of Middle-School Math. The intervention was a year-long 8th-grade math curriculum that included 196 hours of computer-assisted lessons that were delivered by a regular classroom teacher. The intervention curriculum contained 196 lessons that were presented every other day for 85 minutes.
Outcome Measures	●●	The test appeared to be appropriately aligned, but the reliability calculations are based on 62 survey items, although it was reported that the survey contained 78 items. The outcome measure used in the study measured the content that Middle-School Math is meant to affect. The primary outcome measure was the Objectives by Strands test (Mathematical Concepts and Applications Survey).
People, Settings, and Timing	●	The number of participants and settings was too small and homogeneous to allow generalization to the full range of people and settings that are the target of Middle-School Math interventions. The study sample included 90 8th-graders taught by one math teacher in four classrooms—two intervention classes and two control classes at a middle school in suburban Missouri. The Objectives by Strands test was administered at the end of the study.
Testing within Subgroups	●	The intervention effect was tested across the entire sample but not within important variations in settings.
Analysis	●	The results were analyzed at the level of individual students, which matches the unit of randomization. In this study, natural student groupings (classrooms, schools, etc.) may have affected findings. Although the author's analysis does not address this grouping problem, the author does not report significant positive findings, so the impact of groupings on findings is likely minimal. The sample size was too small to allow for a precise estimate of effect.
Statistical Reporting	●●	The author reported unadjusted means and standard deviations of the outcome measure, Objectives by Strands test, as well as the sample sizes for both the intervention and control groups, so an estimate of its effect could be calculated. A one-way analysis of covariance was performed to compare the Objectives by Strands scores of the intervention and control groups. The mean square and *F* statistic for comparison of the study groups on the Objectives by Strands test were also reported.

Summary of Results. There was no statistically significant difference in student performance between students receiving the Expert Mathematician curriculum and those in the control groups. Baker reported negligible differences between the Expert Mathematician intervention and control groups. The outcome measure is sufficiently reliable, based on the author's report of its reliability, but the sample size was relatively small. In addition, the sampled participants and settings were restricted.

Note. ●● Fully meets criteria; ● Meets minimum criteria; **X** Does not meet criteria.

[a] For more information on the criteria used to rate this study, see the WWC Study Review Standards.

Intervention: The Expert Mathematician, Version 3.0

Operational Features

The Expert Mathematician (version 3.0), the treatment curriculum, was developed by the author, J. J. Baker, from LogoWriter. LogoWriter is a computer program that the developer claims is intended to help children learn independently through exploration. It is designed to provide a creative environment that will help foster a child's higher learning skills.

The lessons are based on Papert's constructionist theory. This theory posits that children learn better if they are able to build on their prior knowledge, which provides meaning as they construct new knowledge in situ. The operational difference between Papert's constructionism and Piaget's constructivism is that, to facilitate learning, Papert takes into account the social aspects of learning and the child's culture.

The curriculum package contains 196 lessons, each intended to take about 40–120 minutes. Baker describes the curriculum as covering the range of concepts and content areas in the National Council of Teachers of Mathematics (NCTM) standards. The content areas covered in the study included arithmetic and geometry.

According to Baker, in a typical Expert Mathematician class period, the teacher introduces the lesson for the day by using printed materials. Students then work individually or in pairs (using the printed materials and the computer) to study a new procedure to solve a math problem.

The author randomly assigned students to intervention and control groups. The intervention groups were taught using the Expert Mathematician curriculum.

People, Settings, and Timing

The participants were 8th-grade students from a suburban middle school in St. Louis, Missouri. Most of the students were from low-income families and qualified for free or reduced-price lunch. All but three students were white. Baker reported that the students varied in their ability and none were in special education.

Cost Information

Cost information was unavailable for the Expert Mathematician curriculum used in this study.

Intended Duration

Baker did not explicitly report on the length of the intervention curriculum but stated that it contained 196 lessons. A class period was 85 minutes in length, and classes were held on alternate days. During one class period, between one and two lessons could be completed.

