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WWC Review of the Report "Does Working Memory Moderate the Effects of Fraction Intervention? An Aptitude-Treatment Interaction"[1]

The findings from this review do not reflect the full body of research evidence on *Fraction Face-Off!*[2]

What is this study about?

The study examined the impacts of two versions of *Fraction Face-Off!*—one designed to build fluency (fluency version) in measurement interpretation topics (representing, comparing, and ordering fractions), and the other designed to solidify conceptual understanding (conceptual version) of the same measurement interpretation topics. The study assessed the impact of these versions of the program on the mathematics achievement of fourth-grade students at risk for low mathematics achievement.[3] *Fraction Face-Off!* emphasizes the measurement approach to teaching fractions and the use of a number line to represent, compare, and order fractions.

The study design is an individual-level randomized controlled trial. A total of 277 students at risk for low mathematics achievement from 49 classrooms in 14 schools—approximately half with more severe risk and half with less severe risk—were stratified by classroom and risk severity and randomly assigned to conditions: 94 to the fluency group, 91 to the conceptual group, and 92 to the comparison group.[4] The analytic sample included a total of 243 students; 84 in the fluency group, 79 in the conceptual group, and 80 in the comparison group. The study authors examined each intervention group against the comparison group, and also compared the effect of the fluency version of *Fraction Face-Off!* to the conceptual version of *Fraction Face-Off!* The authors also compared the at-risk students in the *Fractions Face-Off!* conditions to a low-risk group of students to assess whether the intervention was able to reduce the achievement gap between the at-risk and low-risk students.

Students in both intervention groups received three 30-minute lessons per week for 12 weeks in small groups of three students with trained tutors. Both intervention groups received the same content during these small group sessions, focusing on the measurement approach to teaching fractions. The two intervention groups differed in the experiences they received during a 5-minute supplemental activity period. During the supplemental period, students in the fluency group participated in strategic speed activities with flashcards designed to automate problem solving, while students in the conceptual group participated in activities with manipulatives designed to encourage reasoning about the problem. The students in the comparison group received a similar amount of instruction using the regular district curriculum, *enVisionMATH*, which emphasizes the part-whole understanding of fractions.

The study authors assessed impacts using selected released fraction items from the 1990–2009 fourth- and eighth-grade National Assessment of Educational Progress (NAEP) math tests, and two researcher-developed measures—Fraction Number Line and Fraction Battery.

WWC Rating

The research described in this report meets WWC group design standards without reservations

This study is a well-executed randomized controlled trial with low sample attrition for all three sets of comparisons examined through the random assignment design (*Fraction Face-Off!* fluency version versus comparison, *Fraction Face-Off!* conceptual version versus comparison, and *Fraction Face-Off!* fluency version versus *Fraction Face-Off!* conceptual version). The analyses that compared the at-risk students in the *Fraction Face-Off!* conditions to the low-risk group did not meet WWC group design standards because the groups were not equivalent at baseline.

What did the study find?

The study authors found, and the WWC confirmed, that both the fluency and conceptual versions of *Fraction Face-Off!* had a positive and statistically significant impact on all three outcome measures of the mathematics achievement of at-risk fourth-grade students. The study authors found, and the WWC confirmed, that there was no statistically significant difference between the fluency and conceptual groups on any of the three outcomes that measured mathematics achievement.

Features of *Fraction Face-Off!*

Fraction Face-Off! is a math instruction program designed to improve knowledge of fractions and decimals in fourth-graders at risk for low mathematics achievement. The program, delivered individually or in a small group setting, consists of three 30-minute lessons per week for 12 weeks. The curriculum emphasizes a measurement approach to fractions which uses number lines, fraction tiles, and fraction circles to teach fraction concepts and calculations. Each lesson is structured to include teacher instruction, student group work, supplemental activities, and individual student work.

