REVIEW PROTOCOL FOR
SECONDARY MATHEMATICS
VERSION 3.1 (JUNE 24, 2015)

This review-specific protocol guides the review of research that informs the What Works Clearinghouse (WWC) intervention reports in the Secondary Mathematics topic area. The review-specific protocol is used in conjunction with the *WWC Procedures and Standards Handbook (version 3.0)*.

PURPOSE STATEMENT

This review focuses on mathematics interventions that are typically used in grades 9–12 and are designed to affect students' mathematics achievement. Whether an intervention falls under the scope of this review depends on both the grade level and content of the intervention. For example, the review can include students in lower grades (such as grades 7 and 8) if they use a secondary mathematics intervention such as algebra or geometry.

The following research questions guide this review:

- Which interventions are effective at increasing the learning of secondary mathematics content (e.g., algebra, geometry, trigonometry, and calculus) and skills?

- Are some secondary mathematics interventions more effective for certain types of students, particularly students who are at risk of failure in mathematics?

KEY DEFINITIONS

Mathematics content area. In this review, a mathematics content area is defined as the mathematics topics that are the foundation of a mathematics course, such as number sense, measurement/data, algebra, geometry, trigonometry, or calculus.

Mathematics intervention. In this review, a mathematics intervention is defined as a replicable instructional program that delivers secondary mathematics content, clearly delineates mathematics learning goals for students, and is designed to affect student mathematics achievement.

Primary students. Primary students are defined as students in classes where mathematics is presented through multi-topic materials and curricula. In most cases, these courses are taught to students in kindergarten through grade 8, although students in higher grades (such as grades 9 and 10) are considered primary students if they were in multi-topic mathematics courses that do not cover secondary mathematics content, such as pre-algebra.

Secondary students. Secondary students are defined as students in courses that are organized by mathematics content area (e.g., algebra, geometry, trigonometry, calculus). In most cases, these

courses are taught in grades 9–12, although students in lower grades (such as grades 7 or 8) are considered secondary if they were in a course organized by a secondary mathematics content area. Secondary students also include students in integrated high school mathematics courses that include algebra and other secondary content areas.

PROCEDURES FOR CONDUCTING THE LITERATURE SEARCH

The *WWC Procedures and Standards Handbook* discusses the procedures for conducting a literature search in Section II: Developing the Review Protocol and Identifying Relevant Literature (p. 4) and in Appendix B: Policies for Searching and Prioritizing Studies for Review.

Search Terms

The following table presents the search terms by category.

Category	Search Terms	
Study Design	• ABAB design*	• Posttest
	• Alternating treatment*	• Post-test
	• Assignment	• Pretest
	• Baseline	• Pre-test
	• Causal	• QED
	• Comparative math studies	• Quasi-experimental design*
	• Comparison group*	• Random*
	• Control group*	• Randomized control* trial*
	• Data analysis	• RCT
	• Effectiveness	• Regression discontinuity design*
	• Evaluation	• Simultaneous treatment*
	• Experiment*	• Single-case design*
	• Impact	• Single subject design*
	• Matched group*	• Treatment
	• Meta-analysis	
Intervention (Broadly)	• Analysis	• Probability
	• Approach*	• Problem solving
	• Calculus	• Program*
	• Curricul*	• Proof
	• Curriculum	• Reasoning
	• Inquiry-based math	• Remedial math
	• Instruct*	• Representation
	• Instruction	• Spatial ability
	• Intervention*	• Statistic*
	• Mathematics	• Strateg*
	• Mathematics instruction	• Supplement*
	• Measurement	• Teach*
	• Number*	• Teacher-centered

	• Operation*	• Teacher-directed
	• Pattern*	• Technique*
	• Pre-algebra	• Traditional
	• Precalculus	• Trigonometry
Population	• Grade 7	• Ninth grade
	• Grade 8	• Tenth grade
	• Grade 9	• Eleventh grade
	• Grade 10	• Twelfth grade
	• Grade 11	• High school
	• Grade 12	• Middle school
	• Seventh grade	• Elementary school
	• Eighth grade	• Secondary school
Outcomes	• Academic	• Learning
	• Achievement	• Math*
	• Algebra	• Mathematic* ability
	• Arithmetic	• Mathematical aptitude
	• Assessment	• Mathematical concepts
	• Attainment	• Mathematical skills
	• Cognit*	• Mathematics achievement
	• Comprehen*	• Measure*
	• Concept*	• Number*
	• Counting	• Numer*
	• Curriculum-based assessment	• Outcomes
	• Fluency	• Outcomes of education
	• Fractions	• Pattern
	• Geometry	• Problem solving
	• Knowledge	• Reasoning

Additional Sources

In addition to those listed in the *WWC Procedures and Standards Handbook, Appendix B*, this review searched the following electronic databases:

- ***Campbell Collaboration.*** C2-SPECTR (Social, Psychological, Educational, and Criminological Trials Register) is a registry of over 10,000 randomized and possibly randomized trials in education, social work and welfare, and criminal justice.