Scientific Rationale

Baker developed the treatment curriculum, which he based in part on Papert's theory that children understand mathematical concepts better when they can manipulate real objects rather than having to learn abstract concepts. He theorized that students would learn math better within a culturally relevant and individually tailored context, because meaning can be derived only within a context. Papert sees the LogoWriter environment as one that facilitates learning. Thus, the author's choice to use the LogoWriter to develop a computer application for the curriculum was influenced by the fact that it is a software program that facilitates learning in a constructionist context. He compared his curriculum with the traditional, teacher-directed curriculum.

Overview of the Study

Purpose

The main purpose of the study was to determine the relative effectiveness of a constructionist, computer-based curriculum (The Expert Mathematician [which Baker called "generative curriculum"]) compared with a teacher-directed curriculum (Transition Mathematics [which he called "linear curriculum"]). Furthermore, Baker tested for a relationship between students' math attitudes and their math achievement as well as possible gender differences in this relationship.

Intervention Fidelity

Class periods were 85 minutes each, on alternate days. Baker checked in with the teacher frequently over the course of the school year, which was the duration of this study.

In the intervention groups, as students walked into the class, they had to pick up their manila folders, which contained the printed lesson for the day. The teacher checked their homework assignment before discussing the day's lesson. After the introduction, the students were instructed to work in pairs at the computer.

Homework assignments were provided either on paper or on the overhead. The students were allowed to start on their homework whenever they were done with the day's unit, which was usually made up of one or two lessons. Baker reported that the students were not consistent in completing their homework and that the teacher was not consistent in assigning it. To keep the students on task during class, the teacher walked around the class while the students worked at their computers. No training of the teacher was reported.

Outcome Measures

One of the outcome measures was the Objectives by Strands test (sometimes referred to by Baker as the "Mathematical Concepts and Applications Survey"), which was used to measure the students' mathematics achievement before and after the intervention. Baker noted that the test was developed by a large urban school district and contained 78 multiple-choice items.

The other outcome measure was the Fennema-Sherman Mathematics Attitude Survey, which tapped a student's experiences in learning math. Baker used it to develop eight attitude dimensions for this study.

In WWC reports, only math achievement outcome measures are evaluated. Hence, the focus for the rest of this report is on the data from the Objectives by Strands test.

Both the intervention and control students were pretested on these two outcome measures in the early fall. They were retested on these measures during the last week of the school year.

Research Design

The research design for this study was two-group comparison with random assignment. At the start of the study, a computer algorithm was used to divide at random a total of 90 students into two groups—intervention or control. Then the students were again divided randomly, with a flip of the coin, into four classes—two intervention classes and two control classes. Baker did not provide further detail on the methods used to generate or implement the random assignment sequence, such as who was responsible for generating the sequence, what recruitment methods were used, who was responsible for enrolling and assigning participants, or whether participants were blind to group assignment.

Baker reported that, on average, the size of each of the four classes was about 23 students. The same teacher taught all four classes. The unit of assignment (student) matched the unit of analysis.

Participant Flow

At the beginning of the study, Baker reported a total of 90 students, with each of the four classes in the study having an average of 23 students. By the end of the study, during the analysis, only 70 students had both pretest and posttest scores. Of the 70 students, 36 were in the intervention group and 34 were in the control group. (See Figure 1, Participant Flow.)

Reference Periods

Baker did not provide reference periods for when recruitment, baseline data collection, intervention implementation, or outcome measurement occurred.

Baseline Data

Baker did not describe baseline characteristics by intervention and control groups. He provided information on the pretest scores solely for the students who participated in both the pretest and posttest. Pretest scores were not provided for the students who dropped out between the pretest and posttest. (See table 1.)

