The goal of this study was to identify factors of policy that facilitate or hinder teachers’ implementation of technology in their classrooms. This study employed a qualitative research design, focusing on middle school mathematics teachers, their principal, and the district curriculum coordinator. A qualitative research design was used in the study because it allowed for in-depth understanding of teachers’ and administrators’ conceptions of school policy in middle school mathematics, particularly with regard to policy effect on technology implementation.

Data were collected about teachers’ and administrators’ conceptions of school district policies concerning the implementation and use of computing technology for teaching and learning mathematics. Within the district, teachers from Grade 6 were chosen for interviews. I also interviewed the district curriculum coordinator and school principal. A grounded theory approach and constant comparative analysis were applied to the data.

The results of this study indicated the participants’ conceptions and understanding of computers’ educational roles evolved from simple tools for productivity and motivation to diverse and advanced roles for learning concepts and developing thinking skills. They also
developed critical concepts related to teaching with technology, including teachers’ roles, pedagogy and students’ characteristics. The results of this study also indicate that the participants’ conceptions of technologies’ educational roles, which are supported by district policy, were as: (a) simple tools for productivity and motivation (b) a medium through which concepts are learned and thinking skills are developed and (c) tools to help develop critical concepts related to teaching with technology, including teachers’ roles, pedagogy, and students’ characteristics.

This study suggests more effort should be put into effective use and integration of technology into the mathematics classroom. As advances in computing technology occur, the implementation of this technology should be studied in efforts to achieve continuous improvements in technology implementation policy and in mathematics education.

INDEX WORDS: School district policy, Middle school mathematics, Secondary school mathematics, Computing technology, Technology implementation, Conceptions of technology, Beliefs
TEACHERS’ AND ADMINISTRATORS’ CONCEPTIONS OF SCHOOL POLICY AND ITS IMPACT ON TECHNOLOGY IMPLIMENTATION

by

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CHAPTER 1
Introduction and Overview

To a great extent, the success of any educational reform approach depends on teachers’ belief in the reform effort and their will to implement the proposed changes (Handel, 2003). It also depends on district and school administrators and the development of teachers’ professional skills necessary to implement the reform (Roulet, 1998). Similarly, teachers’ conceptions of technology policies, relative to what those policies are, will have an impact on technology implementation (Knapp, 2002). In the current economic and educational context, there has been an increased emphasis on the technological components of teachers’ professional development, because technological growth and increased emphasis on educational accountability have occurred in tandem (Donnelly, Dove, & Tiffany-Morales, 2002).

The United States Constitution delegates accountability for education to the states. Through advocacy, policy, information, and financial support, both nongovernmental educational organizations and governmental agencies at the state and local levels have provided leadership in getting schools technologically equipped to deliver a “world-class” education to all students (Donnelly et al., 2002). These groups have mobilized in pursuit of several common goals: increased equity, improved classroom environments, and improved student outcomes. However, now that the information age is underway and large investments are being made in computing technology, is there evidence that the mathematics education community is moving toward these goals (Donnelly et al.)?
States provide leadership in implementing education reform. This leadership includes, but is not limited to: setting academic standards, setting initial teacher certification and re-certification requirements, and setting technology-related standards for teachers. State-driven policies and standards have created demand for technology-related professional development at the local level because teachers may not be prepared to effectively teach with technology (Donnelly et al., 2002).

In some states, evidence of low student performance has led to a focus on the quality of the teacher workforce and to efforts to align teacher preparation, certification, preservice teacher induction, and continuing professional development policies with the higher academic and performance standards established for students (White, 1998).

**The Effect of Technology on Teaching**

Schools have been integrating increasingly sophisticated technologies into classrooms over the past 100 years (Donnelly et al., 2002). Teachers and school staff quickly embraced and mastered these technologies because they saved time (Donnelly et al.). Many teachers have embraced these technologies because they have made their professional responsibilities easier.

Even though the new technology of the day has been introduced into the classroom, these technologies have had little impact on teaching. In general, the introduction of various technologies into schools and classrooms throughout the past century has not altered basic patterns of teaching (Abrami, 2001; Albion, 2003; Kaput 1992; Kilpatrick, personal communication)—and this is precisely the challenge that confronts current proponents of technology integration. Even though virtually every other type of institution in the country has changed noticeably in the past 100 years because of technology, basic classrooms instruction remains relatively unchanged (Kilpatrick).
Computing Technology and Reform

Computers and related technologies are in classrooms across the nation. As the focus of technology expands, researchers in mathematics education have an opportunity to investigate the use of this technology for teaching and learning (Fouts, 2000).

When the computer was introduced into education, its first use had teachers and students learning to program (Fouts, 2000). As software gained in sophistication, the computer in some cases became the tutor or surrogate teacher. Some teachers saw the value of the computer in creating a rich learning environment. Real problem solving in collaborative groups was often used in these teachers’ classrooms. Abstract concepts could be illustrated and manipulated because of computing technology advances. A whole new learning environment became possible (Fouts).

Over the past few years, much research in mathematics education has focused on reform efforts. This research has been largely driven by reaction to informative documents developed by the National Council of Teachers of Mathematics (NCTM) and other organizations such as the National Research Council (NRC) and the Mathematical Science Education Board (MSEB) (Ferrini—Mundy, 1990; Stallings, 1995). Three major documents published by NCTM (1989, 1991, 2001)—Curriculum and Evaluation Standards for School Mathematics, Professional Standards for Teaching Mathematics, and Principles and Standards for School Mathematics—have influenced many discussions about mathematics teaching and learning among classroom teachers, administrators, researchers, other mathematics educators, and others. One driving question is the following: What type of classroom environment stimulates students to become more mathematically powerful learners? The type of classroom described in the Professional Standards for Teaching Mathematics (NCTM, 1991) is a mathematical community in which
conjecturing, investigating, reasoning, and problem solving are key components. These activities are intended to engage students in the development of mathematical ideas as they attempt to make sense of their environment.

The National Council of Teachers of Mathematics (2000) has a stated vision for school mathematics. In part it states:

Imagine a classroom, a school, or a school district where all students have access to high-quality, engaging mathematics instruction. There are ambitious expectations for all, with accommodation for those who need it. Knowledgeable teachers have adequate resources to support their work and are continually growing as professionals. The curriculum is mathematically rich, offering students opportunities to learn important mathematical concepts and procedures with understanding. Technology is an essential component of the environment. (p. 3)

Although there is a growing body of research that suggests technology can enhance and improve learning (Jonassen & Reeves, 1996), there is no consensus as to how to implement computing technology to enhance and improve learning in the mathematics classroom. The effectiveness of technology will vary with situational variables (Johnston & Barker, 2002). Variations will be caused by goals and resources for instruction, the extent to which all learners’ needs are considered, teachers’ comfort and skill with technology, and the type of technology available (Johnston & Barker).

**Technological Pedagogical Content Knowledge**

The effective use of technology in the mathematics classroom has long been a consideration of mathematics educators (Grandgenett 2008). Important questions are: Should teachers allow students who do not know the fundamentals of basic arithmetic operations to use calculators? Should those same students who are doing real-life application activities that require a great deal of repetitive arithmetic calculations be allowed to use calculators? The answers to these questions depend on how content, pedagogical, and technological knowledge might best
intersect within the learning of specific mathematical topics? It also depends on the individual learner. How and when technology should be used in the mathematics classroom is not an easy question for mathematics educators to answer.

According to Grandgenett, “Technology has had a considerable impact on the content of the mathematics discipline itself (p. 147)” Part of the current challenge in understanding how and when technology can be used effectively is that mathematics content itself is a rapidly moving “target.”

