

**A STUDY OF THE INSTRUCTIONAL EFFECTIVENESS OF**  
*Larson's Big Ideas Math* ©2012

Report Number 432

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# A STUDY OF THE INSTRUCTIONAL EFFECTIVENESS OF LARSON'S *Big Ideas Math*

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This report describes an instructional efficacy study that was conducted to determine the impact of Larson's *Big Ideas Math* ©2012 on students' knowledge and skills in math.

## Introduction

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"All young Americans must learn to think mathematically, and they must think mathematically to learn" (National Research Council, 2001, p. 1). Today students come from increasingly diverse backgrounds, in regard to culture and language as well as in their background knowledge, abilities, motivations, interests and modes of learning (Tomlinson, 2005). To effectively teach mathematics skills and concepts teachers of mathematics must be knowledgeable of and sensitive to the needs of all learners in the mathematics classroom.

The *Common Core State Standards for Mathematics* resulted from a state-led effort coordinated by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO). Teachers, school administrators, and experts collaborated to articulate research-based, internationally benchmarked standards that describe a sequence of instruction intended to prepare students for college and the workforce. Having fewer and clearer expectations allows teachers to concentrate on the heart of mathematics learning and affords students the opportunity to learn deeply key concepts and skills.

Research has long suggested the need for greater focus in U.S. mathematics instruction; "For over a decade, research studies of mathematics education in high-performing countries have pointed to the conclusion that the mathematics curriculum in the United States must become substantially more focused..." (Common Core State Standards Initiative, 2010, p. 3) Reviews of the mathematics curriculum in top-performing countries find that they "present fewer topics at each grade level but in greater depth" (National Mathematics Advisory Council, 2008, p. 20). Experts in mathematics instruction concur: a narrow focus is essential to greater learning and deeper understanding. Students learning from a more focused curriculum benefit over those who experience a shallower, wider coverage of mathematical concepts and skills. According to the National Council of Teachers of Mathematics in its *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics*, "When instruction focuses on a small number of key areas of emphasis, students gain extended experience with core concepts and skills. Such experience can facilitate deep understanding, mathematical fluency, and an ability to generalize." (National Council of Teachers of Mathematics, 2006b, p. 5).

Larson *Big Ideas Math* was specifically designed to allow teachers to cover these more-in-depth standards. This research-based program is the only comprehensive program grounded in both with the *Common Core State Standards for Mathematics* and the *Standards for Mathematical Practice*. In order to evaluate this new program, researchers from Educational Research Institute of America (ERIA) were commissioned to perform a year-long comparative study of the program at grade 7.

## Research Questions

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The following research questions guided the design of the study and the data analyses:

1. When compared to a control group program is Larson's *Big Ideas Math*©2012 program effective in improving students' knowledge and skills in mathematics?
2. Is Larson's *Big Ideas Math*©2012 effective in improving the math knowledge and skills of those students who score at higher and lower levels on the pretest?

### ***Design of the Study***

The study of Larson's *Big Ideas Math* ©2012 mathematics program was conducted at grade 7. Two teachers, from the same school, were recruited to participate in the study. One teacher was assigned to use the *Big Ideas Math* as the primary program for math instruction over an entire school year in three mathematics classes-these classes comprised the Treatment Group. For this study, the published full year edition of Larson's *Big Ideas Math* program ©2012 was used. The *Big Ideas Math* teacher had not used the program prior to her involvement in the study.

The Control Group in the study consisted of another teacher's three sections of grade 7 mathematics. The control teacher continued using the mathematics program that had been used at the school for the last several years. The control classes had no exposure to the Larson's *Big Ideas Math* ©2012 program during the duration of the study.

Each teacher in the treatment and control groups administered two tests to measure student achievement. A pretest was conducted in early/mid-September 2011 and post-testing was conducted in early June 2012. The control group pretests were administered about 2 weeks later than the *Big Ideas Math* group due to the lateness of materials availability. Teachers administered the assessments with directions and answer documents sent to them. All tests were returned to ERIA for scoring and analyses.

## ***Instructional Approach under Study***

Larson's *Big Ideas Math* program is a well-articulated, focused, middle-grades mathematics program designed to teach mathematics and develop students' understanding of the associated concepts and practices. The five-volume program offers two pathways for students to move through middle school mathematics, and emphasizes a balanced approach to customized instruction, with support from interactive technology.

