Equity of Student Use of Graphing Calculators for Mathematics Learning and Assessment

Beverly M. Klecker

Morehead State University

Richard L. Klecker

University of Kentucky

Paper presented at the annual meeting of the

Mid-South Educational Research Association

Lafayette, LA

November 2015

ABSTRACT

This study examined equity through thethrough the differences average scale scores on the NAEP 2015 12th-grade mathematics test by parents' socioeconomic status (SES) and students' use of graphing calculators in the classroom and while taking the NAEP 2015 assessment. Data were national public composite mathematics 12-grade 2015 NAEP assessment scores. The NAEP Data Explorer was used for the secondary analysis. Score range for the 12th-grade mathematics assessment is 0-300. The students' National School Lunch (NSLP) eligibility [SLUNCH3] was selected to serve as a proxy measure of parents' socioeconomic status (SES). Two questions were selected from *student factors*: (1) How often do you use these different kinds of calculators in math class? Graphing**.** Options: never use; sometimes not often; usually use (answered by students). [M817601]; (2) Kind of calculator used for test? Options: no calculator use; scientific non-graphing calculator; NAEP provided calculator; graphing calculator (answered by students). [M830201],

Equity of Student Use of Graphing Calculators for Mathematics Learning and Assessment

The national goal of “mathematics for all” (Schoenfeld, 2002) requires equity in teaching, opportunity to learn, access to technology, and student achievement. Many states required the disaggregation of data by demographics long before the No Child Left Behind Act (U.S. Department of Education, 2001) made the requirement national. Yet, gaps persist in opportunities and achievement. A recent study by the authors (Klecker & Klecker, 2014) found that students' use of graphing calculators during mathematics class and while taking the 2013 grade 12 NAEP mathematics assessment led to higher student mathematics achievement on the NAEP assessment.

Purpose of the Study

The purpose of this study was twofold: (1) to review recent literature on equity in the use of technology in education, and (2) to examine equity through the differences average scale scores on the 12th grade mathematics test by parents' socioeconomic status (SES) and twelfth grade students' use of graphing calculators in the classroom and while taking the NAEP 2013 assessment.

Review of the Literature

Equity of student access to technology has recently studied across cultures and subject matter (e.g., Alghamdi & Pestridge, 2015; Chih-Yuan & Metros, 2011; Jennings, 2012; Luongo, 2012; Ozmusul, 2013, Richardson, Nash & Flora, 2014). Lingard, Sellar, & Savage, 2014 described how the current use of testing and data have developed a new vocabulary which substitutes equity for social justice.

Many researchers have explored the impact of students' use of graphing calculators in mathematics learning and assessment. Higher achievement with use of graphing calculators was found by Tan, et al. (2011). Heller, Curtis, Jaffe, and Verboncoeur (2005) found:

> …Results showed that the more access students had graphing calculators, and the more instructional time in which graphing calculators were used, the higher the test scores. In addition, scores were significantly higher where teachers reported receiving professional development on how to use a graphing calculator in math instruction...(Abstract).

Graphing/Graphic Calculator Use During Learning

Hasan, Azizan, & Kassim (December, 2005) described the introduction of graphic calculators into the Malaysian New Curriculum for secondary schools Form 4 (16 years old). The students came from low-income families and had little access to technology. The experimental control-group design used graphic calculators (TI-83 Plus) as the independent variable. They found that the mean post-test of the group using graphic calculators (M=9.83, SD 2.678) was higher than the post-test mean of the control group (M=3.86, SD=2.248).

In a similar study Nor'ain Mohd. Tajudin & Noraini Idris (2013) used a quasi-experimental non-nonequivalent control group design to compare the effect of the TI-Nspire CX graphing calculator (CG) and conventional instruction (CI) on learning Straight Lines and Statistics. They found that students in the experimental group from all six schools in the study had significantly higher scores on the outcome measures than the students from the control group.

Graphing/Graphic Calculator Use During Assessment

Haimes (1999) examined calculator use and equity on the 1998 Tertiartiary Entrance Exam (TEE) in Australia. This exam required the use of graphic calculators by all students. Haimer examined gender equity and hypothesized that females would have more difficulty than males using graphing calculators. The hypothesis was not supported. A later secondary analysis of the same data by Haimer and Webster (2001) compared the mathematics scores of rural and urban Western Australian students. Urban students scored higher than rural students in the three years studied; however, the gap was inconsistent across items. Haimer and Webster (2001) concluded that rural students were not further disadvantaged by the requirement of graphic calculator use for the test.