In this study, two versions of *Fractions Face-Off!* were examined. The two versions were delivered by tutors in small groups and differed only in the 5-minute supplemental activities. The fluency groups participated in a sprint activity, which entailed collaborating to answer as many flashcard questions as possible during the allotted time, attempting to beat their score from the previous lesson. The activity was designed to automate problem solving. The conceptual groups demonstrated fractions with fraction circles or tiles, earning points for explaining their reasoning to the group and trying to beat the goal established by the tutor. The activity was designed to encourage reasoning about the problem. The activities for both conditions emphasized the measurement interpretation of fractions. To promote on-task behavior, tutors in both groups gave students rewards for on-task behavior and correct work in the study intervention groups.

Appendix A: Study details

Fuchs, L., Schumacher, R., Sterba, S., Long, J., Namkung, J., Malone, A., Hamlett, C., Jordan, N., Gertsen, R., Siegler, R., & Changas, P. (2013). Does working memory moderate the effects of fraction intervention? An aptitude-treatment interaction. *Journal of Educational Psychology, 106*(2), 1–14.

Setting

The study was conducted in 49 classrooms in 14 schools (the location of the schools was not explicitly specified in the study).

Study sample

To identify fourth-grade students without an intellectual disability who were at risk for low mathematics achievement, the authors screened students using the Wide Range Achievement Test-4–Arithmetic (WRAT) and the two-subtest Wechsler Abbreviated Scales of Intelligence (WASI). Students scoring below the 35th percentile on the WRAT and at or above the 9th percentile on both subtests of the WASI were eligible to participate in the study. From the eligible sample, the researchers stratified students by risk severity and randomly selected 2–8 at-risk students from each classroom, for a final sample of 277 fourth-grade students from 49 classrooms in 14 schools—approximately half with more severe risk (below the 15th percentile on the WRAT) and half with less severe risk (between the 15th and 34th percentiles on the WRAT). The randomly selected students were then stratified by classroom and risk level and randomly assigned to conditions: 94 to the fluency group, 91 to the conceptual group, and 92 to the comparison group. The analytic sample included 243 students, including 84 students in the fluency group, 79 students in the conceptual group, and 80 students in the comparison group. In addition, the study also used a non-equivalent comparison group design to assess if the intervention was able to reduce the achievement gap between the at-risk students assigned to receive *Fraction Face-Off!* and a low-risk group of students.

In the fluency group, the average WRAT score was 85.46 (SD = 6.29), and the average WASI score was 94.25 (SD = 12.20). Sixty-three percent of the fluency students were female, 14% were English learners, 93% were receiving subsidized lunch, 8% were receiving special education services, 58% were African American, 24% were Hispanic, 17% were White, and 1% were categorized as other races. In the conceptual group, the average WRAT score was 85.52 (SD = 6.74), and the average WASI score was 93.70 (SD = 11.98). Sixty-two percent of the conceptual students were female, 14% were English learners, 95% were receiving subsidized lunch, 10% were receiving special education services, 61% were African American, 22% were Hispanic, 14% were White, and 3% were categorized as other races. In the comparison group, the average WRAT score was 84.44 (SD = 7.10), and the average WASI score was 93.30 (SD = 11.57). Fifty-nine percent of the comparison students were female, 5% were English learners, 86% were receiving subsidized lunch, 12% were receiving special education services, 58% were African American, 22% were Hispanic, 16% were White, and 4% were categorized as other races.

Intervention group

Students were pulled out in groups of three to receive the intervention during their math block, math center, or intervention period, depending on their teacher's scheduling preferences. The lessons, delivered by a tutor, covered proper fractions; conversion of improper fractions to mixed numbers; and ordering, comparisons, and calculations with proper, improper, and mixed numbers. Concepts were illustrated with number lines, fraction lines, and fraction circles. Each lesson consisted of four components, including teacher instruction, group work, a supplemental activity, and individual student work. Program content was the same for the fluency and conceptual groups, except for the supplemental activity period, which emphasized speedy problem solving with use of strategies for the fluency group and reasoning activities for the conceptual group. Students in the intervention groups did not practice the advanced skills of estimation and word problems, and the range of fractions covered in their sessions was limited.