Following is a description of the program provided by the publisher:

*Big Ideas Math is the only complete middle school math program developed with the Common Core Standards for Mathematical Content and Standards for Mathematical Practice as its foundation. It is the only program to offer both the Regular Pathway and the Compacted Pathway through middle school mathematics. The Regular Pathway prepares students for Algebra 1 or Integrated 1 in 9th grade. The Compacted Pathway is for accelerated learners who will progress on to Geometry or Integrated 2 in 9th grade.*

*Big Ideas Math has been systematically developed using learning and instructional theory to ensure the quality of instruction. Students gain a deeper understanding of math concepts by narrowing their focus to fewer topics at each grade level. Students master content through inductive reasoning opportunities, engaging activities that provide deeper understanding, concise stepped-out examples, rich thought-provoking exercises, and a continual building on what has been previously taught.*

*Big Ideas Math delivers a unique and revolutionary curriculum providing a balanced instructional approach of discovery and direct instruction. This approach opens doors to abstract thought, reasoning, and inquiry as students persevere to answer the Essential Questions that drive instruction. Clearly stepped-out examples complete the lesson and provide students with the precise language and structure necessary to build mathematical understanding and proficiency. The unique teaching edition provides teachers with complete instructional support from a master teacher.*

## Description of the Research Sample

There were two grade 7 teachers included in the study. One teacher used the *Big Ideas Math* program and the other served as a control set of classes and the program used was one which had been used for several years in the school.

Table 1 provides a demographic summary of the school which shows that there were 48% of the students classified as minority and 24% of the students were enrolled in free or reduced price lunch programs. The table does not provide specific data for the classes included in the study. They do, however, provide a general description of the school and, thereby, an estimate of the make-up of the classes that comprised the sample.

**Table 1**  
**Demographic Characteristics of the School Included in the Study**

<i>Location</i>	<i>Grades</i>	<i>Students Enrolled</i>	<i>% Minority</i>	<i>% Free/Reduced Lunch</i>	<i>% Special Needs</i>
Rural	6 to 8	630	48%	24%	N/A

## Description of the Assessments

The outcome measures used for the study were developed by researchers at ERIA. The assessments were developed to assess the students' skills and knowledge in mathematics. The tests included 24 multiple-choice items and 6 open-ended items that required students to write their responses.

Table 2 provides the test statistics for 24 multiple choice test items on the pretests and posttests. The reliability of the posttest shows that the test was reliable for making instructional decisions regarding student growth. The lower reliability of the pretests for both the *Big Ideas Math* group and the control group indicates that students were making some guesses on the pretests. The increase in the reliability of the posttest when compared with the pretest shows the effect of instruction and thus the decrease in guessing answers.

**Table 2**  
**Reliability Estimates, Mean Scores and Reliability**  
**for the Mathematics Assessments**  
**Control and *Big Ideas Math* Groups**

<b>Test</b>	<b>Standard Deviation</b>	<b>Reliability*</b>	<b>SEM**</b>
Control Group Pretest	3.53	.60	2.3
Control Group Post-Test	4.18	.75	2.1
<i>Big Ideas Math</i> Group Pretest	3.19	.62	2.0
<i>Big Ideas Math</i> Group Post-Test	4.24	.77	2.0

\*Reliability computed using the Kuder-Richardson 20 formula.

\*\* SEM stands for Standard Error of Measurement.

## Data Analyses

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The results for each of the two groups were analyzed independently. All raw scores were first converted to standard scores using a linear transformation to a standard score scale with a mean of 300 and a standard deviation of 50. This conversion provided a more normal distribution of test scores.

Four primary analyses were conducted:

1. A Repeated Measures Analysis of Variance (ANOVA) was used to determine if the two groups increased their scores from pretest to post-test, whether there was a significant difference between each group at pretesting and post-testing, and whether either group showed a greater increase from pretesting to post-testing.
2. Independent sample *t*-tests were computed to determine if there were any significant differences between the *Big Ideas Math* group and the control on the pretests or on the post-tests.
3. A Paired Comparison *t*-test was performed for each group to determine the specific increase, if any, from pretesting to post-testing for the *Big Ideas Math* Group and the Control Group.
4. Students in both the *Big Ideas Math* Group and the Control Group were split into two groups based on pretest scores. Paired comparison *t*-tests were conducted to determine if the programs were equally effective with lower performers and higher performers on the pretest.

In addition to the *t*-test, effect-size analyses were computed using Cohen's *d* statistic. This statistic provides an indication of the *strength* of the effect of the treatment regardless of the statistical significance. Cohen's *d* statistic is interpreted as follows:

.2 = small effect

.5 = medium effect

.8 = large effect

In order to provide a more visual interpretation of test score changes from pretesting to posttesting, figures were produced to compare changes for the total group at each grade as well as changes for the lower and higher scoring pretest groups.