As the role of technology continues to expand and evolve, it is important that teachers are adept at deciding where technology fits in mathematics instruction. Without using technology in their teaching, teachers may miss an important opportunity to aid their students’ understanding. They may even misrepresent mathematical concepts that can more appropriately be modeled using technology. However, if technology is used inappropriately or too freely, there may be a risk of deepening students’ misconceptions and expanding bad habits. “Thus, addressing technological pedagogical content knowledge (TPCK) carefully within teacher preparation may well be the difference between students having an effective or ineffective teacher (Grandgenett, p. 149).”

**Rationale**

Though billions of dollars have been spent on technologies for schools, access to that technology continues to be labeled a major barrier to technology implementation (Niess, 2006). In some situations where technology is readily available, some teachers do not know how to take advantage of it and still others are against it (Niess). Are the barriers to computing technology related to access, constraining how mathematics is to be learned (Niess)?
The school district plays an influential role in the local implementation of instructional reform (Berman & McLaughlin, 1977; Firestone, 1989; Spillane, 1996, 1999). This role involves the manner in which state and federal policy proposals are understood and disseminated by the district office. The manner in which instructional policy is understood influences their classroom implementation those of proposals. Implementation failure at the district office level is a function of local actors’ inability or unwillingness to carry out policy proposals and a function of district officials’ interpretations of the policy (Spillane, 2000). Fullan (1994) argues that neither top-down (which entails a view from outside classrooms and schools) nor bottom-up (which is more focused on the individual circumstances of particular teachers and schools, paying particular attention to teachers’ learning and growth over time) strategies work for educational reform. He proposes a blend of the two. Yepes-Baraya (2000) suggests administrators’ support to make time, resources, and support services to teachers, and the willingness of teachers to integrate technology into the classroom are necessary for successful technology integration.

In this study, district officials refers to those district administrators, curriculum specialists, and lead teachers who, because of their formal position or informal role, are actively involved in developing district policies about mathematics instruction and supporting teachers’ efforts to implement these policies. District officials decipher what a policy means and decide whether and how to adopt, adapt, or ignore policy proposals in local policies and practices (Spillane, 2002). Spillane explains:

District officials’ interpretations of policy proposals are not all that is likely to influence local implementation. School districts are not only interpreters of others’ policies but also makers of their own policies and programs, which are designed to guide teachers’ instructional practice. District officials must figure out whether and how to communicate their understandings of the policy message to teachers and school leaders. Rich understandings of the policy at the district level, though necessary, are unlikely to be sufficient for doing that job well. (pp. 377–378)
Administrators’ attitudes and beliefs play a key role in whether technology is used in the classroom. Some researchers have found that technology is best integrated into the curriculum when it is part of a school’s goals (Peterson, 1999; Pickens, 2001). School administrators’ expectations and encouragement are vital to the infusion of technology into the educational process (Chin & Hortin, 1994; Topp, Mortensen, & Grandgenett, 1995). In addition to believing they are being supported and encouraged to use technology, teachers must also believe their environment is supportive of the “risk taking” necessary for trying new techniques (Brunner, 1990; Topp et al., 1995). Brunner (1990) emphasized that, “administrators must encourage experimentation and collaboration among teachers, and not be afraid to risk disruption and even short-term failure in the interest of innovation and reform” (p. 14). Because teachers and administrators are the ultimate decision makers on how and whether technology is used in the classroom, their attitudes and beliefs play a key role (Okinaka, 1992). When teachers understand how technology can be used effectively, their attitudes are positively affected (Okinaka).

Venezky (1999) suggests that teachers need specific models to integrate technology into the classroom beyond the information provided in basic technology skills courses. Effective models provide information relative to technology and about changes in the traditional roles of teachers and students. He argues that few technology-in-education programs explicitly include organizational changes as one of the required elements for successful technology integration into the classroom.

I believe there are questions that frame the challenge for the development of a research agenda for mathematics education that are directed toward assuring that all teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology into teaching and learning mathematics. Some of these questions are the following:
What technologies are adequate tools for teaching and learning mathematics; what are teachers’ conceptions about teaching mathematics with technology? And what are the barriers to implementing appropriate technology in the teaching and learning of mathematics?

To help answer these questions, we need to know how the policy environment surrounding teachers gives guidance about what should be taught and how it could be taught. By looking at the ways in which policy actions can stimulate local systems and motivate or support individuals’ actions, we will be able to generate analyses regarding the often indirect, though potentially powerful, influences policy may have on professional work.

**Significance of the Study**

Research about teachers’ conceptions of school and school district policies concerning the use of technology in teaching and learning mathematics is lacking. My research goal was to identify factors of policy understanding and implementation that facilitate or hinder teachers’ use of technology in their classrooms. I expected to construct a model of relationships among the factors with the hope that such a model would help provide directions for future research, policies, and practice. My study would contribute to the literature on computing technology in the mathematics classroom by addressing technology policy concerns within an education system.

My research can inform school district policy makers, school administrators, teachers, and researchers about teachers’ and administrators’ conceptions of school policy including school district technology implementation policies. I am interested in informing these groups, who are involved in policy decision making, on how policy affects the use of computing technology for teaching and learning in the mathematics classroom.
Research Questions

1. What is the policy of a Georgia school and its district concerning the use of technology in the teaching and learning of mathematics?

2. What do district officials think that policy is?

3. What are a school’s mathematics teachers’ conceptions of their school and district policy concerning the use of technology in the teaching and learning of mathematics?

4. What policy objectives do the teachers believe encourage or discourage them in their efforts to use computing technology in their mathematics teaching?
CHAPTER 2

Theoretical Framework

The role of implementers’ sense-making in the implementation process affects the reform ideas that they construct from policy influence. (Ball, 1994; Hill, 2001; Lin, 1998, 2000; Spillane, 2000; Yanow, 1996). Implementation involves interpretation because implementers must figure out what a policy means and whether and how it applies to their school to decide whether and how to ignore, adapt, or adopt policy locally (Spillane, Diamond, Burch, Hallett, Jita & Zoltners, 2002).

An important aspect of cognition is sense-making, is the ways in which people make sense of their environments. Sense-making implies that “people generate what they interpret;” interpretation is part of sense-making (Weick, 1995). Blumer (1969) argued, “Human beings act towards things on the basis of the meaning that things have for them” (p. 2). Weick (1995) argued that sense-making is takes place in the context of ongoing projects, leading to behaviors that enact the environment. Sense-making is situated, which means that is tied to the situation in which stimuli are noticed, interpreted, and subsequently acted on (Brown, Collins, & Duguid, 1989; Resnick, 1991; Suchman, 1988; Weick, 1995).

Institutional Sector and Sense-making

School officials’ actions are situated in institutional sectors that provide norms, rules, and definitions of the environment that constrain and enable action (DiMaggio & Powell, 1991; Scott & Meyer, 1991). These schemata define appropriate structures and give meaning and order to human action in institutional sectors (Scott, 1992). In this scheme, education policy preserves
the legitimacy of the institution to maintain public support (Meyer & Rowan, 1977).

In this study the cognitive perspective acknowledges that although institutional arrangements structure human sense making they do not obliterate human agency, which shapes these arrangements (Giddens, 1984). Therefore, attention was given to the influence of local agents in constructing policy messages.