Schwarz, Rich, Arenson, Podrabsky & Cook (2002) explored the question of differences by calculator use in evaluation with data from the Tennessee Gateway assessment given as an end-of course test in Algebra 1. Data were from approximately 7,000 students who answered questions about their use of calculators. Response options were “use” or “no use” and type of calculator. Schwartz et al. (2002) found:

> Calculator type, usage, and familiarity were associated with differences in the univariate comparison of test scores. For instance, students who responded that a graphing calculator was used performed higher than the other groups. The use of a graphing calculator could indicate that higher-level mathematics courses had been taken. However, this may not be the case in this instance since all students take the Gateway examination at the conclusion of their first Algebra I class. (p. 16)

DeLoach (2013) used a quantitative, quasi-experimental study to compare the performance of Algebra II students. Students in the experimental group used a graphing calculator to complete a standardized mathematics test. Students in the control group did not use a graphing calculator to complete the same test. The results of the independent *t*-test found that the mean of the experimental group was higher than the mean of the control group (t (51) = 2.69, p = .01).

Ellington (2006) conducted a meta-analysis of research that had investigated the achievement of students using Non-CAS Graphing Calculators. She summarized in the Abstract:

> Forty-two studies comparing students with access to graphing calculators during instruction to students who did not have access to graphing calculators during instruction are the subject of this meta-analysis. The results on the achievement and attitude levels of students are presented. The studies evaluated cover middle and high school mathematics courses, as well as college courses through first semester calculus. When calculators were part of instruction but not testing, students' benefited from using calculators while developing the skills necessary to understand mathematics concepts. When calculators were included in testing and instruction, the procedural conceptual and overall achievement skills of students improved (p. 2).

Large-Scale Study with Scientific Non-Graphing Calculators

Close, Oldham, Shiel, Dooley, & O'Leary (2012) described an extended study with 1,469 Grade nine students; however, the type of calculator was "scientific." The authors described the study:

> Three calculator tests were administered to a national sample of 1,469 Irish students in Grade 9-the last cohort to study mathematics without calculators (Phase 1). Three years later, the same tests were administered to a similar sample with calculators (Phase 2). Scores on a test of calculator-inappropriate items

> showed no significant change over the 3 years. For a test of calculator optional items, students were divided randomly into 2 groups, 1 with calculator access and the other without. In both phases, the students with calculators achieved significantly better than the students without calculators. Achievement on a test of calculator appropriate items showed significant improvement over the 3 years. Students' attitudes toward calculators also improved over the time. (p. 377)

However, the types of calculators used by the Grade 9 students in the study were not well-defined. The authors stated:

> *Students' use of calculators.* [Italicized heading in the original] In Phase 1, 55.8% of students reported that they had access to a calculator at school, whereas practically all students in Phase 2 had access to one. By Phase 2, scientific calculators were most frequently owned, and fewer than 1% of students used or had access to a graphing calculator. (p. 385)

Summary

The literature reviewed included correlational and quantitative experimental and quasi-experimental designs that investigated the effects of graphing (graphic) calculators both in teaching and assessment. The large-scale Irish study that was conducted across time and found no effect included mostly "scientific" calculators and very few (about 1%) graphing calculators.

In the literature reviewed higher assessment scores were obtained by students who used graphing (graphic) calculators for learning and/or during assessments.

Method

This secondary analysis of the National Assessment of Educational Progress (NAEP) data used the national public data composite mathematics scale scores from the 2013 NAEP twelfth-grade mathematics assessment. NAEP Data Explorer (NCESa) was used for the analyses. The score range for the 12th-grade mathematics assessment is 0-300.

NAEP Calculator Policy (NCESb, 2015)

> The mathematics assessment contains some sections for which calculators are not allowed, and other sections that contain some questions that would be difficult to solve without a calculator. At each grade level, approximately two-thirds of the assessment measures students' mathematical knowledge and skills without access to a calculator; the other third allow a calculator's use. The type of calculator students may use varies by grade level, as follows:
>
> - At grade 4, a four-function calculator is supplied to students, with training at the time of administration.
> - At grades 8 and 12, students are allowed to bring whatever calculator, graphing or otherwise, they are accustomed to using in the classroom with some restrictions for test security purposes. For students who do not bring a calculator to use on the assessment, NAEP will provide a scientific calculator.
>
> - No questions in the test are designed to provide an advantage to students with a graphing calculator. Questions are categorized according to the degree to which a calculator is useful in responding to the item:
>
> - A calculator inactive question is one whose solution neither requires nor suggests the use of a calculator.
> - A calculator is not necessary for solving a calculator neutral

question; however, given the option, some students might choose to use one.