In addition to those listed in the *WWC Procedures and Standards Handbook, Appendix B*, this review searched the following websites:

- American Association of Colleges of Teacher Education (AACTE)
- American Association of School Administrators (AASA)
- American Federation of Teachers

- American Mathematical Society (AMS)
- American Statistical Association (ASA)
- Association for Supervision and Curriculum Development (ASCD)
- Broad Foundation (Education)
- Center for Research in Educational Policy (CREP)
- Center for the Study of Instructional Improvement
- Center on Education Policy
- Center on Instruction
- Consortium for Policy Research in Education (CPRE)
- Council of Chief State School Officers
- Council of the Great City Schools (CGCS)
- Editorial Projects in Education (EPE) Research Center
- Erikson Institute, University of Chicago
- Geometry, Reasoning, and Instructional Practices
- Harvard Graduate School of Education
- Johns Hopkins University School of Education
- Mathematical Association of America (MAA)
- Mathematics Teaching and Learning to Teach Project
- Mid-continent Research for Education and Learning
- Millennium Mathematics Project
- National Association for the Education of Young Children
- National Association of Elementary School Principals (NAESP)
- National Association of Secondary School Principals (NASSP)
- National Board for Professional Teaching Standards
- National Center for Children in Poverty
- National Center for Education Research
- National Center for Research on Early Childhood Education (NCRECE)
- National Center for Special Education Research
- National Conference of State Legislatures (NCSL)
- National Council of Supervisors of Mathematics (NCSM)
- National Council of Teachers of Mathematics (NCTM)
- National Head Start Association
- National Math Panel
- National Science Foundation (NSF)
- New America Foundation's Early Education Initiative
- Office of Early Learning (http://www.ed.gov/early-learning)
- Pacific Resources for Education and Learning (PREL)
- Promising Practices Network
- Public Education Network
- Public Policy Research Institute at Texas A&M University
- Society for Research in Child Development
- Southwest Educational Development Laboratory (SEDL)
- Technical Assistance Center on Social Emotional Intervention for Young Children

- TERC
- The National Academies Press
- U.S. Department of Education
- U.S. Department of Health & Human Services
- UCLA Graduate School of Education Research Centers
- University of Chicago School Mathematics Project
- WestEd

ELIGIBILITY CRITERIA

Eligible Populations

In this review, the following populations are of interest:

- *Grade range.* The Secondary Mathematics topic area will review studies of interventions designed to increase the learning of secondary mathematics content (e.g., algebra, geometry, trigonometry, and calculus) and skills. In most cases, these interventions are used in grades 9–12, although students in lower grades (such as grades 7 and 8) fall within this review if they were in mathematics courses organized by secondary mathematics content areas. Secondary students also include students in integrated high school mathematics courses from grades 9–12. Studies of remedial mathematics interventions for high school students should be brought to the attention of the lead methodologist for determination of eligibility.

- *Overlap between the Primary and Secondary Mathematics topic areas.* Studies of multi-topic mathematics interventions (that do not cover secondary mathematics content) administered to students in kindergarten through grade 8 fall within the scope of the Primary Mathematics topic area review. In addition, studies that include students who receive pre-algebra interventions fall within the scope of the Primary Mathematics topic area reviews. Studies that examine the average effect of two or more mathematics interventions that span the Primary and Secondary Mathematics topic areas (such as studies where a portion of the students in the intervention group used pre-algebra and the remaining portion used algebra) will not be reviewed unless disaggregated results can be obtained by intervention course (or mathematics content area). However, longitudinal studies that examine the cumulative effect of two or more mathematics interventions that span the Primary and Secondary Mathematics topic areas will be reviewed based on the intervention course (or mathematics content area) in which the posttest was administered. For example, studies where students use pre-algebra in one grade and algebra in another, and that only posttested students after algebra, will be reviewed under Secondary Mathematics.

- *Overlap with other WWC topic areas.* If students with learning disabilities comprise more than 50% of the sample, the study will fall within the scope of the Students with

Learning Disabilities topic area. Studies with English learners (ELs) will be discussed with the lead methodologist for determination of eligibility.

