The Pedagogical Potential of TI-Nspire™

Research Note 9

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TI-Nspire™ technology extends current graphing calculator technology in ways that fit with research recommendations. Two important enhanced capabilities are (1) dynamically-linked multiple representations and (2) save and review of student work.

Dynamically-linked Multiple Representations

All modern mathematics learning materials build on the insight that students learn more when mathematical concepts are represented in multiple ways. Technology can go beyond what is possible in books by allowing students to directly interact with different representations, including graphs, tables, algebraic expressions, and geometric figures. Research has found strong evidence that appropriate classroom use of graphing calculators increases students' ability to understand concepts and solve problems (Ellington, 2003). Yet graphing calculators can vary in the quality of the representations they provide. Three key features distinguish TI-Nspire technology from its predecessors:

- **Clearer Expression.** TI-Nspire technology displays higher quality graphs and presents mathematical expressions as textbooks do (e.g., $\frac{1}{3}x^2$ rather than 1/3 x^2).
- **Grab-and-Move.** This feature allows students to change a line, curve or location of axis, and observe the impact of changes and mathematical relationships.
- **Multiple Representations on the Same Screen.** TI-Nspire technology displays up to four representations—algebraic, graphical, geometric, numeric and written—on the same screen. These representations can be dynamically linked, so that changes made to one representation of a concept are automatically reflected in others instantly. Changes can be viewed simultaneously across multiple representations.

While we await research that directly examines how TI-Nspire technology improves learning, research on related technologies and approaches can inform educators' decisions. Teachers can draw upon this broader research base both for pedagogical insight and evidence of effectiveness. Researchers have found that students learn concepts more readily when they experience the concepts across different forms of representation (Davis & Maher, 1997; Kaput, 1992; Kaput, Noss, & Hoyles, 2002). A recent large scale study of SimCalc, a curriculum using graphing calculator-based mathematical representations, provided strong evidence of its effectiveness (Roschelle et al., 2007). The study used a high quality research design with 95 educators and over 1,600 students. Another experimental study with 128 students from ages 12-14 found that students who received instruction that emphasized (a) representing math problems in multiple formats, (b) meaningful contexts, and (c) collaborative learning scored significantly higher on relevant tests (Brenner, Mayer, Moseley, Brar, et al., 1997). The study also showed that the representation-based instruction yielded the same achievement gains for Spanish-speaking students as for English-speaking students.

Save and Review of Student Work

Although paper allows students to save and review their work, most graphing calculators do not. With TI-Nspire technology, students and the teacher can create, edit and save a sequence of mathematical steps in a document that can be saved and later re-opened. Research suggests that the save and review feature can improve teaching and learning by:

- **Enhancing Reflection.** Students learn more when they can reflect upon their work at a later time and take steps to improve it. Teachers can use saved work as a conversation starter both with individual students and classroom groups.
- **Enabling Formative Assessment.** By reviewing saved work with students, teachers can monitor student understanding and adjust instruction accordingly.
- **Increasing Academic Learning Time.** By saving their work and continuing it at home, in another class session, or in a study group, students can spend more time working on academic learning tasks. Teachers can collect saved work and review it at their convenience; they can also prepare documents so that students spend less time configuring a screen and more on the mathematics.

Reflection is a necessary component of key mathematical practices, such as conjecturing, generalizing, abstracting, or critiquing, and is central to the deep learning of mathematics (Wheatley, 1992). Freudenthal (1983) suggested that the essence of reflection in mathematics is shifting one's viewpoint to gain additional insight. More recently, reflective activities, such as teacher-facilitated discussions that elaborate student explanation, are recognized as promising practices (Grouws & Cebulla, 2000; The Access Center, 2006).

Formative assessment stems from the idea that providing constructive feedback early in the learning process can improve student achievement. A former president of the American Educational Research Association wrote:

> *In order for assessment to play a more useful role in helping students learn it should be moved into the middle of the teaching and learning process instead of being postponed as only the end-point of instruction (Shepard, 200, p. 10).*

Research has found a strong relationship between increased academic learning time and stronger student achievement (Wang, Haertel, & Walberg, 1993/1994). High quality academic learning time is particularly important for low achievers; much of the benefit comes from engaging low achievers in spending more time doing academic work and experiencing success. For such students, increasing the academic learning time reduces their anxiety and enhances their learning outcomes (Cotton, 1989).

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