- A calculator is necessary or very helpful in solving a calculator active question; a student would find it very difficult to solve the problem without the aid of a calculator. (para 10-11)

Secondary Analysis Using NAEP Data Explorer

One *student demographic* variable was selected to serve as a proxy measure of parents' socioeconomic status (SES), National School Lunch Program (NSLP) eligibility [SLUNCH3]. Student eligibility for NSLP was based on school records (collapsed to three categories, as included in NAEP reports). The three categories were: Eligible, Not Eligible, and Information Not Available. The percentage of students for whom Information Not Available was six percent. Eligible and Not Eligible were used for the analyses in this study.

Two questions were selected from *student factors*: Instructional Content and Practice: Modes of instruction/classroom activities from the Select Variables option in the NAEP Data Explorer (NCES, 2015a):

(1) How often do you use these different kinds of calculators in math class? Graphing**.** Options: never use; sometimes not often; usually use (answered by students). [M817601]

(2) Kind of calculator used for test? Options: no calculator use; scientific non-graphing calculator; NAEP provided calculator; graphing calculator (answered by students). [M830201]

Results

Table 1 presents percentages of students' reports of frequency of using graphing

[Place Table 1 about here]

calculators during mathematics classes by eligibility for NSLP. Data are included for the years 2005, 2009, 2013. The percentages should be read across rows. Thus, of the students who reported in 2013 that they "Never" used a calculator during mathematics classes, 49% were eligible for NSLP and 51% were not.

In the year 2013, of the students who stated that they "Usually Use" a graphing calculator in mathematics class, 32% were eligible for NSLP and 68% were not. In 2009, the 23% of the students who reported that they "Usually Use" a graphing calculator in mathematics class were eligible for NSLP; the 75% of the students who reported that they "Usually Use" a graphing calculator in mathematics class were not eligible for NSLP.

The data in Table 1 present a strong indication that the opportunity to "Usually Use" a graphing calculator in mathematics class is very different for 12th-grade students who are eligible for NSLP than for students who are not eligible for NSLP.

[Place Table 2 about here]

The question: "What kind of calculator did you use for this test?" had four options: no calculator use; scientific non- graphing calculator; NAEP provided calculator; graphing calculator (answered by students) [M830201] was available only in the 2013 database. Thus, Table 3, generated using NAEP Data Explorer (NCESa, 2015) indicates missing data for the years 2009 and 2005.

Of the students who answered "None" to the question, 38% were eligible for NSLP, 61% were not eligible. Of the students who answered "NAEP Provided" 43% were eligible for NSLP and 56% were not eligible for NSLP. Of the students who responded "Scientific not graph," 41% were eligible and 59% were not. Of the students who responded "Graphing" 25% were eligible for NSLP and 75% were not eligible for NSLP (Table 2).

[Place Table 3 about here]

Table 3 presents the average scale score means and standard deviations by the kind of calculator that the students' reported using for the test. The average scale score for students who used no calculator was 153 (33). The average scale score for students who used the NAEP provided calculator was 147 (32). The average scale score for students who used the scientific non-graph calculator was 146 (31). The average scale score for students who used the graphing calculator was 171 (33).

[Place Table 4 about here]

Table 4 presents average scale scores and standard deviations by kind of calculator used for the 2013 twelfth-grade mathematics NAEP test. Data are not available for 2005 or 2009 as the question was not included in the student questionnaires for those years. The data show that there are differences in average scale scores by both kind of calculator used and eligibility for NSLP.

[Place Table 5 about here]

Table 5 presents the analyses performed by NAEP Data Explorer (NCESa, 2015) in response to the command "Significance Test" of the descriptive Table 4. Multiple independent t-tests with alpha set at 0.05 adjusted for multiple pairwise comparisons (Family size=6) was performed. Effect sizes (Cohen, 1988) were hand calculated by the first author.