Potential subgroups of interest for this review include:

- Characteristics of students:
  - Baseline mathematics achievement
  - Grade
  - Gender
  - Socioeconomic status (SES)
  - Race/ethnicity
  - EL status
  - "At-risk" status (as defined by study authors)

- Characteristics of school/classroom settings:
  - Location of the schools involved (e.g., urban, suburban, rural)
  - Homogeneous groupings of students (e.g., tracking)
  - School type (public, private, religious)
  - School socioeconomic status (e.g., Title I school)
  - Average class size (small, medium, large)
  - School size
  - Average teacher characteristics (e.g., teacher education and experience)

Eligible Interventions

Only interventions that are replicable are eligible for review. The following characteristics of an intervention must be known to reliably reproduce the intervention with different participants, in other settings, and at other times:

- Intervention description: skills being targeted, approach to enhancing the skill(s) (e.g., strategies, activities, and materials), unit of delivery of the intervention (e.g., whole group, individual), medium/media of delivery (e.g., teacher-led instruction or software), and targeted population

- Intervention duration and intensity

- Description of individuals delivering or administering the intervention

In this review, the following types of interventions may be included:

- ***Curricula or products.*** A curriculum or product may be textbooks, software programs, or other educational technology that is (1) intended as the primary instructional tool designed to support mathematics instruction or (2) designed to supplement the classroom material with differentiated instruction, remediation, or enrichment. Both

types of curricula and products are included in this review. Examples of secondary mathematics curricula include *Cognitive Tutor* and the *University of Chicago School Mathematics Project*. An example of a supplemental product is *I CAN Learn*.

- ***Practices or strategies.*** The review includes both general and targeted practices. A general practice could be used with a wide range of students and to address a wide range of learning goals. A targeted practice is intended to support instruction for a particular type of student or a particular learning goal for a narrowly defined knowledge or skill. Both general and targeted practices must be clearly described and commonly understood in the field and in the literature. An example of a secondary mathematics practice is *collaborative learning*.

Both "branded" and "non-branded" interventions will be reviewed. Branded interventions are commercial or published programs and products that may possess any of the following characteristics:

- An external developer who provides technical assistance (e.g., instructions/guidance on the implementation of the intervention) or sells or distributes the intervention

- Trademark or copyright

Eligible Research

The *WWC Procedures and Standards Handbook* discusses the types of research reviewed by the WWC in Section II: Developing the Review Protocol and Identifying Relevant Literature (p. 4). Additionally, in this review, the following additional parameters define the scope of research studies to be included:

- ***Topic.*** The study must focus on the effects of a mathematics intervention on one or more measures of mathematics achievement.

- ***Time frame.*** Studies generally must have been released or made public in 1983 or later and be obtained by the WWC for review prior to the drafting of the intervention report.

- ***Sample.*** The study sample must meet the requirements described in the "Eligible Populations" section above. Outcomes can be measured later (e.g., when the sample is older).

- ***Language.*** The study must be available in English to be included in the review. Studies examining mathematics competencies in other languages will be included in the review.

- ***Location.*** The study must include students in the United States, its territories or tribal entities, or in a country that is sufficiently similar to the United States that the study could be replicated in the United States.

Eligible Outcomes

Outcomes must measure students' mathematics achievement. These measures include standardized, nationally-normed achievement tests that are appropriate for students using secondary mathematics interventions; standardized state or local tests of mathematics achievement; and research-based or locally-developed tests or instruments that assess students' mathematics concepts or skills.

The study needs to include at least one type of mathematics achievement measure that involves direct student assessment in at least one of the mathematics content areas (such as arithmetic, algebra, geometry, measurement, graphing, and logical reasoning). Mathematics skills involve the application of this content, as well as an understanding of mathematics concepts, procedures, and problem solving.

Other measures of mathematics achievement, such as student grades assigned by teachers, are not eligible for review.

This review includes outcomes in the following domains:

Algebra. Outcomes that are focused on student ability to solve, graph, or write equations, systems of equations, and inequalities. Also includes tests focused on functions, exponents, polynomials, factoring, and quadratic equations. Examples of outcomes in this area would be end-of-course algebra tests (for Algebra I or Algebra II) or author- or researcher-created algebra assessments.

Geometry. Outcomes that are focused on questions of shape, size, relative position of figures, and the properties of space (such as length, area, and volume). Examples of outcomes in this area would be end-of-course geometry tests or author- or researcher-created geometry assessments.

Statistics and probability. Outcomes that are focused on the collection, analysis, interpretation, and presentation of data, or on measuring the likelihood of an event occurring. Examples of outcomes in this area would be end-of-course statistics or probability tests or author- or researcher-created statistics and probability assessments.

