What Works Clearinghouse™

ies INSTITUTE OF EDUCATION SCIENCES

August 2013

WWC Review of the Report "Improving At-Risk Learners' Understanding of Fractions"[1]

The findings from this review do not reflect the full body of research evidence on *Fraction Challenge*.

What is this study about?

The study examined the effects of *Fraction Challenge*, a supplemental small-group tutoring math program that focuses on improving student understanding of fractions.

Study authors randomly assigned fourth grade "at-risk" students in 53 classrooms in 13 schools to either an intervention group that received *Fraction Challenge* or to a comparison group that did not receive *Fraction Challenge*. At-risk students were identified as students who scored below the 35th percentile on an assessment of whole-number calculations.

Students in the intervention group received tutoring with *Fraction Challenge*, an intervention that emphasizes understanding of fractions using a number line, in groups of three students. The small groups met for 30 minutes at a time, three times a week, for 12 weeks. Students in the comparison group continued with instruction using the *Houghton Mifflin Math* program, an approach that emphasizes part-whole understanding of fractions, which also was used in intervention classrooms during non-*Fraction Challenge* time.

The study examined the effects of *Fraction Challenge* by comparing the performance of 129 students in the intervention group and 130 students in the comparison group on six assessments of knowledge and understanding of fractions that were administered within two weeks of the end of the intervention.

In addition to the analysis that compared at-risk students in the intervention and comparison conditions, the authors also compared the at-risk students who received *Fraction Challenge* to a sample of "low-risk" students (defined as scoring higher than the 35th percentile on the assessment of whole-risk calculations).[2]

Features of *Fraction Challenge*

Fraction Challenge is a supplemental small-group tutoring math program that emphasizes the conceptualization of fractions on a number line from 0 to 1 ("magnitude conceptualization"), rather than as a part of a whole, such as ¾ of a pie ("part-whole conceptualization"). The program includes scripts that provide models for lessons and explanations. Each lesson includes an introduction of concepts, group practice, a speed game intended to improve fluency in fractions (for example, students would spend 1 minute identifying fractions equivalent to "1/2"), and individual work. Over the 12 weeks of the program, students are taught to:

- Identify and name fractions
- Understand unit fractions (fractions where the numerator is "1") and the role of numerators and denominators
- Place fractions on the number line
- Compare and order fractions, and
- Conceptualize fractions as collections of items.

What did the study find?

The study authors reported, and the WWC confirmed, that *Fraction Challenge* had statistically significant positive impacts on fraction knowledge. Students in the intervention group were better able to compare relative magnitudes of fractions, identify where fractions were on a number line from 0 to 1, use magnitude and part-whole representations of fractions, and perform addition and subtraction with fractions.

WWC Rating

The research described in this report meets WWC evidence standards without reservations

Strengths: The study is a well-implemented randomized controlled trial with low attrition.

Cautions: The author's comparison of the performance of at-risk students receiving *Fraction Challenge* to the performance of low-risk students did not meet WWC evidence standards, because the groups were not equivalent at baseline.

Appendix A: Study details

Fuchs, L. S., Schumacher, R. F., Long, J., Namkung, J., Hamlett, C. L., Cirino, P. T., Changas, P., Jordan, N. C., Siegler, R., & Gersten, R. (in press). Improving at-risk learners' understanding of fractions. *Journal of Educational Psychology*.

Setting

The study was conducted in 13 schools in the United States.

Study sample

Fourth-grade students from 53 classrooms in 13 schools were assessed on whole-number calculations using the Wide Range Achievement Test-4 (WRAT-4). Students who scored below the 35th percentile on the WRAT-4 were identified as "at-risk" students and were given an additional assessment: the Wechsler Abbreviated Scales of Intelligence (WASI). Eighteen students were excluded from the study because they scored below the 9th percentile on both subtests of the WASI. Students who scored above the 35th percentile on the WRAT-4 were labeled "low-risk" students.