## Results

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### **Total Group Comparison**

Researchers at ERIA conducted a Repeated Measures Analysis of Variance to determine three different effects as follows:

- **Time** indicates if the two groups increased their scores from pretest to post-tests.
- **Time x Group** indicates whether one group showed a higher increase than the other group.
- **Group** indicates whether there is a significant difference between the two groups at pretesting and post-testing.

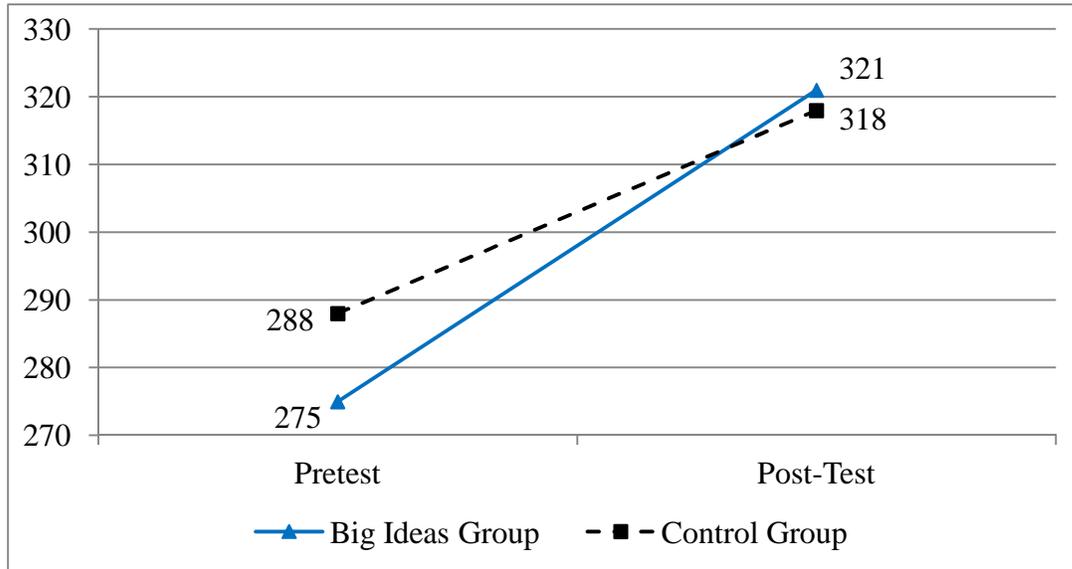
Table 3 shows that there was a significant effect for **Time** which indicates that both groups increased their scores from pretesting to post-testing. The **Time x Group** factor was also significant indicating that either the *Big Ideas Math* group or the control group made greater gains than the other. **Group** was not significant and indicates that the groups were not significantly different at both pretesting and post-testing.

**Table 3**  
**Repeated Measures Analysis of Variance Comparing Pretest and Post-Standard Scores for Control and *Big Ideas Math* Group**

Source	df	Mean Square	F Test	Significance
<i>Time</i>	1	105782.871	131.780	≤.0001
<i>Time x Group</i>	1	4904.016	6.109	≤.02
<i>Group</i>	1	1831.848	.516	≤.474

Figure 1 shows the results from Table 3 in graphic format. It is easy to see the **time factor** as both groups increased their scores significantly from pretesting to post-testing. The non-significance of the **Group factor** is also obvious in that there is a large difference between the two groups at pretesting but there is clearly not a large difference at post-testing. However, Table 3 also shows that the **Time x Group** factor is significant and indicates that the amount of increase from pretesting to post-testing is greater for the *Big Ideas Math* group than it is for the control group.

**Figure 1**  
**Standard Score Increases for the *Big Ideas Math* Group and the Control Group from Pretesting to Post-Testing**



Independent Sample *t*-tests were computed to determine the significance of the differences between the *Big Ideas Math* group and the control group at both pretesting and at post-testing. Table 4 includes the comparison results and shows there was a statistically significant difference ( $\leq .05$ ) at pretesting but there was no significant difference at post-testing. This indicates that the *Big Ideas Math* group started significantly below the control group but by the end of the year the *Big Ideas Math* group was slightly ahead of the control group; although, the difference was not significant. The effect size differences between the groups were small.