Political Circumstances and Sense-making

Political arrangements are also an important context for school official’ sense-making; they face major political challenges because their position in the organizational hierarchy focuses their work in at least two directions. On one hand, school leaders are “street-level” workers dependent on and responsible to their local community stakeholders and the district office for implementing school policy (Lipsky, 1980). On the other hand, school leaders depend on classroom teacher for the successful implementation of these policies.

Relations between district office and school leaders and between classroom teachers and school leaders are characterized by dependency and conflict (Lipsky, 1980). Actors at each level of the school system operate in relatively independent political arenas mobilizing resources that can be used to advance, sabotage, or ignore the efforts of actors at other levels (Firestone, 1989).

The interests and objectives of district office and school leaders are often in conflict with those of teachers. School leaders seek to achieve results consistent with school district objectives and work to restrict teachers’ autonomy and discretion. However, school principals’ formal authority with respect to teachers is limited, with principals relying on more subtle strategies including the manipulation of language and ideological control (Anderson, 1991; Dreeben, 1970; Lortie, 1975).
The autonomy that teachers exercise is in part a product of their isolation and conditions that leave them to practice alone with little direct supervision (Lortie, 1975). Teachers have some important resources with which they can resist managers’ directives such as their expertise and willingness to get involved in the school’s agenda. Teachers use a variety of strategies to influence administrators including bargaining, bluff, threats, and flattery (Bridges, 1970; Fraatz, 1987). Consequently, classroom teachers have a relatively high degree of discretion and relative autonomy from organizational authority, which contributes to school leaders’ dependency on teachers.

School leaders seek to achieve results consistent with school board objectives and work to restrict teachers’ autonomy and discretion. Teachers are partially dependent on principals and other school leaders who allocate funding, curricular materials, and class assignments. School leaders’ sense-making is situated in this set of political relations in which different actors and groups of actors use power to influence each other and preserve their own interests and agendas. Spillane et al. (2002) emphasize

Local actors must first figure out what a policy or innovation means to decide whether and how to ignore, sabotage, adapt, or adopt it to suit their self-interests. Political arrangements are an important context for local actors’ efforts to make sense of policy. (p. 735)

**Theories of Institutional Organization**

Researchers who study policy processes in education have been interested in understanding the conditions under which ideas incubated and tested in the field spread across schools and become adopted at a system level (Coburn 2004). They refer to such processes as “bottom-up approaches” to educational reform (Knapp, 2002). Researchers who study bottom-up processes of institutional change identify three factors as variables in the locus of institutional change. Suchman (1995), defines “locus of institutional change,” as the source from which
changes in established practices originate, whether they arise from local conditions, such as the actions and decisions of school staff, and parents and diffuse upward and outward or originate in the broader environment, such as the actions and decisions of policy decision makers, and diffuse downward. According to Suchman, possible environmental sources of change include (a) the level of ideological conflict in the field, (b) the recurrence of a problem that affects actors who are vocal and not tied to the status quo, and (c) actors’ ability to situate the problem in a broader institutional or policy discourse, by relating the problem to some established policy criterion or value, such as equity or efficiency.

Educators, tend to view policy conflict and contradiction as detracting from successful policy implementation (Coburn, 2004). Institutional theorists offer an alternative view on the role of ideological conflict in social change (Fligstein, 1990; Scott et al., 1996; Scott, Ruef, Mendel, & Caronna, 2000). From their perspective, when there is deep ideological disagreement, there is also ambiguity. Long-standing approaches can come under scrutiny. The ideas that people have taken for granted no longer seem as secure. Because things do not sit right, there is more pressure and support to ask hard questions about what constitutes best practice. From this perspective, where there are heated public debates about public policy, it can be assumed that strategic opportunities also exist. Under these conditions, organizations that lack institutional legitimacy or conventional resources such as money can introduce changes in the design and delivery of educational policy (Coburn, 2004).

**Position in the Field**

A critical insight from implementation research in education is the importance of local *will* and *capacity* in reform implementation (Honig, 2006; McLaughlin, 1990). Will is generally assumed to be implied by implementers’ dispositions toward educational policy. Capacity is
assumed to be the degree to which implementers possess the skills, knowledge, networks, and financial resources to execute reform ideas (Coburn, 2004).

From an institutional perspective, understandings of capacity derive from and reflect wider cultural norms and established practices (Coburn, 2004). The more established an organization is in a field, the more likely that taken-for-granted understanding of capacity will reflect its views. In the organizational field of mathematics education, approaches to teacher learning have tended to reflect the norms of dominant players such as national professional associations and university faculty members in emphasizing the importance of credentialing and formal expertise in teachers’ mathematics preparation. In some ways, this is the kind of deterministic perspective that has alienated some education researchers from institutional theory (Coburn, 2004).

Yet the rise of agency-based perspectives in institutional theory provides scholars with new conceptual tools for examining institutional change. These scholars have attended to how less established individuals and organizations within organizational fields can disrupt long-standing practices and introduce new ideas (Galaskiewicz, 1991; Suchman, 1995; Ventresca & Porac, 2003). Unlike more established players, marginal organizations have less interest in maintaining the status quo and reinforcing existing practices. These organizations can and do intervene preemptively in the cultural environment to develop bases of support for their ideas.

Institutional theorists have tended to explain changes in established practices as largely precipitated by top-down forces originating at a macro level, for example in the practices of nation states or the world economy (Zucker, 1987). More recently, scholars working in the institutional tradition have attempted to understand the conditions that shift this dynamic and enable individuals and organizations working at the local level to initiate changes in established
practice (Dorado, 2002; Edelman, 1992; Edelman Uggen, & Erlanger, 1999; Galaskiewicz, 1991; Oliver, 1991; Suchman, 1995). For example, Oliver considered the range of strategic responses that individuals may adopt when responding to institutional pressures, which include compromise, avoidance, defiance, and manipulation.

Scholars studying policy processes in education also have been interested in understanding the conditions under which ideas incubated and tested in the field spread across schools and become adopted at a system level. They refer to such processes as “bottom-up approaches” to educational reform (Knapp, 2002).

*Educational Policy and Practice*

Institutional theory says that although policy designs and behavior are connected to larger social and cultural beliefs, these frames can change as people go about their work and as they implement policies and plans (Burch, 2007). Through interactions, individuals and organizations can transform the meaning of policy and create new tools and frames for addressing problems, frames that then are incorporated into new policies and the institutions created to support them (Burch).

Research that applies institutional theory to education also has offered explanations for why organizations that are located in very diverse settings and that may have little interaction nevertheless adopt policies and practices that are very similar (Ogawa, 1992; Rowan, 1982, 1995, 2001; Rowan & Miskel, 1999; Tyack & Tobin, 1994). For example, Ogawa argued that the popularity of school-based management as a reform strategy in the 1980s and 1990s originated from institutional pressures, called *structural isomorphism*, and was fueled by schools’ and school districts’ efforts to imitate other schools and signal their commitment to decentralized authority.
**Structural Isomorphism**

Structural isomorphism refers to the convergence in policies and practices among organizations operating in a similar environment or competing for the same goods (Burch, 2007). Organizations adopt practices that they think others view as exemplary or that are considered routine. These cues exist in the broader environment. They may be reflected in public policy designs or laws, they may be visible through the practices of “model” organizations, or they may reside in the public discourse of scientists and professionals such as findings presented at conferences or published in scholarly journals. These cues also are presumed to be interactive (Burch).

