

CHAPTER 2

REVIEW OF THE LITERATURE

The research interests for this project can be divided into five separate areas-

1. Disidentification and the mathematics classroom;
2. Technology in education;
3. Technology in mathematics education;
4. Technology to explore graphing concepts; and
5. Research on hand-held technologies and data collection devices in mathematics education

Disidentification and the Mathematics Classroom

Steele describes academic disidentification as the “process that occurs when people stop caring about their performance in an area, or domain that formerly mattered a great deal.” (Steele, 1992, p.12). Hill (1997) applies this hypothesis to the mathematics classroom and argues that many intrinsic qualities of a traditional mathematics classroom offer motives for student disidentification from mathematics. Mathematics has been described as a gatekeeper subject that has traditionally closed gates for students due to computational reliance and traditional methods of tracking students into ability groups. The traditional mathematics classroom has caused some mathematics students to disidentify with mathematics.

Tracking and filtering are the most overt examples of causes of students’ disidentification and they intertwine with teacher expectations and differing views of mathematics between teacher and student. Tracking in mathematics classes results in oversimplified, repetitive, and fragmented instruction (Oakes, 1990). These classes require more rote memorization and less critical thinking than high tracked classes where teachers pursue understanding of complex

themes. Oakes presented and described this as evidence that implementation and curriculum differ across tracked classes

Many of the disidentification issues involving tracking and filtering are based on inequalities evidenced by large numbers of African-American and Hispanic minorities and the poor in lower tracked classes (Oakes, 1990). NCTM recommends opportunity for all indicating that those who study advanced mathematics are most often white males. This is occurring, as careers are becoming more focused on technical and technological literacy. Careers are rapidly evolving that require more scientific and problem-solving skills. Advancement in mathematics can provide a background and education in these skills for the workforce of the future. At the same time as the increased focus on mathematics and technical skills, women and most minorities study less mathematics and are seriously underrepresented in careers using science and technology.

Mathematics has become a critical filter for employment and full participation in our society (NCTM, 1989). Walter Secada presents calculators as example technological tools that may aid in removing the computational gate and filters to the study of mathematics. "Certainly by middle school if not before, all students should have access to calculators, and the focus of the curriculum should be enlarged beyond number and computation." (Secada, 1990, p.139) The influence of technology as an instructional practice has been identified and described as a component of an organized program as a tool to increase students' conceptual understanding of mathematics and facilitate more students taking additional and advanced mathematics courses. "Teachers in OFA (Organized for Advancement) used Calculators and Computers as tools to allow concentration on concepts and strategies instead of getting mired in arithmetic, and students also learned more problem-solving." (Gutiérrez, 1996, p.519)

Many students face self-esteem issues and on occasion demonstrate negative attitudes toward mathematics and schooling especially those who are tracked in lower mathematics classes. Technology offers opportunities to create instructional and educational environments that promote the mathematical learning of all students. NCTM, in fact, describes the deprivation of technological tools in the mathematics classroom as inequitable and handicapping to the students in our society. (1998)

Reviewing Steele's disidentification hypothesis and additional studies focused on technology in mathematics education it may be possible to develop methods that may help both high and low performing students improve their self-esteem in their mathematics classes and help them identify more with mathematics with technology. Research on graphing calculators in the mathematics classroom (Hembree & Dessart, 1986) has shown there is an increase in positive attitudes toward mathematics and an increase in self-concept in mathematics with students using calculators. Dunham (1995) also found that female students' confidence levels and algebra skills increased in the mathematics classroom with the introduction of the graphing calculator.