Trigonometry/Precalculus. Outcomes that are focused on trigonometry topics such as relationships involving lengths and angles of triangles, and/or precalculus topics such as functions, complex numbers, vectors, and matrices. Examples of outcomes in this area would be end-of-course trigonometry and/or precalculus tests or author- or researcher-created trigonometry/precalculus assessments.

Calculus. Outcomes that are focused on differential calculus (concerning rates of change and slopes of curves) or integral calculus (concerning accumulation of quantities and the areas under and between curves). Examples of outcomes in this area would be end-of-course calculus tests or author- or researcher-created calculus assessments.

General mathematics achievement. Outcomes that combine two or more of the outcome domains (algebra, geometry, statistics/probability, or calculus) or provide some other type of summary

score that is not specific to the other outcome domains, such as a "total math score" on a standardized or author-created mathematics test.evidence standards

Eligible studies are assessed against WWC evidence standards, as described in the *WWC Procedures and Standards Handbook,* Section III: Screening and Reviewing Studies (pp. 7–21).

Sample Attrition

The *WWC Procedures and Standards Handbook* discusses the sample attrition standards used by the WWC in Section III: Subsection B.2 Sample Attrition: Is the combination of overall and differential attrition high? (pp. 11–15).

This review uses the ***conservative*** boundary for attrition. This boundary was selected based on the assumption that most attrition in studies of Secondary Mathematics was due to factors that were strongly related to intervention status. For example, in secondary classes, students often have the ability to pick their mathematics courses, and thus, could drop, add, or delay taking a mathematics course for any number of reasons, including the presence (or lack) of a particular mathematics intervention. The *WWC Procedures and Standards Handbook* contains a figure illustrating the attrition boundary and an associated table with attrition levels that define high and low attrition. Based on the choice of the boundary, the study review guide calculates attrition and whether it is high or low.

Baseline Equivalence

If the study design is a randomized controlled trial or regression discontinuity design with high levels of attrition or a quasi-experimental design, the study must demonstrate baseline equivalence of the intervention and comparison groups for the analytic sample. The onus for demonstrating equivalence in these studies rests with the authors. The *WWC Procedures and Standards Handbook* discusses how authors must demonstrate baseline equivalence in Section III: Subsection B.3 Baseline Equivalence: Is equivalence established at baseline for the groups in the analytic sample? (pp. 15–16).

Baseline equivalence must be demonstrated for the intervention and comparison groups in the analytic sample on the following pre-intervention (or baseline) characteristic:

- A pretest of an acceptable outcome measure

This review requires that, in a domain that requires statistical adjustments, the adjustment is made only for that outcome. For example, if A, B, and C are available as pre- and post-intervention measures, and the pre-intervention difference in B requires statistical adjustment, only the analysis of outcome B must adjust for B.

For other sample or setting characteristics that are believed to be associated with the outcome, though perhaps less correlated than the pretest (e.g., grade), a large baseline difference could be evidence that the intervention and comparison groups are not sufficiently comparable for the purposes of the review. When differences in these characteristics are systematic due to the study

design or larger than 0.50 standard deviations, the review team leadership has discretion to determine the groups to be too dissimilar for the analysis to provide an unbiased estimate of the effect of the intervention, provided the differences are documented clearly and the same standard is applied consistently for all studies within the review in question. For this review effort, reviewers should document differences in:

- Grade
- Gender
- Socioeconomic status (SES)
- Racial/ethnic breakdown
- Percentage of ELs
- Percentage of "at-risk" status (as defined by study authors)
- Location of the schools involved
- Homogeneous groupings of students (e.g., tracking)
- School type (public, private, religious)
- School SES (e.g., Title I school)
- Average class size (small, medium, large)
- Average teacher characteristics (e.g., teacher education and experience)
- School size

Outcomes

The *WWC Procedures and Standards Handbook* discusses the types of outcomes, criteria the outcomes must meet, and how outcomes are reported by the WWC in Section III: Subsection B.4 Outcome Eligibility and Reporting (pp. 16–19). In this review, the general guidance regarding reliability, outcomes measured at different points in time, impacts measured at different points in time, composite and subscale scores, subgroup findings, categorical ordinal measures, and estimated effects using imputed data are followed.

Statistical Adjustments

The *WWC Procedures and Standards Handbook* discusses the types of adjustments made by the WWC in Section IV: Subsection B Statistical Significance of Findings (p. 24).

Other Study Designs

Studies that use regression discontinuity or single-case designs are eligible for review using the appropriate pilot standards.

The *WWC Procedures and Standards Handbook* discusses the pilot standards for reviewing regression discontinuity design studies in Appendix D.

The *WWC Procedures and Standards Handbook* discusses the pilot standards for reviewing single-case design studies in Appendix E.