Should students have frequent access to graphing calculators?

Research Note 3

Prepared for Texas Instruments by the Center for Technology in Learning, SRI International,
Updated May 26, 2009

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Research shows that when students use graphing calculators frequently, they tend to score higher on national, state and school level tests. Frequent use can occur in class and/or during homework. Research also indicates that it is not simply the frequency of access, but types of use that matter.

Findings from National Assessment of Educational Progress (NAEP)

Results reported in The Nation's Report Card: Mathematics 2000 highlight the value of frequent graphing calculator use (NCES, 2001). For grades 8 and 12, students who used graphing calculators in class had higher average NAEP scores as compared to nonusers. Moreover, when 12th grade students used graphing calculators at least once a week, their mathematics scores were higher. Eighth graders who used calculators almost every day achieved the highest scores.

A comparison of 1996 and 2000 responses reveals an increase in the percentage of students reporting their graphing calculator use for schoolwork. Responses collected in 2000 highlight nuances in classroom usage that contribute more to student achievement. More frequent use of graphing calculators on both homework and quizzes was associated with higher scores for students in grades 8 and 12. Eighth grade teachers who report allowing the use of calculators during class tests had their students outperforming those who did not have access to calculators during class tests. Furthermore, students granted unrestricted use of calculators had higher average scores than students of those teachers with limited access.

The report by the National Mathematics Advisory Panel's Task Group on Assessment (2008) references a subsequent analysis of the 2003 NAEP assessment on grade 8 mathematics conducted by Chazan and colleagues. Their findings resonate with earlier results about the impact of experience with calculators: in comparison to students who reported little use of calculators in classrooms, regular users scored higher on algebra and function items. This result was consistent across high and low socioeconomic status, with average scale scores ranging from 6 to 11 points higher.

Findings from Algebra 1 End-Of-Course Tests

Similar findings are reported by a study that examined the relationship between graphing calculator use during instruction and student achievement in Algebra 1 courses in two suburban school districts in Oregon and Kansas (Heller Research Associates, 2005). Results showed that students who had more access to graphing calculators scored higher on end-of-course tests. Moreover, test scores were higher for those classes that incorporated the use of graphing calculators more often in terms of time and lesson coverage. Classrooms with enough graphing calculators for individual student use scored significantly higher than those who did not have graphing calculators in class. Additionally, the majority of the teachers in this sample used graphing calculators more often than what the textbook prescribed.

The study identified three specific benefits: allowing for higher-level learning, efficiency (i.e., getting more work done), and greater accuracy. Teachers stated that it allows them "to take the concepts to a higher level and connect the different concepts" and enables "accurate and expedient solutions to graphing a variety of functions." This, however, should not be misconstrued as unlimited access. In fact, selective access to graphing calculators during class was another teacher practice that proved to have a significant effect on student test scores. Students' scores were higher in those classes where they were occasionally restricted from using a graphing calculator, signaling the need to be cognizant of the ways in which graphing calculators are integrated with instruction.

Findings from Texas Assessment of Knowledge and Skills (TAKS™)

Propelled by policies that required use of graphing calculators in math curricula (beginning 1996) and during state tests (beginning 2000), graphing calculators have become standard in Texas. A study with a representative sample of nearly 4,000 teachers in Texas found that the majority of teachers have access to graphing calculators (98%), and use graphing calculators daily (81%) or weekly (17%) (Dimock & Sherron, 2005).

This finding was consistent across rural, suburban and urban schools, although a greater percentage of urban schools used graphing calculators weekly rather than daily. Across all three settings, the issue of access is most commonly addressed by providing a classroom set of graphing calculators (96%) where the majority reported using graphing calculators for in-school activities (99%) such as class work, class tests and state assessments. This may explain why a smaller percentage (82%) of teachers employs graphing calculators for homework. Schools struggle to address the increasing demands of classrooms and mitigate circumstances by providing shared resources rather than adding the burden of requiring students to purchase their own.

The same study found that schools whose teachers reported assigning graphing calculators for homework had higher TAKS™ scores than those who did not require such usage. In addition, the study references findings from the Trends in International Mathematics and Science Study (TIMSS 2003), which reported that eighth graders in countries allowing frequent access to calculators tended to score higher on the assessment (Mullis, Martin, Gonzalez & Chrsotwski, 2003, cited in Dimock & Sherron, 2005). While these studies favor frequent use, correlational study designs do not eliminate other possible reasons for the effect, such as the likelihood that poorer students were less likely to have a calculator at home.

Findings from Calculus Classrooms in The Netherlands

A study in The Netherlands compared the performances of Calculus students in 12 classes who were randomly assigned to one of the three conditions: (1) no access to graphing calculators (control group), (2) access during one unit, and (2) access for one year (Harskamp, Suhre, & van Streun, 1998; 2000; van Streun, Harskamp, & Suhre, 2000, all cited in Kastberg & Leatham, 2005). While all students were taught function and calculus concepts with the same textbook, graphing calculator groups received additional instructions on how to use calculators for checking algebraic solutions, finding solutions graphically and graphing functions. More advanced operations were not explored.

Researcher-developed pre-tests and post-tests were administered to assess students' problem-solving strategies. On the pre-test, all students were allowed to use scientific calculators. On the post-test, control students were allowed to use scientific calculators and the treatment group students used graphing calculators. Results showed that students with year-long access to graphing calculators used a wider range of problem-solving strategies, attempted more questions, and obtained higher scores than those with less or no access. Additionally, those students who were identified as "below average" by the researchers made more frequent use of a graphical approach to problems (in contrast to a trial-and-error approach or algorithmic strategy) and scored significantly higher on the post-test (van Streun et al., 2000).

How Technology is Used Matters

The Netherlands study provides the strongest evidence to date of the benefits of frequent access to graphing calculators. In addition, correlations with achievement scores at three levels – a national assessment, state test, and end-of-course examinations – support frequent graphing calculator use, but do not eliminate other possible explanations.

For example, graphing calculator usage is more prevalent in higher level math courses, which typically consist of more mathematically able or mathematically inclined students (NCES, 2001). Other studies suggest that higher ability students are more likely to use graphing calculators with advanced features (Morgan, 2000; Scheuneman, et. al., 2002) or that able students use graphing calculators differently from less able students, possibly employing different meta-cognitive strategies that increase performance on selected items (Scheuneman, et. al., 2002).

Likewise, Burrill and colleagues (2002) emphasize the need for a change in teacher practice: "the type and extent of gains in student learning with handheld graphing technology are a function, not simply of the presence of handheld technology, but of how the technology is used in the teaching of mathematics."

Thus, a recommendation to allow students to use graphing calculators frequently would be an oversimplification of best practice. In the future, research may provide more detailed guidance about *how* graphing calculators should be used when students can use them frequently.

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