Technology in Education

Technology has frequently been viewed as a widely useful asset to education. It is only in recent years that concerted efforts have been undertaken to mandate the inclusion of technology in educational settings. Prior to recent reform movements to incorporate technology and recent technological advances Seymour Papert in Mindstorms (1980) presented insights into the future of education with the advent of the personal computer. Papert describes two major research themes from the early 1980s that are relevant to research in technology and education

even today. "Children can learn to use computers in a masterful way, and that learning to use computers can change the way they learn everything else." (Papert, 1980, p.83)

Papert then explains a very important aspect of learning through technological means. Learning through technology is more than just fun, very powerful kinds of learning are taking place. Children are learning to speak mathematics and acquiring a new image of themselves as mathematicians (Papert, 1980).

Interest in the use of technology to improve K-12 Education for US students has increased in recent years. This interest has promoted the creation of committees and interest groups to promote the implementation of technology in the K-12 setting. The Panel on Educational Technology was formed in April 1995 under the President's Committee of Advisors on Science and Technology (PCAST) to inform and advise the President on the application of technology in the K-12 setting. PCAST summarized six recommendations on the use of technology in K-12 education. These are:

(1) Focus on learning with technology, not about technology. It is important to distinguish between technology as a subject area and the use of technology to facilitate learning about any subject area. The importance of technical knowledge in the coming century is very evident however, PCAST recommends that technology be integrated across the K-12 curriculum and not solely for purposes related to learning technical or technology-related skills.

(2) Emphasize content and pedagogy, not just hardware. Current educational reform efforts emphasize the development of higher-order reasoning and problem solving skills. These same emphases are evident in NCTM standards documents that emphasize the "process standards of problem solving, and reasoning." (1989). The role of technology in achieving the goals of these reform efforts should be emphasized. PCAST recognizes the importance of appropriate

hardware and software in educational settings but attention should be given to the potential role of technology in achieving the goals of current educational reform efforts through the use of new pedagogic methods. PCAST draws attention to reform movements that extol the benefits of constructivist learning in education, whereby students actively construct the knowledge of a particular concept and negotiate goals and meanings with others in the class, including the instructor.

(3) Give special attention to professional development. K-12 teachers should be provided with preparation and support to implement technology in their classrooms. Teachers should be provided with ongoing mentoring and should have time and support to familiarize themselves with software and content to incorporate technology into their lesson plans.

(4) Engage in realistic budgeting. PCAST encourages schools to incorporate technology expenditures into their operating budgets rather than relying on one-time grant awards or other capital campaigns.

(5) Ensure equitable, universal access regardless of socioeconomic status, race, ethnicity, gender, or geographic factors, and special attention should be given to students with special needs.

Access to knowledge-building and communication tools should be made available to *all* students. "Educational technologies have the potential to ameliorate or exacerbate the growing gulf between advantaged and disadvantaged Americans, depending on policy decisions involving the ways in which such technologies are deployed and utilized." (PCAST, 1997)

(6) Initiate a major program of experimental research to ensure the efficacy of technology use within our nation's schools. A program of research on education in general and educational technology will prove necessary to ensure the effectiveness of technology use. PCAST

recommends that this research take place concurrently with the infusion of technology in K-12 education.

(PCAST, 1997, p.7-10)

Important aspects of the PCAST report are the emphasis on infusion of technology into the curriculum to promote learning through the technology instead of learning the technology. Students do not need to know exactly how a retractable pen or mechanical pencil works but they are required to use them throughout education. Technology tools can be handled in much the same way as pencils and other tools for learning. Students should be introduced to and instructed through the technology as a tool for understanding, exploration, and problem solving. PCAST also recommends the infusion of technology in all schools and with all students through an equitable and universal allocation process thereby granting all students access to technology tools. These two aspects are mirrored within reform movements recommending the incorporation of technology into the current school curriculum.