[Place Table 6 about here]

Table 6 presents the effect sizes (Cohen's *d*) between the average scale scores of students who used no calculator and students who used a graphing calculator (d=0.55) (moderate). The effect size of the average scale score differences between the students who used NAEP provided and students who used a graphing calculator was d=0.74 (large). The effect size of the average scale score differences between the students who used scientific non-graphing and the students who used a graphing calculator was d=0.78 (large).

[Place Table 7 about here]

Average scale scores and standard deviations by eligibility for NSLP across the years 2013, 2009, and 2005 are presented in Table 7.

[Place Table 8 about here]

Table 8 was generated by NAEP Data Explorer (NCESa, 2015). An independent t test, with alpha set at 0.05 was performed to test for statistically significant differences in average scale scores by eligibility for NSLP. Effect size (0.70) was hand calculated by the author.

[Place Table 9 about here]

Table 9 was generated by NAEP Data Explorer to test for significance of observed average scale scores by kind of calculator used and eligibility for NSLP.

Discussion

The finding of this study are consistent with equity issues discussed in the review of literature. This section of the paper will be completed after presentation of the paper and discussion with colleagues at the annual meeting of MSERA 2015.

References

Alghamdi, A. & Pestridge, S. (2015). Alignment between principal and teacher beliefs about technology use. *Australian Educational Computing*, *30* (1). ERIC No. EJ1072302.

Chih-Yuan, J. & Metros, S.E. (2011). Digital divide and its impact on academic performance. *US-China Education Review A* 2, 153-161. ERIC Document No. ED524846

Close, S., Oldham, E., Shiel, G., Dooley, T., & O'Leary, M. (2012). Effects of calculators on mathematics achievement and attitudes of ninth-grade students. *The Journal of Educational Research*, *105*(6), 377-390. DOI: 10.1080/00220671.2011.629857

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2. Auflage)*. Hillsdale, NJ: Erlbaum.

DeLoach, M. (2013). *The impact of graphing calculators on high-school students' performance on a standardized test* (Unpublished doctoral dissertation). University of Phoenix. ProQuest Dissertations & Theses. Publication Number: 3585951

Ellington, A. J. (2006). The Effects of Non-CAS Graphing Calculators on Student Achievement and Attitude Levels in Mathematics: A Meta-Analysis. *School Science & Mathematics, 106*(1), 16-26. Retrieved from ERIC Database (EJ751981)

Haimes, D. (1999). *Graphics calculators in examinations: A question of equity*? Paper presented at the combined Annual Meeting of the Australian Association for Research in Education and the New Zealand-Association for Research in Education Melbourne, Australia, November 29-December 2, 1999. Retrieved from ERIC Database (ED453068)

Haimes, D., & Webster, B. (2001). Rural students and graphics calculators in examinations. *Education in Rural Australia*, *11*,(1). 54-61 Retrieved from ERIC Database (EJ631525)

Hasan, H., Azizan, M., & Kassim, S. (2005, December). The use of graphic calculators in Malaysian secondary schools: Students' perception and teachers' constraints. In *Proceedings of 10th Asian Technology Conference in Mathematics. Blacksburg, VA: TCM Inc*. Retrieved from http://epatcm.any2any.us/EP/EP2005/2005P146/fullpaper.pdf

Heller, J. I., Curtis, D.A., Jaffe, R., & Verboncoeur, C.J. (2005). The impact of handheld graphing calculator use on student achievement in algebra 1 *Online submission*. ERIC Document No. ED493688. [Abstract].

Jennings, Z. (2012). Resource and technology: A beacon for change in the reform of Jamaica's secondary education system--or a "pipedream"? *International Review of Education, 58* (2), 247-269. ERIC No. EJ962456

Jesson, R., McNaughton, S. & Wilson, A. (2015). A design-based approach in New Zealand. *Curriculum Journal*, *26* (2), 198-223. ERIC No. EJ1065969

Klecker, B., & Klecker, R. (2014). *Impact of student calculator use on the 2013 NAEP twelfth-grade mathematics assessment*. Paper presented at the annual meeting of the Mid-South Educational Research Association. Knoxville, TN. ERIC No. ED548035

Lingard, B., Sellar, S., & Savage, G.C. (2014). Re-articulating social justice as equity in schooling policy: The effects of testing and data infrastructures. *British Journal of Sociology of Education, 35* (5), 710-730. No. EJ1036566

