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RESEARCH SUMMARY

Effectiveness of Graphing Calculators in K–12 Mathematics Achievement: A Systematic Review

In this report we systematically review research that examines the effect of calculator use, including the graphing calculator, on K–12 students' mathematics achievement. Our goal was to determine whether there is scientific evidence of effectiveness of graphing calculator use on students' mathematics learning. A thorough review of the research literature and a careful examination of the methods used narrowed our selection of reports to those that used acceptable methods and adequately reported quantitative findings. We summarize a total of 13 studies. For four of these studies, which address the impact of graphing calculators specifically on algebra achievement, we conducted a meta-analysis, yielding evidence of a strong effect of the technology.

Selection of Qualified Research

To support the emphasis of the No Child Left Behind Act of 2001 (NCLB) on teaching methods with evidence of effectiveness, the U.S. Department of Education established the What Works Clearinghouse (WWC) in 2002. The clearinghouse has established the WWC Study Review Standards, which research studies must pass to be included in their reviews. Our work on this review makes use of a study-screening and classification procedure that closely parallels the one used by the WWC. These criteria were the following:

- The research should assess the effect of calculator (scientific and graphic) use on mathematics achievement
- The research should be experimental (randomized control or quasi-experimental). The research should be analyzed quantitatively and provide information for calculating effect sizes.
- The research should be conducted in elementary to secondary schools (K–12) levels.
- The research should be published within the past 20 years, i.e., since 1985.
- The research paper should be accessible.

The search led to six published research papers and seven unpublished dissertations. The following list provides the author, publication date, sample student grade levels and mathematics topics covered by the studies.

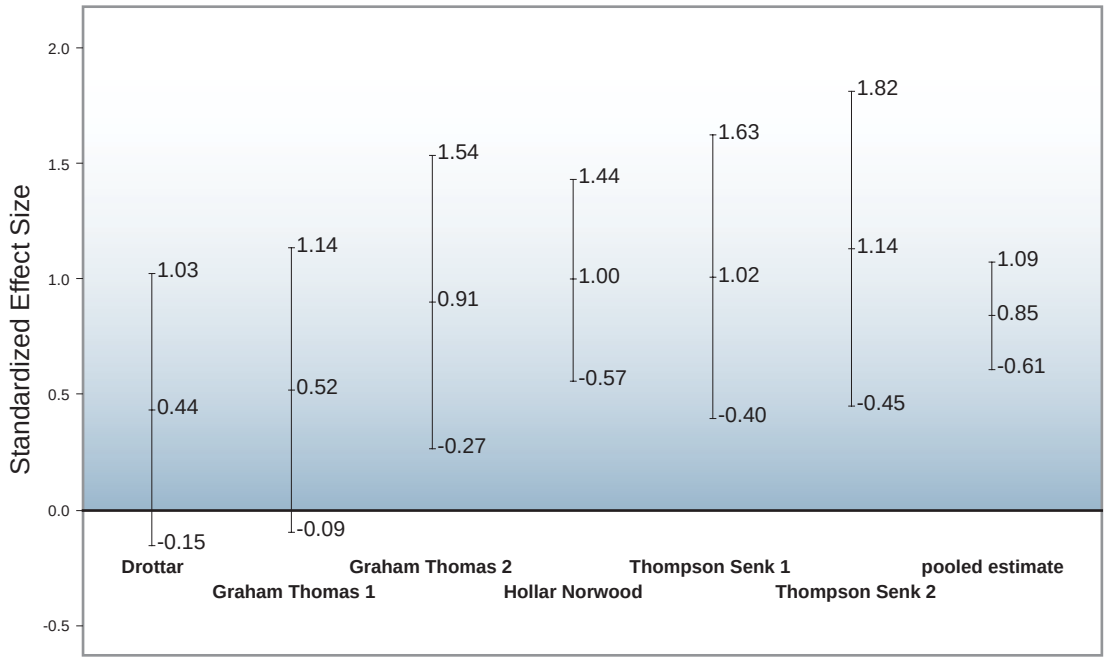
1. Ruthven, K. (1990) Upper secondary students in England. Symbolization and interpretation. .
2. Graham, A.T., and Thomas, M. O. J. (2000) Year 9 and 10 students in New Zealand. Algebra
3. Thompson, D. R., and Senk, S.L. (2001) Grades 10 and 11 in Chicago. Second-year algebra
4. Hollar, J. C., and Norwood, K. (1999) University freshmen in U.S. Intermediate algebra
5. Autin, N. P. (2001) Grade 12 students in U.S. Trigonometry
6. Drottar, John F. (1998) Grades 10, 11, and 12 U.S. Algebra II
7. Rodgers, K. V. (1995) Algebra II class students U.S. Quadratic equations
8. Wilkins, C. W. (1995) Grade 8 students in U.S. Factoring quadratic equations
9. Szetela, W., and Super, D. (1987) Grade 7 students in Canada. Translation process and complex problems
10. Loyd, B. H. (1991) Grades 8, 9, and 10 in U.S. Subsets of 4 different item types
11. Liu, S. (1993) Grade 5 students in Taiwan. Mathematics computation problem-solving ability
12. Ellerman, T. B. (1998) Grades 7 and 8 students in U.S. Mathematics concepts and applications
13. Glover, M. A. (1991) Grades 5, 6, 7, and 8 students with Learning Disabilities, U.S. Computation and problem solving

Meta-analysis of Graphing Calculator Impact on Algebra Achievement

A meta-analysis gives us a way of combining the impact of multiple studies to arrive at a single estimate of the impact. Impact is expressed as an effect size, which uses the metric of the standard deviation.

A meta-analysis requires that the studies being combined be studies of the same or closely related educational problems or interventions. First, studies are selected that address similar problems based on researcher judgment. Second, a statistical test of homogeneity is used to verify that the studies have reasonably similar effect sizes. Since our initial focus of the review was on graphing calculators, we restricted the meta-analysis to these studies. There are four published research papers and four unpublished dissertations that investigated the effect of graphing calculators. Among these studies, the researchers measured the impact on a variety of skills and abilities, most commonly on algebra. We judged that four of the studies that met the inclusion criteria measured the effect of using graphing calculators on algebra skills. Our meta-analysis addresses these studies only. Two of the studies report two separate effect sizes. We treated these as separate outcomes, so we worked with six outcomes in the meta-analysis.

We computed standard errors for the effect sizes. We then carried out a statistical test of homogeneity to determine that the studies can reasonably be described as sharing a common effect size . The point estimates for the effect sizes for the six results are displayed in the figure below.



Each point estimate is centered on its 95% confidence interval. The rightmost confidence interval represents the result for the pooled estimate, which has an effect size of .85 and a 95% confidence interval that does not contain zero. This result gives us strong evidence that the use of graphing calculators is associated with better performance in algebra.

To read the complete report, contact:

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