Technology in Mathematics Education

NCTM recommends that technology receive increased emphasis in the K-12 mathematics curriculum especially in relation to teachers' professional development, equitable and universal access, and emphasizing content and pedagogy. NCTM Emphases include-

- appropriate calculators should be available to all students at all times;
- a computer should be available in every classroom for demonstration purposes;
- every student should have access to a computer for individual and group work;
- Students should learn to use the computer as a tool for processing information and performing calculations to investigate and solve problems. (NCTM, 1989)

The focus on technology in mathematics education has received increased attention in recent years and drawn serious criticism. Critics of technology in the mathematics classroom describe the use of calculators as a crutch or replacement for understanding and learning the basics (Pomerantz, 1997). Proponents of technology generally contend that technology should not replace the learning of the basic concepts but supplement the curriculum to encourage deeper and more substantial explorations into the mathematics concepts. Pea (1985) suggests using technology to help students cognitively reorganize mathematical knowledge.

Computers are commonly believed to change how effectively we perform traditional tasks, amplifying or extending our capabilities with the assumption that these tasks stay fundamentally the same. A primary role of computers is changing the tasks we do not by merely amplifying but by reorganizing our mental functioning. (Pea, 1985, p. 5)

This is a crucial point that Pea makes in drawing the line between technology that simply makes tasks quicker or easier in mathematics education. Which often comes under fire from those who would oppose technology in mathematics education. Rather Pea supports a complete restructuring in the nature of the activities explored and the nature of the tasks performed.

Kaput (1992) has analyzed the position and importance of technology in mathematics education while posing the question: "What are the new things that you can do with technology that you could not do before or were not practical to do?" This notion reflects Pea's writing on the potential for technology to reorganize mathematical and scientific thinking and not solely amplify what is currently pursued. Kaput explains research on graphing systems to make accessible to students as young as the middle school level some of the core ideas of calculus like rate of change and explains that this can be done without the introduction of algebra (1992).

This opens such questions as: what curricular ideas are appropriate for what grade level and even what curricular ideas are appropriate for certain ability tracked classrooms? When and how

should graphing concepts and complex concepts such as rate be introduced to mathematics students?

Technology to Explore Graphing Concepts

As Frances Van Dyke (1994) explains, graphs should be emphasized when algebra is first introduced. Picturing the correct graph when given a situation or statement is a good intermediate exercise and promotes abstract thinking for the students. She explains that with the arrival and increased use of graphing calculators, students should become comfortable working with graphs. Van Dyke points out that often in real-world contexts, and examples, there are very few occurrences that can be explained or presented in clean algebraic notation, whereas a graph of this data can be drawn with the aid of a calculator and can then be analyzed.

Mevarech and Kramarsky (1997) report that graphing involves interpretation - the ability to read a graph and gain meaning from it - and construction - building a graph from data or points. Students do not read graphs without prior knowledge and they generally come into situations where reading graphs is necessary with a number of conceptions and misconceptions. Several misconceptions surrounding graphs and graph interpretation are common-

- considering the graph as a picture of an event or events (graph as a map);
- confusing an interval and a point; and
- Conceiving a graph as constructed of discrete points.

(Mevarech, 1997)

Fernandez (1998) also presents common student conceptions and misconceptions about graphs. She found that students often confuse the graph with the actual event and mistakenly use the visual configuration of the graph to describe the actual event. This is very much related to

students who consider a graph as a map or picture of an event. She eventually designed a research study where she examined student approaches to graphs and features of graphs created in real-time using motion-detectors.

Dunham's review of calculator research (1993) presented reports and studies that show students who use graphing calculator technology-

- place at higher levels in a hierarchy of graphical understanding;
 - are better able to relate graphs to their equations;
 - can better read and interpret graphical information;
 - obtain more information from graphs;
 - have greater overall achievement on graphing items;
 - are better at "symbolizing," that is, finding an algebraic representation for a graph
 - better understand global features of functions;
 - increase their "example base" for functions by examining a greater variety of representations, and;
 - better understand connections among graphical, numerical, and algebraic representations;
 - had more flexible approaches to problem solving;
 - were more willing to engage in problem-solving and stayed with a problem longer;
 - concentrated on the mathematics problems and not on the algebraic manipulation;
 - solved non-routine problem inaccessible by algebraic techniques; and
 - believed calculators improved their ability to solve problems.
- (Dunham, 1993, p.442-443)

This broad band of research conclusions gathered by Dunham points to the potential of graphing technology to affect the way students learn graphing concepts and problem-solving strategies.