Figure 1. Participant Flow

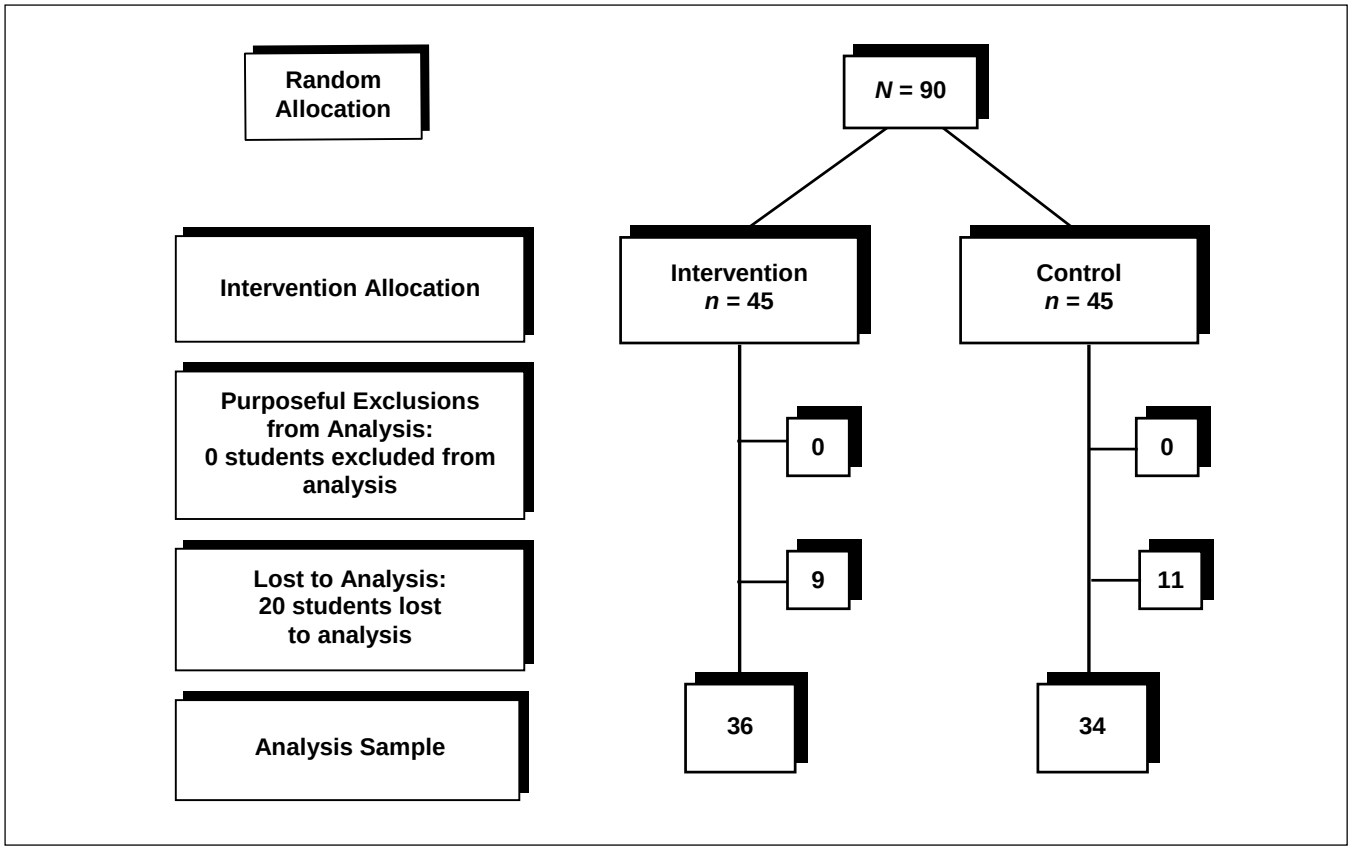


Table 1. Pretest Characteristics of the Study Sample

	Intervention group	Control group	Intervention–control *p* value
Pretest on math achievement: Objectives by Strands			
Mean (*SD*)	28.1 (12.90)	33.4 (11.50)	< .05
Sample size	36	34	

Statistical Methods

First, Baker did a two-way analysis of variance (ANOVA) with condition and gender as the two variables. However, the intervention and control groups differed on the pretest math achievement score, with the intervention group scoring significantly lower than the control group. Hence, a two-way analysis of covariance (ANCOVA) was done with the Objectives by Strands pretest as the covariate. This same test was used as the posttest.