Luongo, N. (2012). Increasing elementary school teachers' awareness of gender inequity in student computer usage. International Electronic Journal of Elementary Education, 4 (3), 519-544. ERIC No. EJ1068597

National Center for Educational Statistics (NCES). (November, 2013). NAEP Calculator Policy

Retrieved from http://nces.ed.gov/nationsreportcard/mathematics/whatmeasure.aspx

NCES (2014a). *NAEP Data Explorer* . Retrieved from http://nces.ed.gov/nationsreportcard/naepdata/dataset.aspx

NCES (2014b). *NAEP assessment sample design 12th grade*. Retrieved from http://www.nationsreportcard.gov/reading_math_g12_2013/#/about#naep_samples

Nor'ain Mohd. Tajudin & Noraini Idris (2013). TI-NSPIRE CX graphing calculator: Enhancing students' performance in mathematics learning. Asia Pacific Journal of Multidisciplinary Research, 1, (1), 105-115.

Organization for Economic Co-Operation and Development (OECD). (March 2013). *PISA 2015 draft mathematics framework*. Retrieved from http://www.oecd.org/callsfortenders/Annex%20IC_PISA%202015%20Math%20Frame w ork%20.pdf

Ozmusul, M. (2013). Equity index in the school systems of selected OECD countries. *Educational Research and Reviews, 8* (18), 1722-1741. ERIC No. EJ1017412

Richardson, J.W., Nash, J.B., & Flora, K.L. (2014). Unsystematic technology adoption in Cambodia: Students' perceptions of computer and internet use. *International Journal of Education and Development using Information and Communication Technology, 10* (2), 63-76. ERIC No.: EJ1071301

Robelen, E.W. (2013, August 21). Use of calculators to shift with Core-aligned exams. *Education Week, 33*, (1), pp. 1, 12.

Samson, J.P., Jr., & Makela, J.P. (2014). Ethical issues associated with information and communication technology in counseling and guidance. *International Journal for Educational and Vocational Guidance, 14* (1), 135-148. ERIC No. EJ1037731

Schoenfeld, A.H. (2002). Making mathematics work for all children: Issues of standards, testing, and equity. *Educational Researcher, 31*(1), 13-25.

Schwarz, R.; Rich, C.; Arenson, E.; Podrabsky, T.; & Cook, G. (2002). *An analysis of Differential Item Functioning based on calculator type*. Paper presented at the annual meeting of the National Council on Measurement in Education, New Orleans, LA.

Stoilescu, D. (2014). Exploring social equity aspects in integrating technology in primary mathematics education. International Association for Development of the Information Society. Paper presented at International Conference of Education Technologies (ICEduTech) and Sustainability, Technology and Education (STE). New Taipei City, Taiwan, December 10-12. ERIC No. ED557317

Tan, Choo-Kim; Harji, Madhubala Bava; Lau, Siong-Hoe. Fostering positive attitudes in probability learning using graphing calculator.

Computers & Education, 57 (3), 2011-2024. ERIC No. EJ934154

U.S. Department of Education (2001). *The no child left behind act*. Retrieved from http://www2.ed.gov/policy/elsec/leg/esea02/index.html

U.S. Department of Education. (2015). Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2013 Mathematics Assessment. Retrieved from http://www.nationsreportcard.gov/reading_math_g12_2013/files/Tech_Appendix_Math_G12.pdf

Table 1. Percentage of Kind of Calculator Used by Students' During Math Class by NSLP

This report was generated using the NAEP Data Explorer.
http://nces.ed.gov/nationsreportcard/naepdata/ http://nces.ed.gov/nationsreportcard/naepdata/

Use graphing calculator in math class	Year	Jurisdiction	Eligible Percentage	Not eligible Percentage	Information not available Percentage
Never use	2013	National public	49	51	#
	2009	National public	37	61	2
	2005	National public	33	65	2
Sometimes but not often	2013	National public	46	53	1
	2009	National public	38	61	1
	2005	National public	33	65	2
Usually use	2013	National public	**32**	**68**	#
	2009	National public	**23**	**75**	2
	2005	National public	**19**	**78**	3

Rounds to zero.
NOTE: Detail may not sum to totals because of rounding. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2005, 2009 and 2013 Mathematics Assessments. (NCES, 2015a)