Burch (2007) explains:

> For example, when a new organizational position, such as chief technology officer, becomes widespread across districts, the idea gains legitimacy and starts to be seen as necessary and contributing to district innovation or efficiency. These ideas then can become further codified in policy, as when states and federal government start to require that districts establish chief technology officers as a condition for receiving funds. (p. 85)

**Loose Coupling**

Loose coupling is the third core construct frequently used in institutional analyses of educational reforms (Coburn, 2004; Deal & Celotti, 1980; Driscoll, 1995; Firestone, 1985; Malen, Ogawa, & Kranz, 1990; Rowan & Miskel, 1999). The dependence between organizations and their institutional environments produces organizational forms and policy practices that often are loosely coupled with policy makers’ intentions.

In the 1970s and early 1980s, institutional analyses of organizations tended to be built around Parson’s (1960) ideas about the inevitability of loose coupling between the technical and institutional levels of management in organizations. Parson’s view was that actions taken to align organizations with societal norms and values frequently conflicted with technical activities
designed to foster organizational goal attainment, leading to what he saw as a “qualitative break” across the technical and institutional levels of organizational management.

Schools in the United States have been pointed to as a prime example of this kind of loose coupling (Coburn, 2004). Operating in a societal sector characterized by fragmented, multi-layered governance, U.S. schools were seen as striving to conform to many different, and potentially inconsistent, rules and regulations (Coburn, 2004). It was feared that the faithful implementation of such diverse rules would produce classroom conflict and uncertainty. Given the variability of local instructional activities, some questioned whether such implementation was even possible.

Studies that draw on institutional theory have helped in understanding of how educational policies and practices interact with institutional environments to shape policy outcomes (Burch, 2007). In particular, these studies have drawn attention to the role of non-rational factors in shaping whether and how policies achieve their intended impacts. They have provided explanations of why schools and governing agencies with different needs and in diverse settings adopt practices and policies that are similar. These studies have provided a conceptual framework for understanding the absence of substantive change in classroom practice even when adopters comply with policy (Burch).

**District Officials’ Conceptions**

District officials’ interpretations of policy proposals influence local implementation (Spillane, Reiser & Reimer, 2002). School districts are interpreters of others’ policies and makers of their own policies and programs, which are designed to guide teachers’ instructional practice. District officials figure out whether to and how to communicate their understandings of policy messages to teachers and school leaders. Good understandings of the policy at the district level,
though necessary, are unlikely to be sufficient for communicating understanding well (Spillane, et al., 2002).

Research by Spillane (1999) and Spillane and Zeuli (1999) is based on data from a 5-year study that examined relations between state and local government policy making and mathematics and science instruction. The study investigated the implementation of national and state policies at the district office and classroom levels using quantitative and qualitative methods.

Focusing on district officials’ theories about instructional change, the Spillane and Zeuli (1999) analysis explores district officials’ thinking about teacher learning and change. Such a focus is important because structural aspects of professional development alone are unlikely to provide a good gauge of its likely effectiveness. Instead, what is important are the pedagogy and content of professional development (Ball, 1994). Professional development is rooted in the training paradigm, focused on individual teachers through short-term activities that involve little follow-up and little coherence or coordination (Little, 1981; 1993; Miller, Lord, & Dorney, 1994).

District officials’ theories about teacher learning are important issues (Spillane, Reiser & Reimer, 2002). A combination of pressure including bureaucratic control and accountability mechanisms, and support in the form of curricular materials and professional development is thought necessary by some researchers if teachers are to implement instructional reform proposals (Elmore & McLaughlin, 1988; McDonnell & Elmore, 1987). In the U. S. education system, many governmental and nongovernmental agencies provide support and sometimes apply pressure to guide teachers’ practice. Pressure, though necessary, is believed to be insufficient for local implementation (Elmore & McLaughlin). Support is essential, and the
school environment is possibly the most influential environment with respect to teacher support (Elmore & McLaughlin).

Support is especially important with respect to the implementation of standards-based reform because the complex changes in instruction that characterize these reform proposals require substantial learning by those who are expected to implement these changes (Cohen & Barnes, 1993). Teachers often mistakenly understand instructional reform proposals to involve only minor changes in their existing conceptions of teaching, learning, and subject matter (Spillane & Zeuli, 1999). Even if teachers construct the reform message in ways that resonate with its intent, they may lack the requisite knowledge to put it into practice. Hence, teachers will have to learn a great deal to successfully implement the tremendous changes in instruction pressed by standards-based reforms (Cohen & Barnes, 1993; Schifter, 1996).

This learning is difficult, both for the teachers and for those who teach them, because the new disciplinary content and pedagogy represent such a tremendous shift from how teachers teach and how they learned in school (Spillane et al. 2002). Further, this learning depends in some measure on the capability of district officials, both administrators and lead teachers, to promote teacher learning from and about standards. District officials’ support of teachers’ learning from and about standards depends on their understanding of the instructional ideas advanced through these reforms and on their ideas about communicating these understandings to teachers; that is, their beliefs about and knowledge of teacher learning. One’s understanding of a policy message does not ensure that one can help others understand that message (Spillane et al.).

Most district officials in the Spillane et al. (2002) study thought that professional development was crucial if teachers were to implement the mathematics and science standards.
District officials’ theories about teacher change learning fell into three categories—behaviorist, situated, and cognitive.

The behaviorist perspective, associated with B.F. Skinner, holds that the mind at work cannot be observed, tested, or understood; thus, behaviorists are concerned with actions (behavior) as the sites of knowing, teaching, and learning. Knowledge is transmitted by teachers and received, but not interpreted, by students. Transmission is the instructional mode, and to promote effective and efficient transmission, complex tasks are decomposed into hierarchies of component sub skills that must be mastered in sequence from simple to complex (Gagne, 1965). Learning is externally motivated by reward and requires developing correct reactions to external stimuli. Well organized routines of activity, clear instructional goals with frequent feedback and reinforcement, and the sequencing of skills from simpler to more complex are important in the design of learning opportunities.

The situative-sociohistoric perspective (Lave, 1988; Pea, 1993; Resnick, 1991; Vygotsky, 1978) regards individuals as inseparable from their communities and environments. This perspective views knowledge as distributed in the social, material, and cultural artifacts of the environment. Knowing is the ability of individuals to participate in the practices of communities (e.g., the mathematics community). Learning involves developing practices and abilities valued in specific communities and situations. The motivation to engage in learning is seen in terms of developing and sustaining learners’ identities in the communities in which they participate. Thus, learning opportunities need to be organized so that they encourage participation in practices of inquiry and learning, support the learner’s identity as skilled inquirer, and enable the learner to develop the disciplinary practices of discourse and argumentation. Learning opportunities need to be grounded in problems that are meaningful to the learner.
The cognitive perspective (Piaget, 1970) seeks to understand and describe the working of the mind. Knowledge, in this view, includes reflection, conceptual growth and understanding, problem solving (Newell & Simon, 1972), and reasoning. Learning involves the active reconstruction of the learner’s existing knowledge structures, rather than passive assimilation or rote memorization, with learners using personal resources including their prior knowledge and experiences to construct new knowledge (Anderson & Smith, 1987). In this view change is enabled through reflection on one’s beliefs and knowledge. The motivation to learn is intrinsic and extrinsic motivators can undermine intrinsic motivation (Lepper & Greene, 1979). Learning activities engage students’ interest and prior knowledge, sequence their conceptual development, and introduce students to the core principles of a domain. This view of learning resembles what Richardson (1996) terms the normative-re-education perspective on teacher learning, in which change is enabled through reflection on one’s beliefs and knowledge.