Outcomes and Estimation

Table 2 and Figure 2 present the effects of The Expert Mathematician on mathematical

achievement, as reported by Baker. In one of several analyses, Baker (1997) found that there was no significant difference in gain scores between students in the Expert Mathematician and the control groups when controlling on pretest. However, Baker (1997) did report that the average gain in scores of students in the Expert Mathematician group were similar to the gain scores of students in the control group on the Objectives by Strands test. In this study, natural student groupings (classrooms, schools, etc.) may have affected findings. Although the author's analysis does not address this grouping problem, the author does not report significant positive findings, so the impact of groupings on findings is likely minimal. The WWC has not compared effect sizes for this study report because the possible effects of grouping on findings must first be addressed.

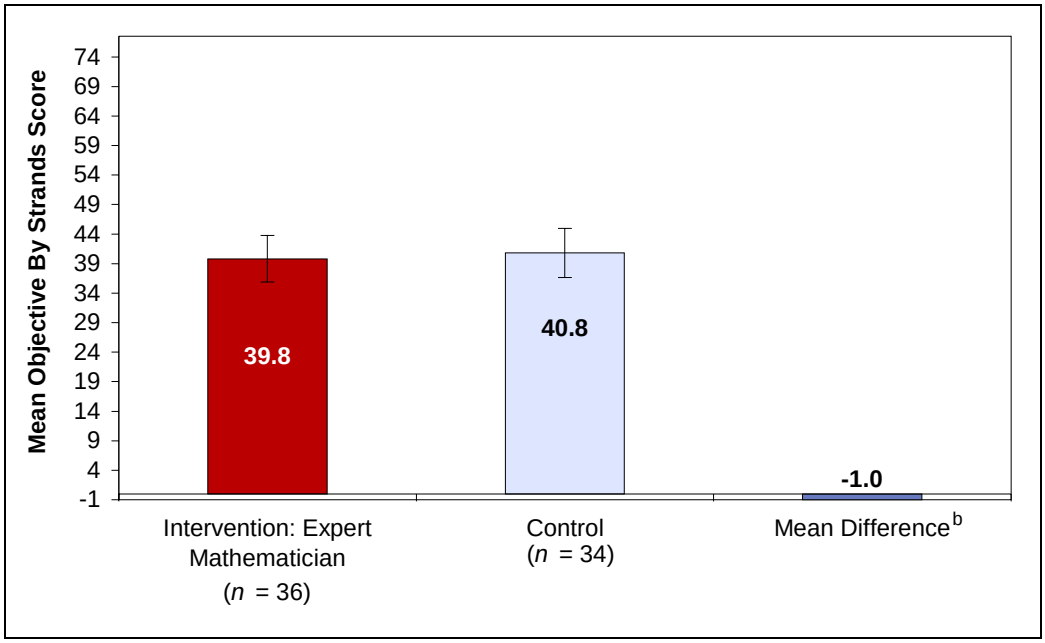
The author also reports the effects of the curriculum on the students' attitudes toward mathematics; however, this report focuses on the achievement results only. Baker does report findings by gender but does not separate them by intervention and control, and therefore they are not presented.

Table 2. Impact Reported by Baker

	Intervention group posttest	Control group posttest	Intervention group estimated effect size (and significance)
Posttest on math achievement: Objectives by Strands			
Mean (*SD*)	39.8 (12.03)	40.8 (12.41)	NR[a]
Sample size	36	34	

[a] The author did not report these effect sizes or the significance of the difference between posttest scores.

Figure 2. Impact Reported by Baker[a]



[a] Confidence intervals were computed by the WWC.

[b] The intervention group scores were not significantly lower than the control group scores ($p \leq .05$).

