

# What are the benefits of graphing calculators for students in developmental mathematics courses at the post-secondary level?

Research Note 1

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*Existing research suggests that integration of graphing calculators can improve student conceptual understanding, attitudes toward math, and retention in college level studies in math and related fields.*

### Developmental Education Programs and Retention

Developmental education programs in two- and four-year colleges help under-prepared students to develop core academic skills so that they will be successful at college level courses. Today, developmental education programs are an integral part of the undergraduate and community college curriculum, because many students are entering colleges without the sufficient academic skills and knowledge. Michael Kirst at Stanford University estimates 60 percent of students between ages 17 and 20 in two-year colleges and 30 percent of students in four-year institutions need remedial courses (Kirst, 2007). Remedial work in algebra is particularly important because college algebra has a very high withdrawal and failure rate (Stratton, 1996). Many students rely on developmental courses to overcome this constraint and continue their studies in math and related fields.

A recent study with a strong research design has shown the outcome of developmental math program on student retention (Lesik, 2007). According to this study, students who participated in a developmental math program were approximately four times less likely to drop out over the course of their first three years as compared to students who did not participate in the program. The difference in the risk of dropout is statistically significant. Unlike prior research, this study was able to draw a causal link between the developmental program and student retention by using a regression discontinuity design. While this study demonstrates that successful developmental programs can have significant effects on student retention, we should be cautious about making broad conclusions from only one study.

### Graphing Calculators in Developmental Math Programs

Some researchers have explicitly examined the role of graphing calculators as a primary teaching tool in developmental algebra classes and its effect on student learning, attitudes towards mathematics, and, subsequently, retention in subsequent college level courses.

- A developmental mathematics program at Columbia College of South Carolina was drastically modified to focus on conceptual understanding by building on student intuitive understanding, using algebraic manipulatives and employing graphing calculators (Hopkins & Kinkard, 1998). A preliminary study showed positive outcomes favoring the group of students in the new program. Compared to students who were taught the same content with the traditional approach, students in the new program performed better on the final exam, had better mathematical attitudes at the conclusion of the program, and had a higher pass rate at the subsequent college level math courses. Additionally, the study presented anecdotal evidence that many students in the new program were planning to enter math and science fields that would have previously not been open to them.
- At Georgia State University, a Study Support course was offered as an adjunct to a college algebra course to better support students who had previously failed a regular college algebra course and/or who felt in need of extra support. The adjunct course focused on cooperative learning, mastery of mathematical processes, and daily practice with a graphing calculator. The joint program yielded a 100% pass rate, as compared to a pass rate of 79% for students who did not enroll in the Learning Support portion of the program. Moreover, the average grade for the joint program students was significantly higher than the one for those who did not receive the Learning Support component.

It is important to note that neither of these studies controlled for pre-existing differences among the two study groups. The difference in the student outcomes therefore cannot be attributed solely to the graphing calculator-based developmental math instruction.

## Features of Graphing Calculators that Matter

Research has shown that the use of graphing calculators matters particularly in fostering conceptual understanding of developmental math students (Hopkins & Amelia, 1998; Laughbaum, 2002, 2003; Shore & Shore, 2003). Two key features of graphing calculators include:

- **Display multiple representations:** Students can see mathematical concepts represented in multiple ways (e.g., graphs, tables, algebraic expressions, and geometric figures) and make connections between them. At The Ohio State University, developmental mathematics classes focus on conceptual understanding of functions by helping students make connections among different forms of functional relationships through real-world examples and multiple representations made available on graphing calculators (Laughbaum, 2002, 2003).
- **Enable hands-on activities:** Students can collect, explore, and analyze data through the use of a data collection extension device. At Allegany College of Maryland, developmental math courses for health professions incorporated problem-based learning that required students to collect and analyze data related to functioning of kidneys (Shore & Shore, 2003).

While there is a debate on the extent to which developmental math education should focus on conceptual understanding over basic computational skills (MacDonald, Vasquez, and Caverly, 2002), proponents of graphing calculators argue that developmental mathematics education should go beyond arithmetic calculations done on a scientific calculator or pencil and paper (Laughbaum, 2001). Moreover, developmental math instruction must address particular needs of students, a majority of whom had failed in a more traditional curriculum because they lack motivation and interest in math or even have math anxiety (Armington, 2002). Graphing calculators can be catalysts for drastically changing the developmental math curriculum (Laughbaum, 2001; Hopkins & Amelia, 1998).

While we await research with a stronger design that directly examines the contribution of graphing calculators to student retention in developmental mathematics, existing research suggest that integration of graphing calculators can improve student conceptual understanding, attitudes toward math, and, subsequently, retention in college level studies in math and related fields.

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