Comparison group

Students in the comparison group received the regular district math curriculum, *enVision-MATH*, which emphasizes the part-whole approach to fractions. The curriculum has six elements, including introduction of new concepts, practice on new concepts and skills, interactive discussions focusing on conceptual understanding, visual displays to support conceptual understanding, daily teacher assessment of student progress to understand individual needs, and differentiated instruction. In addition to classroom instruction, most at-risk students received instruction during the intervention period by a teacher in a small group (but groups were always larger than three students). The comparison curriculum included some advanced material, including estimation and word problems, and did not limit the range of fractions covered.

Outcomes and measurement

The study authors administered released fraction items from the 1990–2009 NAEP, the Fraction Number Line, and Fraction Battery 2011–Revised assessments in September and October, before the intervention began in late October, and in early March, 2 weeks before the end of the intervention. For a more detailed description of these outcome measures, see Appendix B.

Support for implementation

Tutors participated in a week-long workshop training followed by bi-weekly 1-hour trainings. The follow-up trainings focused on lesson content, student behavior management, and responding to varying student skill levels. The curriculum provided a manual with scripts for all 36 lessons. Tutors were provided the opportunity to practice lesson delivery with other tutors before each new lesson.

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), with a subcontract to Vanderbilt University from the Institute of Education Sciences (IES).

Appendix B: Outcome measures for the mathematics achievement domain

Mathematics achievement	
Fraction Battery 2011–Revised	This researcher-developed measure included one subtest on fraction addition and one subtest on fraction subtraction. Students received one point for providing the correct answer to questions that did not require students to reduce a fraction and two or three points for correctly reducing fractions one or two times, respectively, as required by the problem. The correlation of the two subtest scores was .81. A total score across the two subtests was computed for each student. The maximum score for the measure was 41, and alpha for the study sample was .93.
Fraction Number Line	Fraction Number Line is a researcher-developed assessment. For this measure, students were presented with 20 proper fractions, improper fractions, and mixed numbers to place on a number line with endpoints of 0 and 2. For each item, a score was calculated as the difference between the student's placement and the correct position of the fraction. Researchers computed the percent of absolute error score by taking the average of the 20 item scores, dividing by two, and then multiplying by 100. The measure achieved test-retest reliability of .80 on a sample of 63 students across 2 weeks.
National Assessment of Educational Progress (NAEP)–selected items	The study administered 19 released fraction items from the 1990–2009 NAEP math items, including easy, medium, or hard items from the fourth-grade assessment and easy items from eighth-grade assessment. Problems were read aloud to students. The assessment included eight items on part-whole interpretation and nine items on measurement interpretation of fractions. The maximum score for the measure was 25, and alpha for the study sample was .81.

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								
Fraction Number Line	Fluency vs. comparison	14 schools/ 164 students	–0.20 (0.08)	–0.27 (0.06)	0.07	0.98	+34	< .01
NAEP-selected items	Fluency vs. comparison	14 schools/ 164 students	14.45 (3.91)	12.07 (3.56)	2.38	0.63	+24	< .01
Fraction Battery–Revised	Fluency vs. comparison	14 schools/ 164 students	17.53 (7.83)	8.16 (4.71)	9.37	1.44	+42	< .01
Domain average for fluency vs. comparison						**1.02**	**+35**	**Statistically significant**
Fraction Number Line	Conceptual vs. comparison	14 schools/ 159 students	–0.19 (0.07)	–0.27 (0.06)	0.08	1.22	+39	< .01
NAEP-selected items	Conceptual vs. comparison	14 schools/ 159 students	14.40 (3.64)	12.07 (3.56)	2.33	0.64	+24	< .01
Fraction Battery–Revised	Conceptual vs. comparison	14 schools/ 159 students	17.36 (7.90)	8.16 (4.71)	9.20	1.41	+42	< .01
Domain average for conceptual vs. comparison						**1.09**	**+36**	**Statistically significant**
Fraction Number Line	Fluency vs. conceptual	14 schools/ 163 students	–0.21 (0.08)	–0.21 (0.08)	–0.01	–0.13	–5	> .05
NAEP-selected items	Fluency vs. conceptual	14 schools/ 163 students	14.69 (3.91)	14.64 (3.64)	0.05	0.01	+1	> .05
Fraction Battery–Revised	Fluency vs. conceptual	14 schools/ 163 students	18.01 (7.83)	17.84 (7.90)	0.17	0.02	+1	> .05
Domain average for fluency vs. conceptual						**–0.03**	**–1**	**Statistically significant**