Between two and eight at-risk and low-risk students were sampled from each classroom, stratifying by risk severity. The at-risk students were randomly assigned to either the intervention or the comparison group, and the randomization was stratified by classroom and an indicator of risk severity (whether each student scored below the 15th percentile or between the 15th and 34th percentiles). The analysis sample of at-risk students included 129 students in the intervention group and 130 students in the comparison group. The low-risk students were not randomized and were used for a contrast that did not meet WWC standards.

Intervention group

Students in the intervention condition received occasional small group tutoring instead of their regular classroom math instruction, which used *Houghton Mifflin Math*. The small groups consisted of three students and one tutor who met for three lessons per week of 30 minutes each for 12 weeks. The tutors used *Fraction Challenge*, which contains scripts and other materials for the lessons. The instruction focused on conceptualizing fractions on a number line from 0 to 1. Each lesson included an introduction of concepts, group practice, a speed game intended to improve fluency in fractions (for example, students would spend 1 minute identifying fractions equivalent to "1/2"), and individual work. Over the 12 weeks of the program, students were taught to identify and name fractions, unit fractions (fractions where the numerator is "1"), and the role of numerators and denominators; place fractions on the number line; compare and order fractions; and conceptualize fractions as collections of items.

Comparison group

Students in the comparison condition received the regular (whole class) classroom instruction using *Houghton Mifflin Math*, which emphasizes the part-whole conceptualization of fractions. Part-whole conceptualization interprets fractions as representing a part of an object. Many of the students in the comparison group also attended a remediation course provided by the schools three times a week. That said, the amount of instructional time was similar for intervention and comparison students, so the effective difference in experiences across conditions is the use of small group tutoring (rather than whole class instruction) and the content in the *Fraction Challenge* program, relative to the use of *Houghton Mifflin Math*.

Outcomes and measurement

The study authors examined scores from six assessments about fractions: (a) Comparing Fractions, a measure from the 2010 Fraction Battery, (b) Fraction Number Line, (c) eighteen questions from the National Assessment of Educational Progress (NAEP) assessment during 1990–2009 that assess part-whole and magnitude, (d) a subscale of the 18 questions selected from the NAEP assessment that address part-whole understanding, (e) a subscale of the 18 questions selected from the NAEP assessment that address magnitude understanding, and (f) Fraction Calculations, a measure from the 2010 Fraction Battery. Pretests were administered in September and October, and posttests were administered the following April, less than 2 weeks after the end of the intervention. For a more detailed description of these outcome measures, see Appendix B.

Support for implementation

Tutors included licensed teachers and non-licensed instructors. Tutors received a 2-day training and met bi-weekly to discuss tutoring topics and challenges. Each tutor worked with two to four small groups.

Reason for review

This study was identified for review by the WWC because it was supported by a grant to the University of Delaware (Principal Investigator: Nancy Jordan) from the National Center for Special Education Research (NCSER) at the Institute of Education Sciences (IES).

Appendix B: Outcome measures for the mathematics achievement domain

Mathematics achievement	
Comparing Fractions	This measure is from the 2010 Fraction Battery and consists of 15 pairs of fractions. Students write an inequality sign to relate the fractions in each pair. Each correctly-answered item is worth one point. Internal consistency for this assessment was 0.84.
Eighteen items selected from NAEP during 1990–09 ("Items from NAEP")	The researchers selected 18 items about fractions from the NAEP during 1990–2009. Eight items assess part-whole understanding, eight items assess magnitude understanding, one item requires subtraction of two fractions with the same denominator, and one asks how many quarters there are in a whole. Internal consistency for this assessment was 0.72.
Magnitude subscale of the Items from NAEP	This measure consists of eight items in the Items from NAEP outcome that assess magnitude understanding of fractions. Magnitude conceptualization interprets fractions as points on a number line from 0 to 1. Internal consistency for this assessment was 0.62.
Part-whole subscale of the Items from NAEP	This measure consists of eight items in the Items from NAEP outcome that assess part-whole understanding of fractions. Part-whole conceptualization interprets fractions as representing a part of an object. Internal consistency for this assessment was 0.60.
Fraction Calculations	This measure is from the 2010 Fraction Battery and consists of 10 fraction addition questions and 10 fraction subtraction questions. Internal consistency for this assessment was 0.90.
Fraction Number Line	This measure gives 10 fractions to a student and asks him or her to identify the corresponding point on a number line from 0 to 1. The score is the sum of the absolute differences between the fraction and the student's placement on the line. Test-retest reliability for this assessment was 0.79.