Table 2. Percentages of Kind of Calculator Used for NAEP Test by NSLP Eligibility

12th Grade Mathematics National Public

This report was generated using the NAEP Data Explorer.
http://nces.ed.gov/nationsreportcard/naepdata/ http://nces.ed.gov/nationsreportcard/naepdata/

			Eligible	Not eligible	Information not available
Kind of calculator used for test	Year	Jurisdiction	Percentage	Percentage	Percentage
None	2013	National public	38	61	1
	2009	National public	—	—	—
	2005	National public	—	—	—
NAEP-provided	2013	National public	43	56	1
	2009	National public	—	—	—
	2005	National public	—	—	—
Scientific not graph	2013	National public	41	59	1
	2009	National public	—	—	—
	2005	National public	—	—	—
Graphing	**2013**	**National public**	**25**	**75**	**1**
	2009	National public	—	—	—
	2005	National public	—	—	—

— Not available.
NOTE: Detail may not sum to totals because of rounding. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2005, 2009 and 2013 Mathematics Assessments.

Table 3. Average Scale Score by Kind of Calculator Used for NAEP Test

None 35%*		NAEP Provided 39%*		Scientific Not Graphing 8%*		Graphing 17%*	
M	SD	M	SD	M	SD	M	SD
153	33	147	32	146	31	171	33

Scale: 0-300; Percentages do not sum to 100% due to rounding.

Table 4. Average Scale Score by Kind of Calculator Used for NAEP Test by NSLP 2013

None				NAEP Provided				Scientific Not Graphing				Graphing			
Eligible (36%)		Not Eligible (58%)		Eligible (41%)		Not Eligible (54%)		Eligible (39%)		Not Eligible (56%)		Eligible (22%)		Not Eligible (68%)	
M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
140	30	162	31	137	30	155	31	136	30	154	30	153	35	177	29

NOTE: Percentages are within categories of calculator use for NAEP Assessment. Data available 2013 only because the question was not asked 2005 or 2009.

Table 5. Average Scale Score Differences by Kind of Calculator Used for NAEP Test

	None (153)	NAEP-provided (147)	Scientific not graph (146)	Graphing (171)
None (153)		> Diff = 6 P-value = 0.0000 Family size = 6 *d*=0.18	> Diff = 7 P-value = 0.0000 Family size = 6 *d*=0.22	< Diff = -18 P-value = 0.0000 Family size = 6 *d*=0.55
NAEP-provided (147)	< Diff = -6 P-value = 0.0000 Family size = 6 *d*=0.18		x Diff = 1 P-value = 0.4592 Family size = 6 *d*=0.03	< Diff = -24 P-value = 0.0000 Family size = 6 *d*=0.74
Scientific not graph (146)	< Diff = -7 P-value = 0.0000 Family size = 6 *d*=0.22	x Diff = -1 P-value = 0.4592 Family size = 6 *d*=0.03		< Diff = -25 P-value = 0.0000 Family size = 6 ***d*=0.78**
Graphing (171)	> Diff = 18 P-value = 0.0000 Family size = 6 *d*=0.55	> Diff = 24 P-value = 0.0000 Family size = 6 *d*=0.74	> Diff = 25 P-value = 0.0000 Family size = 6 ***d*=0.78**	
LEGEND:				
<	Significantly lower.			
>	Significantly higher.			
x	No significant difference.			
NOTE: All comparisons are independent tests with an alpha level of 0.05 adjusted for multiple pairwise comparisons according to the False Discovery Rate procedure. For comparisons between two jurisdictions, a dependent test is performed for cases where one jurisdiction is contained in the other. For more detailed information about the procedures and family sizes please see the Help document.				

Table created by NAEP Data Explorer (NCES, 2015a) Effect size (Cohen 1988) added by author.

Table 6. Effect Sizes of Differences in Scores by Calculator Use during NAEP Test

Type of Calculator		Cohen's *d* Effect Size
Graphing Calculator	No Calculator	$d = 0.55$
Graphing Calculator	NAEP-Provided	$d = 0.74$
Graphing Calculator	Scientific Non-Graphing	$d = 0.\ 78$

NOTE: In each comparison, scores of students who used graphing calculators for the 12th-grade NAEP Assessment in 2013.

