Should graphing calculators be allowed on important tests?

Research Note 2

Prepared for Texas Instruments by the Center for Technology in Learning, SRI International,
July 3, 2008

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Broadly speaking, unless a test's goal is to measure mental arithmetic and related simple computational skills, including graphing calculators on tests does no harm. Further, including graphing calculators may increase the validity of the test and enable more accurate measurement of student skills in realistic situations.

The National Mathematics Advisory Panel (NMP) recently reviewed research on the use of calculators on tests, concluding that "…Based on the literature review conducted by the Task Group, it does not appear that using a calculator has a significant impact on test scores overall" (NMP, 2008, p. 8-34).

Given this neutral finding, it makes the most sense to decide this issue in specific cases, based on what a test aims to measure. At one obvious extreme, if the test aims to measure whether young children can perform simple calculations in their head, calculators should not be allowed. (And indeed, the NMP recommends against allowing calculators at the 4th grade level).

At another extreme, in most realistic workplace situations, people use calculators and similar tools to solve problems. Furthermore, in higher level science and engineering courses, calculators are considered essential tools. A test that allows calculators may have greater validity for assessing students' practical ability to use mathematics in such realistic situations.

The difficult decisions are in between the extremes (e.g., in late middle school and early high school), when students have achieved proficiency in simple calculations but are not yet being prepared for realistic, tool-rich situations.

A further consideration in allowing calculators is whether all students will be equally familiar with the use of the calculator. Students who are more familiar could have an advantage. Two studies considered this possibility.

Hanson, Brown, Levine, & Garcia (2001) studied fifty 8th grade students completing problems with their own calculator and comparable problems with a scientific calculator provided to them. The researchers found neither performance advantages associated with calculator type, nor an advantage related to student background characteristics (gender, race, math ability, socioeconomic status).

Chazan et al. (2007) discovered on the 2003 8th grade National Assessment of Educational Progress that students who use calculators on a regular basis in their schooling scored higher on algebra and functions items than students who reported little use of calculators. Among all eighth graders, regardless of socioeconomic status, the average scale scores of students who reported that they used calculators was six to 11 points higher on algebra and functions items than those who reported that they did not use calculators. This would suggest an advantage for students who frequently use calculators outside of the testing situation.

Three additional high-quality correlational studies are of particular interest:

- A study by Educational Testing Service and the College Board (Scheuneman et al., 2002) examined effects of calculator use on the SAT I math test. It concluded that "use of calculators was associated with higher test performance, but more able students were more likely to have calculators and used them more often. Overall, the effects of calculator use were found to be small, but detectable." The effects were not influenced by gender or ability level, and were not due to simply working faster (*a speeded test effect*).

- A study of calculator use on the ACT math test reported that average test scores increased for virtually all groups when calculator use was permitted. This effect was found for virtually all genders, ethnicities, income levels, high school grades and courses completed (Colton, 1997).

- A study of the Tennessee Gateway assessment end-of-course test in Algebra I found that "students who responded that they used a graphing calculator performed higher than other groups" but there was no pervasive pattern across all types of calculators (Schwarz et al., 2002). There was no evidence of students failing to complete the tests (*speediness*).

Three additional findings add further understanding to this effect:

- A meta-analysis of findings from 54 experimental and quasi-experimental studies shows that the effect of graphing calculators on gains extends from calculations and operations to conceptual understanding and problem-solving performance (Ellington, 2003).

- The effect of graphing calculators on student performance depends on how the test is written. Different types of items have different sensitivities to calculator use. For example, items which require complex calculations or graphing may show effects of calculators, while items testing for conceptual understanding (without calculation) may not (Hearn & Lloyd, 1987; Lloyd, 1991; Morgan & Stevens, 1991; Lawrence & Dorans, 1994; Schwarz et al., 2002).

- There is some suggestion that the calculator effect may be greatest for minority or low-ability students (Gao, 1997). However, not all studies show this effect.

Overall, with careful attention to item design and sensible policies to handle equity issues, calculators can be safely included on tests in middle school and secondary school; moreover, the inclusion of calculators may increase the validity of tests that seek to predict how students will perform in realistic everyday and academic situations.

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