Table Notes: For mean difference, effect size, and improvement index values reported in the table, a positive number favors the intervention group and a negative number favors 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 individual outcomes, representing the average change expected for all individuals who are given the intervention (measured in standard deviations of the outcome measure). The improvement index is an alternate presentation of the effect size, reflecting the change in an average individual's percentile rank that can be expected if the individual 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. Some statistics may not sum as expected due to rounding. NAEP = National Assessment of Educational Progress.

Study Notes: A correction for multiple comparisons was needed but did not affect whether any of the contrasts were found to be statistically significant. The *p*-values presented here were reported in the original study. The WWC calculated the program group mean using a difference-in-differences approach by adding the impact of the program (i.e., difference in mean gains between the intervention and comparison groups) to the unadjusted comparison group posttest means. Please see the WWC Procedures and Standards Handbook (version 3.0) for more information. The authors reported similar effect sizes for each of the three comparisons using a cross-classified partially nested model for each of the outcomes that accounted for nesting at the classroom level for all three conditions and at small group level for just the intervention conditions, while controlling for pretest scores. Effect size was calculated as an across-group mean difference divided by the SD within the comparison group only. For the fluency vs. comparison group, author-reported effect sizes were 0.99 for the Fraction Number Line, 0.60 for the NAEP, and 1.12 for the Fraction Battery. For the conceptual vs. comparison group, author-reported effect sizes were 0.80 for the Fraction Number Line, 0.63 for the NAEP, and 1.13 for the Fraction Battery. For the fluency vs. conceptual group, author-reported effect sizes were 0.24 for the Fraction Number Line, –0.03 for the NAEP, and –0.02 for the Fraction Battery. Both the fluency and conceptual versions of *Fraction Face-Off!* are characterized as having a statistically significant positive effect because 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. The comparison of the fluency version of *Fraction Face-Off!* against the conceptual version of *Fraction Face Off!* is characterized as having an indeterminate effect because the mean effect reported is neither statistically significant nor substantively important. For more information, please refer to the WWC Standards and Procedures Handbook (version 3.0), pp. 25–26.

Endnotes

[1] Single study reviews examine evidence published in a study (supplemented, if necessary, by information obtained directly from the authors) to assess whether the study design meets WWC group design standards without reservations. The review reports the WWC's assessment of whether the study meets WWC group design standards and summarizes the study findings following WWC conventions for reporting evidence on effectiveness. This study was reviewed using the Primary Mathematics protocol, version 3.0.

[2] A related intervention, *Fraction Challenge*, was the subject of a study examined in a previous single study review. See 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*, available at http://whatworks.ed.gov. According to the authors, the two interventions differ primarily in that "*Fraction Face-Off!* addresses a more ambitious set of skills, aligned with the Common Core State Standards" (p. 6).

[3] This study examined two research questions: (a) whether differences in working memory moderate the effects of the two versions of the intervention on student math achievement, and (b) whether the two versions of the intervention had effects on student math achievement. This review focuses only on the second research question because there are no WWC standards for examining the effect of a continuous moderator of an intervention.

[4] From the full population of students eligible to participate in the study, 2–8 students per classroom were randomly selected to be included in the study sample. For more detail on sample eligibility, see the description of the study sample in Appendix A.

Recommended Citation

U.S. Department of Education, Institute of Education Sciences, What Works Clearinghouse. (2014, December). *WWC review of the report: Does working memory moderate the effects of fraction intervention? An aptitude-treatment interaction.* 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 individual 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 individuals, the improvement index represents the gain or loss of the average individual due to the intervention. As the average individual 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 study participants 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 eligible study participants are randomly assigned to 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% ($p < .05$).

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 3.0) for additional details.