WWC Evidence Criteria: Middle School Math[a]

Causal Validity

The WWC evidence criteria for determining the level of evidence of a study reviewed under the topic Middle School Math Interventions are:

Meets Evidence Standards

- Randomized controlled trial with no randomization,[b] attrition, or disruption problems
- Regression discontinuity study with no comparability, attrition, or disruption problems

Meets Evidence Standards with Reservations

- Randomized controlled trial with a randomization,[c] attrition, and/or disruption problem
- Regression discontinuity study with a comparability, attrition, or disruption problem
- Quasi-experimental design with equivalent groups and no problems with attrition or disruption

Other Study Characteristics

In addition to determining whether a study Meets Evidence Standards or Meets Evidence Standards with Reservations, the WWC also assesses the strength of a study's evidence based on the following other study characteristics:

Intervention Fidelity. A study fully meets criteria for Intervention Fidelity (●●) if the intervention contains most of the key characteristics that commonly define it, the author provides evidence of good implementation, and the intervention is documented well enough for others to replicate it. A study meets the minimum criteria (●) if the author does not evaluate implementation or finds partial implementation, or the intervention is not documented. A study is excluded from the review (**X**) if it does not meet the initial screening requirements for the intervention by omitting key characteristics of Middle School Math.

Outcome Measures. A study fully meets criteria for Outcome Measures (●●) if the outcome measure has face validity and reliability, and is not too closely aligned[d] to the content of the intervention. A study meets the minimum criteria (●) if the outcome measure is not too closely aligned to the content of the intervention. A study is excluded from the review (**X**) if it does not meet initial screening requirements by not focusing on important Middle School Math outcomes or if it lacks face validity and/or reliability.

People, Settings, and Timing. A study fully meets criteria for People, Settings, and Timing (●●) if it broadly samples from the people (units of interest) and settings that are the target of the intervention and the outcomes are measured at an appropriate time. A study meets the minimum criteria (●) if narrow but relevant samples and settings are included. A study is excluded from the review (**X**) if it does not include at least a relevant narrow sample of people or settings.

Testing within Subgroups. A study fully meets criteria for Testing within Subgroups (●●) if it identifies important subgroups among its sample and settings, and tests the intervention effect within each subgroup separately. A study meets the minimum criteria (●) if it simply tests the intervention effect across the entire sample. A study is not excluded from the review based on this standard.

Analysis. A study fully meets criteria for Analysis (●●) if the analysis is conducted at the same level (for example, students, classes, schools) as the unit of assignment and the unit of intervention delivery or if there is a mismatch between units but sufficient information is provided to permit an approximate estimation of the intervention's effect and in either case, the data characteristics support the analysis. The study meets the minimum criteria (●) if an approximate estimation of effect at the level of assignment cannot be made. A study is not excluded from the review based on this standard.

Statistical Reporting. A study fully meets criteria for Statistical Reporting (●●) if the findings are reported for most outcome measures and effect sizes can be calculated. The study meets the minimum criteria (●) if findings are reported and effect sizes can be calculated for only some outcome measures. A study is excluded from the review (**X**) if it does not report findings for any relevant outcome measures.

Note. For each study characteristic, the WWC considers a number of features to determine if the study fully meets criteria of that characteristic (●●), meets minimum criteria (●), or does not meet minimum criteria (**X**).

[a] These criteria are applied to studies that have passed initial WWC screening for Middle School Math. For more information on screening requirements.

[b] Studies with randomization problems that make statistical adjustments Meet Evidence Standards.

[c] Studies with randomization problems that do not make statistical adjustments Meet Evidence Standards with Reservations.

[d] An overaligned outcome measure uses material that was part of the intervention. The control group was not exposed to this material.

Intervention Developer Contact Information

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Related Studies

To see reports on other studies of the Expert Mathematician.

How Can You Find Out More?

To learn more about this study, read the original study (PDF)

Report Production

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Topic area reviewed under: Curriculum-Based Interventions for Increasing K–12 Math Achievement—Middle School.