**Table 4**  
**Independent Sample *t*-Tests *Big Ideas Math* and Control Groups**

	<i>Mean</i>	<i>Standard Deviation</i>	<i>t-Test</i>	<i>Significance</i>	<i>Effect Size</i>
<b><i>Pretest Comparison</i></b>					
<i>Big Ideas Math Group</i>	275.1	39.7	1.946	$\leq .05$	.31
<i>Control Group</i>	288.2	42.3			
<b><i>Post-Test Comparison</i></b>					
<i>Big Ideas Math Group</i>	321.2	51.3	.372	$\leq 0.71$	.05
<i>Control Group</i>	318.0	52.1			

To analyze and determine if there were any differences in gains made by each group from pretesting to post-testing, the gains for each of the groups were considered individually and examined by computing Paired Comparison *t*-tests. The figures in Table 5 show that both groups increased statistically significantly ( $\leq .0001$ ). However, the effect size for the *Big Ideas Math* group was large while the effect size for the control group was medium.

**Table 5**  
**Paired Comparison *t*-Tests *Big Ideas Math* and Control Groups**

<b><i>Big Ideas Math</i> (N=74)</b>	<b>Mean</b>	<b>Standard Deviation</b>	<b><i>t</i> Test</b>	<b>Significance</b>	<b>Effect Size</b>
Pretest	275.1	39.7	10.229	≤.0001	1.00
Post-Test	321.2	51.3			
<b><i>Control Group</i> (N=73)</b>					
Pretest	288.2	42.3	6.153	≤.0001	.63
Post-Test	318.0	52.1			

***High Pretest and Low Pretest Student Comparison***

An analysis was next conducted to determine if both the *Big Ideas Math* group and the control group increased the scores of the lower and higher pretest scoring groups. Table 6 shows that both the low pretest group and the high pretest group from the *Big Ideas Math* group made statistically significant gains (≤.0001). The effect size was large for both groups.

**Table 6**  
***Big Ideas Math* Group Paired Sample *t*-Tests  
for Low and High Pretest Scoring Groups**

<b>Low Pretest Group (N=37)</b>	<b>Mean</b>	<b>Standard Deviation</b>	<b><i>t</i> Test</b>	<b>Significance</b>	<b>Effect Size</b>
Pretest	245.5	16.2	6.922	≤.0001	1.50
Post-Test	295.5	44.3			
<b>High Pretest (N=37)</b>					
Pretest	304.6	33.9	7.777	≤.0001	1.06
Post-Test	346.9	45.0			

Table 7 shows that both the low pretest group and the high pretest group from the control group made statistically significant gains (≤.0001). The effect size for the low group was large and the effect size for the high group was medium.

**Table 7**  
**Control Group Paired Sample *t*-Tests  
for Low and High Pretest Scoring Groups**

<b>Low Pretest Group (N=37)</b>	<b>Mean</b>	<b>Standard Deviation</b>	<b><i>t</i> Test</b>	<b>Significance</b>	<b>Effect Size</b>
Pretest	255.2	16.5	4.283	≤.0001	.98
Post-Test	286.9	42.6			
<b>High Pretest (N=36)</b>					
Pretest	322.1	32.6	4.422	≤.0001	.76
Post-Test	349.9	40.6			

## Conclusions

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This study sought to determine the effect of Larson's *Big Ideas Math* ©2012 program on students' knowledge and skills in math. For this year-long study, Larson's *Big Ideas Math* ©2012 was used with students at grade 7 and were compared to grade 7 students in the same school.

**Research Question 1:** *When compared to a control group program is Larson's Big Ideas Math©2012 program effective in improving students' knowledge and skills in mathematics?*

Both the Big Ideas math classes and the control classes made statistically significant gains from pretesting to post-testing. The effect size was large for the Big Ideas group and medium for the control group.

The control math group scored significantly higher than the Big Ideas math group at pretesting. At post-testing *Big Ideas Math* group scored a few points higher than the control math group; however was no significant difference between the two groups.

**Research Question 2:** *Is Larson's Big Ideas Math©2012 effective in improving the math knowledge and skills of those students who score at higher and lower levels on the pretest?*

Both the high and low pretest scoring *Big Ideas Math* students made significant gains from pretesting to post-testing and the effect sizes were large for both groups.

Both the high and low pretest scoring control classes made significant gains from pretesting to post-testing. The effect size was large for the low pretest scoring students and medium for the high pretest scoring students.

***The conclusion for research question 1 is that the Larson's Big Ideas Math is effective in improving the math skills and knowledge of middle grade students. Moreover gains were greater for Big Ideas math students than they were for control group students.***

***The conclusion for research question 2 is that the Larson's Big Ideas Math is effective in improving the math skills and knowledge of both higher pretest scoring students as well as lower pretest scoring students.***

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