**Teachers’ Conceptions**

Thompson (1984) defines teachers’ *conceptions* as their beliefs, views, and preferences about the subject matter and the teaching of that subject matter. Her research report presented case studies conducted to investigate the conceptions of mathematics and mathematics teaching held by three junior high school teachers. Thompson examined the relationship between conceptions and practice and looked at properties of the participants’ conceptual systems. She found that “the teachers' beliefs, views, and preferences about mathematics and its teaching regardless of whether they are consciously or unconsciously held, play a significant, albeit subtle, role in shaping their instructional behavior” (pp. 124-125). She also explained differences among the teachers in their conceptions and practices.
**Beliefs Systems**

Teachers’ *mathematical beliefs* refer to those belief systems held by teachers on the teaching and learning of mathematics. Some educational researchers have tried to decompose a framework for teachers’ mathematical belief systems into smaller sub–systems (Handal, 2003). Most researchers believe that a system should consist primarily of beliefs about; what is mathematics, how mathematics teaching and learning actually occurs, and how mathematics teaching and learning should ideally occur (Ernest, 1989; Thompson, 1991).

From the Third International Mathematics and Science Study (TIMSS), Beaton, et al. (1996) concluded that most teachers believe mathematics is essentially a vehicle to model the real world. They also believe that ability in mathematics is innate, and that more than one representation should be used in explaining a mathematical concept.

According to Telese (1997), a combination of beliefs may be described as a belief system, which is restricted as individuals reflect on their beliefs. Individual teachers possess particular beliefs of varying degrees of conviction that develop into personal perspectives of the subject matter. Thompson (1992) argues that belief systems are organized into teachers’ conceptions of mathematics with the following components: conscious or subconscious beliefs, concepts, meaning, rules, mental images, and preferences concerning the discipline of mathematics. Ernest (1988) believes that the teacher’s subject matter conception resides in his or her belief system. He suggests that the key belief component of the mathematics teacher is the teacher's conception of the nature of mathematics and his or her belief system concerning the nature of mathematics as a whole. Ernest suggests that although knowledge is important, it is not sufficient by itself to account for the differences among mathematics teachers.
There is a broad diversity in the direction and intensity of teachers' beliefs (Carpenter, Fennema, Loef, & Peterson, 1986; Moreira, 1991). This fact led some researchers to think that these differences could be alternatively interpreted either as stages of a developmental process, individual cognitive differences, or as simply due to differences in socio-economic status, educational systems, or cultural environments (Moreira, 1991; Stonewater & Oprea, 1988; Thompson, 1991; Whitman & Morris, 1990).

Handel (2003) contends that “the range of teachers’ mathematical beliefs is vast since such a list would include all teachers’ thoughts on personal efficacy, computers, calculators, assessment, group-work, perceptions of school culture, particular instructional strategies, textbooks, students’ characteristics, and attributional theory, among others” (p. 47). Teachers hold unique belief systems that consist of a wide range of beliefs about learners, teachers, teaching, learning, schooling, resources, knowledge, and curriculum. Their decisions are filtered through their belief systems; therefore they do not rely wholly on their pedagogical knowledge or curriculum guidelines (Clark & Peterson, 1986).

Teachers’ theories of learning and teaching are related to their approaches used in the classroom. They are fundamental because they indicate the teacher’s perception of the learner’s role as active or passive, as dependent or autonomous, or as receiver or creator of knowledge. Ernest (1991) outlined a developmental sequence of five mathematics-related belief systems that can be found among mathematics teachers: authoritarian, utilitarian, mathematics-centered, progressive, and socially aware. Ernest’s contribution showed that it is possible to relate these attitudinal representations to conceptions on the theory of mathematics, learning mathematics, and teaching mathematics, and beliefs on the aims of mathematics education, as well as assessment in mathematics.
According to Ernest (1991), the most important aspect of these mathematics-related belief systems is the teacher’s philosophy of mathematics. Ernest proposed three main philosophical conceptions of mathematics that vary on a continuum from absolutist to constructivist views among teachers: the instrumentalist view, the Platonist view and the problem solving view. In the instrumentalist view, mathematics is seen as a collection of rules and skills that are to be used for the attainment of a particular goal. Teachers who hold the Platonist view maintain that “mathematics is a static but unified body of certain rules” (p. 250) that are to be discovered and are not amenable of personal creation. Teachers who hold the problem solving view present mathematics as a continuous process of inquiry that always remains open to revision.

Beliefs aligned with the traditional absolutist view and non-traditional constructivist views of mathematics are associated with teachers' conceptions of mathematics (Roulet, 1998). Absolutist and constructivist views are distinguished in the teaching of mathematics (Thompson 1984), as well as teachers’ conceptions of mathematics and science (Ernest, 1988).

Teachers’ with a traditional or absolutist conception of mathematics describe the mathematics subject as a vast collection of fixed and infallible concepts and skills (Romberg, 1992) and a useful but unrelated collection of facts and rules (Ernest, 1989). These teachers adhere to the belief that mathematics is an unrelated collection of facts and mathematical knowledge becomes certain and absolute truths. Finally, Ernest (1996) summarizes teachers’ absolutist views about mathematics by saying:

Absolutist views of mathematics are not concerned to 'describe' mathematics or mathematical knowledge…Thus mathematical knowledge is timeless…it is superhuman…it is pure isolated which happens to be useful because of its universal validity; it is value-free and culture-free, for the same reason. (p. 2)
A different more “fashionable and fruitful” (Philip, 2000, p. 2) conception of mathematics among teachers is constructivism: “the image of mathematics, which is growing in popularity among mathematics educators” (Roulet, 1998, p. 29). The reforms proposed by NCTM (1989) are rooted in constructivism and they support the transition of teachers’ mathematics conceptions from the traditional absolutist view to a non-traditional constructivist view (Roulet, 1998). Constructivism, a theory of learning, is one alternative view to the traditional absolutist view.

Teachers tend to have a more traditional absolutist orientation in their beliefs about teaching because early in their careers their beliefs are influenced by the way they were taught. Consequently, they tend to model their previous teachers. As teachers gain experience and are exposed to professional development, a good number of them will adopt beliefs more consistent with the non-traditional constructivist views advocated by the National Council of Teachers of Mathematics (NCTM), (Roulet, 1998).

Hersh (1986) suggests, “One’s conception of what mathematics is affects one’s conception of how it should be presented” (p. 13). Further, according to Ernest (1988), teachers’ conceptions of the nature and meaning of mathematics are crucial to teachers’ approach to mathematics teaching.

Teachers’ practices are influenced by many factors. Ernest (1988) emphasizes there are these factors (elements): teachers’ system of beliefs about mathematics and its teaching and learning, the social context of the teaching situation, and teachers’ level of reflection. Although it seems teachers’ beliefs about mathematics and its teaching and learning receives attention equal to the other elements, Ernest emphasizes the importance of mathematics teachers’ beliefs by claiming that teachers' approaches to mathematics teaching depend basically on their
systems of beliefs; in particular on their conceptions of the nature of mathematics, and on their mental models of teaching and learning mathematics.

**Teachers’ Conceptions and Instructional Practices**

Because of the relationship between teachers’ beliefs and students’ learning outcomes, in order to improve the quality of mathematics teaching and learning, a researcher should begin with an understanding of the conceptions held by the teachers and how these are related to their instructional practices. According to Thompson (1984), failure to recognize the role that the teachers’ conceptions might play in shaping their behavior is likely to result in misguided efforts to improve the quality of mathematics instruction in the schools. It is often the case that teachers are not fully aware of their beliefs (Garrah, 2003). By helping them to define their own implicit theories, it is possible they may become more reflective (Herring, 2000). If teachers have a chance to reflect upon their own beliefs and behaviors, they will be able to evaluate their role as teachers. Those who do reflect have greater control over their thinking and consequently can make more informative decisions as to their instructional practices and behaviors and how these affect their students (Jost, 1992).