Appendix C: Study findings for the mathematics achievement domain

Domain and outcome measure	Study sample	Sample size	Mean (standard deviation)		WWC calculations			*p*-value
			Intervention group	Comparison group	Mean difference	Effect size	Improvement index	
Mathematics achievement								
Comparing Fractions	At-risk students	13 schools/ 259 students	12.91 (3.37)	7.07 (2.84)	5.84	1.87	+47	0.00
Fraction Calculations	At-risk students	13 schools/ 259 students	17.57 (3.76)	7.50 (4.30)	10.07	2.49	+49	0.00
Fraction Number Line	At-risk students	13 schools/ 259 students	–0.21 (0.09)	–0.32 (0.12)	0.11	1.03	+35	0.00
Items from NAEP	At-risk students	13 schools/ 259 students	14.36 (3.11)	11.35 (3.43)	3.01	0.92	+32	0.00
Domain average for mathematics achievement						**1.58**	**+44**	**Statistically significant**

Table Notes: Positive results for mean difference, effect size, and improvement index favor the intervention group; negative results favor the comparison group. The signs of the means for the *Fraction Number Line* outcome were made negative so that a positive mean difference would reflect a favorable impact of the intervention. The effect size is a standardized measure of the effect of an intervention on student outcomes, representing the change (measured in standard deviations) in an average student's outcome that can be expected if the student is given the intervention. The improvement index is an alternate presentation of the effect size, reflecting the change in an average student's percentile rank that can be expected if the student is given the intervention. The WWC-computed average effect size is a simple average rounded to two decimal places; the average improvement index is calculated from the average effect size. The statistical significance of the study's domain average was determined by the WWC. NAEP = National Assessment of Educational Progress.

Study Notes: A correction for multiple comparisons was needed but did not affect significance levels. The *p*-values presented here were calculated by the WWC. The WWC calculated the intervention group mean by adding the difference-in-differences adjusted estimate of the average impact of the program (i.e., difference in mean gains between the intervention and comparison groups) to the unadjusted comparison group posttests means. Please see the WWC Handbook v2.1 for more information. The average impacts of the program are calculated from the means reported in the study instead of the estimation model reported in the study because the model included an interaction term of the intervention with the pretest score for each outcome measure, and therefore, the effect of the intervention would differ depending on the score on the pretest.

The study is characterized as having a statistically significant positive effect because univariate statistical tests are reported for each outcome measure, the effect for at least one measure within the domain is positive and statistically significant, and no effects are negative and statistically significant, accounting for multiple comparisons.

Appendix D: Supplemental findings by domain

Domain and outcome measure	Study sample	Sample size	Mean (standard deviation)		WWC calculations			*p*-value
			Intervention group	Comparison group	Mean difference	Effect size	Improvement index	
Mathematics achievement								
Magnitude subscale of the Items from NAEP	At-risk students	13 schools/ 259 students	6.96 (2.21)	4.66 (2.08)	2.30	1.07	+36	0.00
Part-whole subscale of the Items from NAEP	At-risk students	13 schools/ 259 students	5.78 (1.12)	5.36 (1.71)	0.42	0.29	+11	0.02

Table Notes: Positive results for mean difference, effect size, and improvement index favor the intervention group; negative results favor the comparison group. The effect size is a standardized measure of the effect of an intervention on student outcomes, representing the change (measured in standard deviations) in an average student's outcome that can be expected if the student is given the intervention. The improvement index is an alternate presentation of the effect size, reflecting the change in an average student's percentile rank that can be expected if the student is given the intervention.

