Highlights from Research on Graphing Calculators

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Handheld Technology

- Arithmetic calculators
- Scientific calculators
- Graphics calculators
- Algebraic calculators
- Palmtop computers
- Laptop computers
- Data collection devices

1. What does research tell us about the effects of handheld technology on the teaching and learning of mathematics?

2. Is there empirical evidence to support the value of teaching with technology?

Growth In Graphics/CAS Calculator Research

- Dunham, 1991 review for ICTCM
  - 5 journal articles
  - 12 dissertations
  - 11 conference papers
- Dunham, 1999 website
  - 70 journal articles
  - 139 dissertations
  - 76 conference papers

Research Resources

URL:
www.ti.com/calc/docs/research.htm

Categories of Research Findings

- Achievement
- Conceptual understanding
- Attitudes and beliefs
- Behavior
- Strategies
- Special population effects
- Assessment

Achievement Benefits In …

- Developmental mathematics
- Algebra
- Precalculus
- Calculus
- Statistics
- Geometry
- Science

Achievement Results

- Students taught with technology - but tested without it - perform as well or better than students taught with more traditional methods.

Testing w/o Technology

- Many studies show positive benefit for technology group
- Many studies show no significant differences
- Almost none show greater gains for traditional group
- “No harm done” - no loss of paper-and-pencil skills when tested without technology, provided the skills were taught

Achievement Results

- Students taught and tested with technology had significantly higher achievement in computation and problem solving in a variety of content areas.

Understanding Concepts

- Graphs
- Functions
- Algebra
- Calculus
- Symbol sense

Graphing Concepts

Students in technology-based courses . . .

- Placed at higher levels in a hierarchy of graphical understanding
- Better related graphs to their equations
- Read and interpreted graphical information better
- Got more information from graphs

Graphing Difficulties

- Pixel & scale issues
- Domain and range concepts
- Sampling issues

Function Concepts

Students in technology-based courses . . .

- Better understood global features
- Increased their example base for functions
- Linked graphic, numeric, and algebraic representations more often
- Used dynamic “process” terms when talking about functions
- Improved transformation knowledge

Function Difficulties

- Novices distracted by learning techniques & syntax for calculators
- Transformations difficult for those with poor links between graphs & equations

Components of function understanding

(O'Callaghan, 1998; Hollar & Norwood, 1999)

- Modeling realistic problems
- Interpreting functions in realistic context
- Translating among representations
- Reifying functions

All aspects improved with CAS use.

Student Behavior

- Less passive learning
- More conjecturing & testing
- More inquiry & independent investigation
- Less time on manipulation
- More modeling & problem-solving

Student Behavior

- Less note-taking and listening to teacher
- More discussion with peers & reflection
- More group work
- Better communication & vocalization
- More mature & fluent language

Student Behavior: Difficulties

- Faith in calculator authority
- Least critical of machine answers
- Ignoring known machine limitations
- Novices need time to learn techniques & syntax and develop confidence

> Calculators act as a “third agent” in the classroom as students consult both teacher and technology. (Farrell, 1996)

Teacher Behavior

When technology is in use, pedagogy changes …

- Less lecturing & explaining
- More inquiry
- More higher-order questions
- More consulting & monitoring
- Different use of examples
- Greater stress on estimation in problem solving

Strategies: Problem Solving

Students in technology-based courses . . .

- Had more flexible approaches to p.s.
- Were more willing to engage in p.s.
- Made more attempts
- Used multiple methods on one problem
- Applied single method to many problems

Strategies: Problem Solving

Students in technology-based courses . . .

- Used more “trial & error” strategies
- Did more self-correction & checking
- Stayed with a problem longer
- Concentrated on the mathematics and not the manipulation
- Solved more nonroutine problems
- Had greater access to mathematics

Research Confirms:

Calculators are useful tools that can …

- Enhance mathematical instruction
- Foster improved teaching and learning
- Increase mathematical achievement