Teachers’ instructional practices are greatly influenced by their beliefs, but mitigated by other factors in the educational environment and the community (Thompson, 1992; Pajares, 1992). The context of school instruction may cause teachers to teach mathematics in a traditional way, even when they may hold alternative views about mathematics and about mathematics teaching and learning. Parents and professional colleagues expect teachers to teach in a traditional way. Teachers are also expected to focus on external examinations, to adhere to a textbook, and to keep a low level of noise and movement in their classrooms. In these kinds of
school environments, even teachers with progressive educational beliefs may be forced to compromise and conform to traditional instructional styles (Handal, 2003).

Examining teachers’ beliefs and the relationship between their beliefs and their instructional practices can play a significant role in improving the quality of mathematics instruction. The literature on teachers’ beliefs reveals that although many researchers indicated that there is a strong relationship between teachers’ beliefs and instructional practices, many also indicated that teachers’ stated beliefs and their instructional practice are not always consistent. It is often the case that teachers are not fully aware of their beliefs. Because of the very close relationship of beliefs and knowledge, one might treat one’s knowledge as beliefs or vice versa (Thompson, 1992).

Research indicates that mathematics teachers’ conceptions about subject matter, teaching, and learning influence their actions in the classroom (Carpenter, Fennema, & Peterson, 1986; Dougherty, 1990; Madsen, Nason, & Lanier, 1986; Thompson, 1984). Thompson (1992) notes such new areas as the nature of teachers' beliefs about mathematics subject matter and about its teaching and learning, as well as the influence of those beliefs on teachers' classroom practices. In her earlier study, Thompson (1984) also contends that there is a strong reason to believe that in mathematics, teachers' conception (their beliefs, views, and preferences) about the subject matter and its teaching play an important role in affecting their effectiveness as the primary mediators between the subject and the learners. Cooney (1994) stated that mathematics teachers' beliefs about mathematics, mathematics teaching and mathematics learning have been shown to critically influence what happens in the classroom.

Other research (Pepin, 1999; Teo, 1997) provides evidence that teachers' instructional practices, especially in mathematics, reflect the teachers' conception of the subject matter.
Pepin (1999) studied the conceptions and instructional practices of mathematics teachers in three countries: England, France, and Germany. The study explored issues concerning conceptions of mathematics, conceptions of mathematics teaching and learning, and the way in which mathematics teachers’ classroom practices reflect their conceptions of mathematics and mathematics teaching and learning. Pepin's findings suggest that teachers’ conceptions are manifested in their practices and can be traced back to the educational trends of mathematics and mathematics education, as well as to personal constructions. The findings also suggest that a teacher’s pedagogical style is a personal response to a set of assumptions about the subject (mathematics) and its teaching and learning, to a set of educational and philosophical traditions, and to a set of institutional and societal constraints. The findings of the research demonstrate that “teachers' classroom practices in the three countries reflected their beliefs and conceptions of mathematics and its teaching and learning.” (p. 144)

Teo (1997) conducted a small-scale survey of 16 mathematics teachers in Singapore. He wanted to know the teachers’ views of the effectiveness of teachers' beliefs on their teaching practices. Some of his survey questions drew upon findings on teachers’ consciousness of their own beliefs about mathematics and whether their beliefs influenced their instructional practices. The results of the study indicate that all the teachers (except one) in the survey declared their awareness of their own beliefs about mathematics and felt that these beliefs did influence their instructional practice.

In an attempt to modify a teacher’s beliefs through a process of conceptual change, Taylor (1990) found there were conflicting beliefs. Because of these conflicting beliefs, Taylor reported that change in instructional behavior was restricted. An example was the teacher’s belief
that he had to teach for constant assessment and for covering the syllabus given that he did not want to jeopardize students’ learning with alternative strategies.

Teachers’ Conceptions about Curriculum and Curriculum Reform

Pajares (1992) believes there are internal and external factors that mediate teacher’s beliefs and practice. This situation has serious implications for the implementation of curricular innovations because teachers’ beliefs may not match the belief system that underpins educational reform (p. 47). Handel (2003) states, “Even if teachers’ beliefs match curricular reform, very often the traditional nature of educational systems makes it difficult for teachers to enact their espoused progressive beliefs” (p. 48).

The context of school instruction may cause practicing elementary and secondary teachers to teach traditional mathematics even when they may hold alternative views about mathematics and about mathematics teaching and learning. For example Cooney (1985) studied a beginning mathematics teacher who was committed to problem solving instruction in belief and in practice. He observed that the students preferred a more content-based instruction even though the teacher struggled to teach problem solving.

Parents and professional colleagues expect teachers to teach in a traditional way. Teachers are also expected to focus on external examinations, to adhere to a textbook, and to keep a low level of noise and movement in their classrooms. In these kinds of school environments, even teachers with progressive educational beliefs are forced to compromise and conform to traditional instructional styles (Handal, 2003).

Prawat (1992) conducted a case study into teaching mathematics for understanding. In the study, 4 fifth-grade teachers with absolutist views of mathematics were expected to implement a reformed mathematics (designed to reflect the NCTM, 1989, Standards) program
with only a new textbook for guidance. Results from the study showed that teachers’ beliefs and knowledge affect how they perceive and act upon different messages about changing the way they teach mathematics. The conceptions teachers assumed about what mathematics is and how it is learned had influence on their decisions about what and how to teach. The Pawat noted:

The teachers in our cases believe that the computational algorithms that pervade the traditional elementary school curriculum constitute the core of mathematics. The teachers have differing views on what it means to understand those algorithms and how important that understanding is, but it is the algorithms of arithmetic that define their mathematics. (p. 223)

When faced with the new textbook with the expectation to encourage students to develop what NCTM (1989) calls “mathematical power” these teachers made major adjustments to the reformed program to regulate teaching practices compatible with their beliefs.

In a study of the beliefs of Australian lead secondary mathematics teachers and classroom secondary mathematics teachers as independent samples, Perry, Howard, and Tracey (1999), lead teachers reported that curriculum demands were an obstacle to implementing innovative teaching. In the respondents’ words:

We try to make the work relevant but we are constrained by the syllabus. Sometimes, I feel pressure of the syllabus tends to force us to cut corners with the kids…If I sound cheesed off, it’s just that I may be a disillusioned mathematics teacher. (p. 14)

Research also shows that teachers may not hold consistent belief systems. Using a sample of United States mathematics teachers taken from 178 typical eighth-grade classes, Sosniak & Ethington and Varelas (1991) analyzed the teachers’ mathematical beliefs and self-perceptions. Based on their data, the researchers attempted to profile teachers in either a traditional absolutist or non-traditional constructivist orientation to the curriculum. They found through their analysis

that teachers lacked a consistent theoretical orientation towards the curriculum. According to the authors, there are beliefs that appear to be ideologically incompatible within each teacher’s belief system. Andrews and Hatch (1999), working with mathematics teachers in the United Kingdom, and Howard, Perry, and Lindsay (1997) working with mathematics teachers in Australia, reached similar conclusions.

In general, inconsistencies between teachers’ beliefs and practices are due to constraining forces that are out of a teachers’ control. Some of these constraining forces are as follows: parental and administrative pressure to follow traditional oriented methods of instruction, the traditional oriented mathematical learning style of the students, and lack of time and materials. These forces seem to act as major barriers for some teachers in implementing their progressive beliefs. Current approaches in mathematics education do not take these constraining forces into account (Nolder, 1990).