Table 7. Grade 12 Mathematics Average Scale Scores by NSLP Eligibility 2013, 2009, 2005

		Eligible		Not eligible		Information not available	
Year	Jurisdiction	Average scale score	Standard deviation	Average scale score	Standard deviation	Average scale score	Standard deviation
2013	National public	139	31	161	32	137	35
2009	National public	137	31	159	32	155	41
2005	National public	132	31	154	33	153	33

NOTE: The NAEP Mathematics scale ranges from 0 to 300. Some apparent differences between estimates may not be statistically significant.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2005, 2009 and 2013 Mathematics Assessments.

Table 8. Differences in 12th Grade Mathematics Average Scale Score by NSLP Eligibility

	Eligible 139	Not Eligible 161
Eligible 139		< Diff = -23 P-value = 0.0000 ***d*=0.70**
Not Eligible 161	> Diff = 23 P-value = 0.0000 ***d*=0.70**	

LEGEND:

< Significantly lower.

> Significantly higher.

x No significant difference.

NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2013 Mathematics Assessment.

This report was generated using the NAEP Data Explorer. http://nces.ed.gov/nationsreportcard/naepdata/ http://nces.ed.gov/nationsreportcard/naepdata/

Table 9. Average Scale Score by Eligibility for NSLP by Kind of Calculator Used for NAEP Test

2013 12th Grade Mathematics Composite Average Scale Score National Public Data (NCESa, 2015)

	Eligible NAEP-provided(137)	**Eligible Scientific not graph(136)**	**Eligible Graphing(153)**	**Not eligible NAEP-provided(155)**	**Not eligible Scientific not graph(154)**	**Not eligible Graphing(177)**
Eligible NAEP-provided(137)		x Diff = 1 P-value = 0.4602 Family size = 15 *d*=0.03	< Diff = -16 P-value = 0.0000 Family size = 15 *d*=0.49	< Diff = -18 P-value = 0.0000 Family size = 15 *d*=0.57	< Diff = -16 P-value = 0.0000 Family size = 15 *d*=0.49	< Diff = -40 P-value = 0.0000 Family size = 15 ***d*=1.36**
Eligible Scientific not graph(136)	x Diff = -1 P-value = 0.4602 Family size = 15 *d*=0.03		< Diff = -17 P-value = 0.0000 Family size = 15 *d*=0.52	< Diff = -19 P-value = 0.0000 Family size = 15 *d*=0.62	< Diff = -18 P-value = 0.0000 Family size = 15 *d*=0.60	< Diff = -41 P-value = 0.0000 Family size = 15 ***d*=1.39**
Eligible Graphing(153)	> Diff = 16 P-value = 0.0000 Family size = 15 *d*=0.49	> Diff = 17 P-value = 0.0000 Family size = 15 *d*=0.52		x Diff = -2 P-value = 0.3310 Family size = 15 *d*=0.06	x Diff = 0 P-value = 0.8671 Family size = 15 *d*=0.00	< Diff = -24 P-value = 0.0000 Family size = 15 *d*=0.81
Not eligible NAEP-provided(155)	> Diff = 18 P-value = 0.0000 Family size = 15 *d*=0.57	> Diff = 19 P-value = 0.0000 Family size = 15 *d*=0.62	x Diff = 2 P-value = 0.3310 Family size = 15 *d*=0.06		x Diff = 2 P-value = 0.3039 Family size = 15 *d*=0.50	< Diff = -22 P-value = 0.0000 Family size = 15 *d*=0.73
Not eligible Scientific not graph(154)	> Diff = 16 P-value = 0.0000 Family size = 15 *d*=0.49	> Diff = 18 P-value = 0.0000 Family size = 15 *d*=0.60	x Diff = 0 P-value = 0.8671 Family size = 15 *d*=0.00	x Diff = -2 P-value = 0.3039 Family size = 15 *d*=0.50		< Diff = -24 P-value = 0.0000 Family size = 15 *d*=0.81
Not eligible Graphing(177)	> Diff = 40 P-value = 0.0000 Family size = 15 ***d*=1.36**	> Diff = 41 P-value = 0.0000 Family size = 15 ***d*=1.39**	> Diff = 24 P-value = 0.0000 Family size = 15 *d*=0.81	> Diff = 22 P-value = 0.0000 Family size = 15 *d*=0.73	> Diff = 24 P-value = 0.0000 Family size = 15 *d*=0.81	