Dunham expanded the research to explore the possibility for graphing technology to affect the types of learning students experienced and the attitudes students exhibited when using graphing calculator technology. After this review, Dunham found studies that concluded those students who use graphing calculator technology-

- were more active , they participated in more group work, investigations, and problem solving explorations (Dunham, 1993; Dunham & Dick, 1994);
- are better able to read and interpret graphs, understand global features, and relate graphs (Dunham, 1996); and
- female students improve in confidence, spatial ability, and algebra skills (Dunham 1995)

Hand-Held Technology and Data Collection Devices

Recommendations for graphing calculators in mathematics education and research supporting these recommendations have explored the potential of graphing calculators to enhance the students' experience with multiple representations of mathematical ideas, recommended by NCTM, (1989).

The NCTM Standards 2000 Draft states that the collection of real-time data through computer or calculator-based laboratories and data-collection devices provides ways for the students to analyze the data in meaningful and relevant ways. NCTM recommends these tools for the middle school classroom for the exploration of topics such as rate and rate of change that were previously reserved for calculus courses through empirical trial methods. While promoting the increased use of technology NCTM warns against the reliance upon such technology in lieu of development of knowledge of facts and procedures.

Pea's distinction between amplification and reorganization (1985) is relevant in terms of calculator technology. Calculators as supported by NCTM, and used effectively to explore graphs, should not take the place of learning to plot points on axes but rather open doors for exploring these points and graphs in terms of real-world conditions and scenarios. The tasks and approaches should be reorganized to support new and different ways of performing procedures instead of amplifying the tasks that had previously been performed.

Fernandez (1998) emphasized data collection devices used with graphing calculators in her study of students understanding graphs with technology. She describes data collection devices as having the potential to focus mathematics instruction on the features of the graphs rather than point by point analyses. Data collection devices such as the Texas Instruments CBR

and CBL units seem to be especially valuable for enhancing students' ability to interpret graphs and create graphical representations to describe actual events.

In her study, Fernandez (1998) worked with a high school mathematics teacher to observe the teacher instruct a weeklong unit to geometry and algebra students using calculators and data collection devices. Using motion detector devices attached to graphing calculators, the students manipulated graphs by exploring changes in their motion and subsequent changes in the graphs they were creating. The students became "investigators, and problem solvers/posers" (1998) in this study while discussing patterns and generalizations of the graphs they created. The results of the Fernandez study and research show that student understanding of graphical features and concepts such as rate of change had improved with the implementation of the graphing tools. Her study also suggests that data collection devices and units arranged around this equipment have implications for improving the attitude that students exhibit toward mathematics.

This technology provides students with tools to experiment in creating different graphical representations that involve motion and time, two important variables in the analysis of real data. Through this experimentation in a social context, the students expanded their roles in classroom interactions. Additionally, this study suggests the potential of this technology in promoting positive attitudes toward learning about mathematics. (Fernandez, 1998, p.78)

Summary

The research on technology in education presents evidence that the infusion of technology can prepare students for the entrance into an increasing technological workforce. Research on graphing calculators presents opportunities to involve more students learning through technology and for students to identify with mathematics. The disidentification hypothesis was of interest to this research as Steele (1992) outlines ways in which students might actively choose to not participate in mathematics after they are subjected to stimuli that devalue their achievement within a particular area.

Fernandez and Dunham's research imply that graphing calculators have the potential to help students identify with mathematics. Dunham's research on graphing calculator use among female students who improved in areas of confidence and spatial ability is relevant in this case. How can technology help students gain more positive attitudes toward mathematics, especially those low performing students who may exhibit negative attitudes toward mathematics and tracked into lower ability groups? How can hand-held calculators help middle school students learn mathematics?

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