The inconsistencies between beliefs and practice can also be explained through the agitation and unpredictability of classroom life and the external pressures put on teachers. Thompson (1985) suggested that these inconsistencies are caused by the frequency of unexpected occurrences that teachers face in the classroom. The high frequency of these incidents may prevent the teacher from reflecting on alternative responses; instead, teachers have time only to react.

Another source of inconsistencies lies in the personal resolution of conflicting beliefs. Orton (1991) suggested that teachers who are committed to progressive beliefs are not always guaranteed that their beliefs will be translated into practice. This absence of translation occurs because sometimes teachers have to compromise their progressive beliefs for the reality of traditional oriented educational environments. For instance, a teacher might be motivated to
provide rote-learning activities in class when that teacher knows that his or her students will be tested on basic skills in a district proficiency exam. Thus, the teacher might perceive that drill and repetitive practice is the best strategy to attain a temporary goal. Therefore, the teacher may suspend his or her own progressive beliefs for other beliefs that are more closely held by others at that particular time.

Sometimes, teachers are caught in a conflict of interest between their “traditional-oriented” beliefs and their “constructivist” beliefs and therefore they compromise (Taylor, 1990). Further, teachers know that even though administrators and supervisors may promote reform efforts, professional assessment is in terms of the traditional paradigm. Because of this fact, they may tend to conform to the status quo in order to minimize disturbance and professional risk in an ethical-practical way (Anderson & Piazza, 1996).

School cultures also influence teachers’ mathematical beliefs (Anderson, 1997). This influence is particularly strong when teachers hold beliefs different from the school culture in which they work. For example, one school environment may effectively support values associated with progressive practices, and this influence may be stronger than in other schools.

A teacher’s resistance to adopting new approaches in the teaching of mathematics may be part of a defense mechanism that teachers adopt to avoid changes in their own mental structures (Clarke, 1997) because “changing beliefs causes feelings of discomfort, disbelief, distrust, and frustration” (Anderson & Piazza, 1996, p. 53). Orton (1991) stated that it is not easy to change a long-cherished mathematical belief since this belief proved before to be rewarding and useful to the teacher in the performance of his or her professional duties. Also, changing a particular belief implies a re-structuring of the whole network of one’s belief system, which may cause feelings of anxiety and emotional pain (Rokeach, 1968). In reference to teachers’ resistance to change, it
has been observed that teachers holding more relativistic orientations to teaching mathematics, which is an orientation toward the belief that mathematics is not an absolute science, are more likely to consider and adopt new ideas (Arvold & Albright, 1995).

Further, Richardson (1996) adds that in some cases teachers cannot articulate a particular belief because they are unfamiliar with a specific educational innovation. Richardson (1996) states:

It cannot be assumed that all changes in beliefs translate into changes in practices, certainly not practices that may be considered worthwhile. In fact, a given teacher’s belief or conception could support many different practices or no practices at all if the teacher does not know how to develop or enact a practice that meshes with a new belief. (p. 114)

Handal (2003) based on his review of the research on teachers’ mathematical beliefs (a part of teachers’ conceptions), and argued the following:

Despite many educational reforms, a large number of teachers still perceive mathematics in traditional rather than in progressive terms; that is, as a discipline with a priori rules and procedures, “out-there,” that has to be mechanically discovered rather than constructed. As such, students have to learn mathematics by rote and removed from human experience. …The relationship between teachers’ mathematical beliefs and their instructional practice is dialectical in nature and is mediated by many conflicting factors. Teachers’ beliefs do influence their instructional practice; however, a precise one-to-one causal relationship cannot be asserted because of the interference of contingencies that are embedded in the school and classroom culture. Even teachers holding progressive beliefs find it difficult to render their ideas into practice due to mediating factors such as the pressure of examinations, administrative demands or policies, students’ and parents’ traditional expectations, as well as the lack of resources, the nature of textbooks, students’ behavior, demands for covering the syllabus, and supervisory style, among many others. (p. 54)

He pointed out that beliefs appear to mediate between theory and practice as a powerful interface. Teachers’ mathematical beliefs are self-perpetuating within a system that seems to promote progressive teaching but in actuality, helps to maintain traditional beliefs and practices. He also concluded that:
by the time an individual enters a teacher education program, traditional conceptions are so solidified and entrenched in their personal philosophy that change to alternative beliefs is difficult although not impossible…. therefore, pedagogical knowledge is not a total predictor of instructional behavior. (p. 54)

**Technology Implementation**

There have been many studies showing that computing technology—that is, computers and calculators,—have positive effects on students’ cognitive and attitudinal outcomes when used regularly in class (Godfrey, 2001; Newhouse, 1998). Despite this evidence and the fact that governments are putting resources in place for the integration of computing technology into mathematics classroom instruction, there is a body of research that suggest technology has not been adequately adopted in schools (Maddux, LaMont Johnson, & Willis, 1997; Mann, 2000; Newhouse, 1998). In the words of Ertmer, Addison, Lane, Ross and Woods (1999, p. 54), “Despite the fact that the number of computers in teachers’ classroom has increased dramatically in the last 20 years, researchers and educators alike report that integrating technology into classroom curricula is not easily accomplished.”

Many reasons have been offered as an explanation for this low rate of integration. Reasons include lack of supporting teachers’ beliefs, traditional teaching practices, lack of teacher training, not enough instructional preparation time, and unavailability of adequate educational software and hardware in general (Godfrey, 2001a; Handal, Handal, & Herrington, 2003; Hadley & Sheingold, 1993). A number of the studies that are discussed below seem to indicate that the lack of teachers’ supporting beliefs and traditional teaching practices appear to be the major factors in the low rate of integration of computing technology into classroom instruction.

For example, Ertmer, Addison, Lane, Ross and Woods (1999) examined barriers to technology implementation by interviewing and observing seven primary teachers. The authors
classified these barriers between first (external) and second (internal) order barriers. First order barriers included the practical aspects of implementation such as availability of hardware and software, administrative support and insufficient time to prepare instructional tasks. Second order barriers (internal) refer to teachers’ instructional beliefs and attitudes towards the implementation of technology in education and established classroom practices.

According to Ertmer et al. (1999), the effect of many external barriers can be ameliorated by providing adequate training and by confronting teachers’ beliefs. However, changes in the classroom will not be very effective until teachers adopt more positive beliefs about technology. In their study, Ertmer et al. concluded that internal barriers were determinant in achieving higher levels of use of technology and argued that resistance to implementation of technology was still present even when external barriers were removed. Teachers with a poor perception of technology as an instructional tool referred to computers as “an add-on,” an “optional activity,” “supplemental,” and “a way to keep kids busy”. One teacher commented that, “I kind of see it [computing technology] on the outside. It’s still touching [the curriculum], but it’s not my focus” (p. 62). Another teacher saw the “classroom computer not as a teaching tool but kind of as a reward kind of thing, like when kids are done with their work” (p. 62).

Norton, McRobbie, and Cooper (2000) observed that in some situations where technology is readily available, some teachers do not know how to take advantage of it and still others are against it. The researchers wanted to know whether the barrier is lack of knowledge of integration or teachers’ beliefs about how mathematics is to be learned. They investigated this question by studying a mathematics staff in a technology-rich secondary school in which the technology was rarely used in the teaching of mathematics. Their results suggested that the teachers’ resistance was related to their beliefs about mathematics teaching and learning and
their existing pedagogies. These findings indicate that knowledge and beliefs may be the actual barriers. Norton et al. suggest that perhaps the teachers are uncomfortable with technology and are unsure how to incorporate technology into their curricula because they have not seen examples of effective use.