Study Notes: A correction for clustering was needed but did not affect significance levels. The *p*-values presented here were calculated by the WWC. The WWC calculated the intervention group mean by adding the difference-in-differences adjusted estimate of the average impact of the program (i.e., difference in mean gains between the intervention and comparison groups) to the unadjusted comparison group posttests means. Please see the WWC Handbook v2.1 for more information. The average impacts of the program are calculated from the means reported in the study instead of the estimation model reported in the study because the model included an interaction term of the intervention with the pretest score for each outcome measure, and therefore, the effect of the intervention would differ depending on the score on the pretest. These findings are not included in Appendix C because the two subscales make up the total score for the "Items from NAEP" outcome.

Endnotes

[1] Single study reviews examine evidence published in a study (supplemented, if necessary, by information obtained directly from the author[s]) to assess whether the study design meets WWC evidence standards. The review reports the WWC's assessment of whether the study meets WWC evidence standards and summarizes the study findings following WWC conventions for reporting evidence on effectiveness. This study was reviewed using the Elementary School Math review protocol, version 2.0. The WWC rating applies only to the results that were eligible under this topic area and met WWC standards without reservations or met WWC standards with reservations, and not necessarily to all results presented in the study.

[2] Because the two groups of students in this contrast were not randomly assigned to receive *Fraction Challenge*, the WWC considers this analysis to be based on a quasi-experimental design that must demonstrate baseline equivalence to meet WWC standards with reservations. The intervention and comparison groups in this contrast were not equivalent at baseline, so this portion of the study does not meet WWC standards.

Recommended Citation

U.S. Department of Education, Institute of Education Sciences, What Works Clearinghouse. (2013, August). *WWC review of the report: Improving at-risk learners' understanding of fractions.* Retrieved from http://whatworks.ed.gov

Glossary of Terms

Attrition Attrition occurs when an outcome variable is not available for all participants initially assigned to the intervention and comparison groups. The WWC considers the total attrition rate and the difference in attrition rates across groups within a study.

Clustering adjustment If intervention assignment is made at a cluster level and the analysis is conducted at the student level, the WWC will adjust the statistical significance to account for this mismatch, if necessary.

Confounding factor A confounding factor is a component of a study that is completely aligned with one of the study conditions, making it impossible to separate how much of the observed effect was due to the intervention and how much was due to the factor.

Design The design of a study is the method by which intervention and comparison groups were assigned.

Domain A domain is a group of closely related outcomes.

Effect size The effect size is a measure of the magnitude of an effect. The WWC uses a standardized measure to facilitate comparisons across studies and outcomes.

Eligibility A study is eligible for review if it falls within the scope of the review protocol and uses either an experimental or matched comparison group design.

Equivalence A demonstration that the analysis sample groups are similar on observed characteristics defined in the review area protocol.

Improvement index Along a percentile distribution of students, the improvement index represents the gain or loss of the average student due to the intervention. As the average student starts at the 50th percentile, the measure ranges from –50 to +50.

Multiple comparison adjustment When a study includes multiple outcomes or comparison groups, the WWC will adjust the statistical significance to account for the multiple comparisons, if necessary.

Quasi-experimental design (QED) A quasi-experimental design (QED) is a research design in which subjects are assigned to intervention and comparison groups through a process that is not random.

Randomized controlled trial (RCT) A randomized controlled trial (RCT) is an experiment in which investigators randomly assign eligible participants into intervention and comparison groups.

Single-case design (SCD) A research approach in which an outcome variable is measured repeatedly within and across different conditions that are defined by the presence or absence of an intervention.

Standard deviation The standard deviation of a measure shows how much variation exists across observations in the sample. A low standard deviation indicates that the observations in the sample tend to be very close to the mean; a high standard deviation indicates that the observations in the sample are spread out over a large range of values.

Statistical significance Statistical significance is the probability that the difference between groups is a result of chance rather than a real difference between the groups. The WWC labels a finding statistically significant if the likelihood that the difference is due to chance is less than 5% ($p < 0.05$).

Substantively important A substantively important finding is one that has an effect size of 0.25 or greater, regardless of statistical significance.

Please see the WWC Procedures and Standards Handbook (version 2.1) for additional details.