Another important factor for explaining resistance to the use technology is teachers’ traditional instructional styles (Hannafin & Savenye, 1993; Hativa & Lesgold, 1996). These styles are characterized by lecturing, lack of group-work, the classroom organization of desks by rows, and the use of the blackboard as the main instructional tool. Many teachers have been educated in teacher training colleges and schools, at a time in which computers were not part of the educational environment. Many teachers tend to repeat the instructional pattern they learn while in classrooms as students. This follows the apprentice style of learning in which the learner actually learns by watching. Godfrey (2001), citing a number of research studies, adds that teachers’ are “reluctant to hand over control of the learning environment to their students” (p. 15).

A number of studies show that the current nature of teachers’ beliefs is not favorable to adopting technology. Newhouse (1998) surveyed 60 Australian teachers and found that, even when teachers had technical skills, they were reluctant to implement technology in their classrooms. Teachers were not convinced about the benefits of computers in education and supported very limited roles of technology in the classroom. The Newhouse concluded that one of the factors for such resistance was teachers’ preference for traditional methods of instruction. Similarly, Mills and Ragan (1998) examined the instructional practices of 30 elementary teachers in their implementation of educational software in classrooms in the United States. The findings showed that there were substantial differences in the way teachers implemented the innovation.
There were also differences in the levels of use of the software, which were attributed to different beliefs on the role of the software.

Niederhauser and Stoddart (1994) surveyed 2170 secondary teachers and found two groups of teachers. The first group associated with the non-traditional constructivist view believed that computers “are tools that students use in collecting, analyzing, and presenting information” (p. 2), whereas the second group associated with the traditional absolutist view believed “teaching machines can be used to present information, give immediate reinforcement, and track student progress” (p. 2). In the former constructivist group, teachers strongly believed that computers can be used as a tool to generate knowledge and learning with understanding. Becker (2000) had similar results after investigating beliefs and instructional practices of 4083 middle and high schools teachers. He found that teachers with higher constructivist inclinations towards teaching and learning were more likely to use technology in the classroom. Fulton and Torney-Purta (2000) had similar findings in their study.

Other researchers found that there are many teachers that dislike using technology in instruction because there are not enough computers in school as well as a lack of computer maintenance and availability (Erickson, 1994). In the area of mathematics and science education, many primary and secondary teachers believe that calculators do not contribute to learning and therefore should be banned from the classroom (Brosnan, Edwards, & Erickson, 1996; Fine & Fleener, 1994; Ford, 1994; Howard, 1992; Reed, 1986; Rogers, 1983; Schmidt & Callahan, 1992). This view is contrary to constructivist views on the use of calculators for mathematics teaching and learning, which endorse the use of calculators as an instructional device to enhance problem-solving skills.
Evidence from a six-year study conducted by Medcalf-Davenport (1998) indicates that there have not been major changes in teachers’ attitudes towards technology in education. In Medcalf-Davenport’s words,

The computer is still viewed as the curriculum rather than as a tool for teaching in the classroom. There is resistance and fear in the integration of anything new into the classroom and teachers do not recognize the usefulness or the necessity of using technology for teaching and leaning. (p. 1)

**Knowledge in interaction with technology**

The focus of this section is on what Touche (2002) terms “*instructional genesis*”, which concerns the mutual transformation of learner and artifact in the course of constructing knowledge with technology. Hoyles, Noss, and Kent (2004) conjectures that to this point in history, the integration of technology into mathematical education has been “marginal”. This is in part due to a failure to theorize adequately the complexity of supporting learners to develop a fluent and “effective” relationship with technology in the classroom.

Hoyles, et al. (2004) defines *effective* as helping learners engage with, develop, and articulate understandings of mathematical procedures, structures and relationships through the technology and according time and status to this process. She also suggests the value attached to mathematical knowledge under technological transformation “can hardly remain invariant” (p. 312). Changes in the valuation of knowledge are expected when students interact with technology. As Artigue (2002) asks, “Can the price which needs to be paid in order to transform complex objects into effective mathematical instruments be justified?”

Studies by Hoyles (2003) and Noss (2003) about how mathematical knowledge is transformed by the computer’s presence have increasingly focused on the epistemological transformations of students’ knowledge in interactions with computers in mathematics classrooms. These transformations of mathematical meanings generated in a “context of
integration” requires a conception of understanding and of mathematical knowledge, which accurately accounts for the specificity of situations and the contingencies of mathematical expression on tools and technologies and on the communities in which they are used.

Hoyles et al. (2004) believes that this developing view of mathematical knowledge has helped make sense in a range of different situations such as activities with adults in work situations as well as students with technologies. She has tried to elaborate a unified theoretical account of how conceptions of mathematics might be situated with the artifacts, goals, and discourse that form part of the activity. These accounts are abstract in that they extend beyond immediate concerns to more general conceptions of knowledge in the sense that they can be mapped onto parts of formal mathematics.

According to Hoyles et al (2004), “the transformation of mathematical knowledge may or may not be judged desirable from an educational point of view; it depends on the value of the transformed knowledge as perceived, perhaps differently, by teachers and students” (p. 313). Even if students are engaged and feel that the activities they are engaged in are legitimate it may still pose a problem of legitimacy for the teacher, because what is expressed by students have to be recognizes as mathematical within the discourse of the “discourse of the institutional learning system for mathematics” (p. 313).

**Instrumental genesis and situated abstraction**

The analytical framework of Luc Trouche’s (2003) research of the use of technology in the classroom is based on the notion of artifact and scheme, where scheme is the psychological component of an instrument, a psychological construct that a person operationalizes in activity with an artifact in order to carry out some task. Instrumented activity is activity that employs and
is shaped by the use of instruments. This is a process in which the subject shapes the artifact for specific use and simultaneously, the subject is shaped by actions with the artifact.

Verillon and Rabardel (1995) stress the difference between an artifact—a given object—and an instrument as a psychological construct: “The instrument does not exist in itself, it becomes an instrument when the subject has been able to appropriate it for himself and has integrated it with his activity” (Trouche, 2004, p. 285). An instrument can be considered as an extension of the body, a functional organ made up of an artifact component (an artifact, or the part of an artifact mobilized in the activity) and a psychological component. The construction of this organ, named instrumental genesis, is a complex process, needing time, and is linked to the artifact characteristics (its potentialities and its constraints) and to the subject’s activity, the subject’s knowledge and former method of working. The psychological component is defined through the notion of a scheme.

**Social Schemes and Individual Schemes**

According to Rabardel and Samurcay (2001) social schemes are elaborated and shared in communities of practice and can give rise to appropriation by the subjects, even come under training processes. They suggest that viewing social schemes as elaborated and shared in communities of practice allows researchers to move beyond a former opposition between two theoretical approaches: genetic epistemology (Piaget, 1936), with its focus on the world of nature, and mediation theories focused on the world of culture. A scheme, according to Piaget, is, for a subject, a means of personal assimilation of a situation and objects he or she is confronted with and, at the same time, Rabardel and Samurcay insist on the point that a scheme is itself the product of an assimilation activity, in which the environment—and the artifacts available—play a major role. Noss and Hoyles (1996) emphasize that artifacts always carry a social element: They
are products of social experience: ‘‘Tools are not passive, they are active elements of the culture into which they are inserted’’ (p. 58). From this point of view it is impossible to distinguish, on the one hand, cognitive structures (schemes) and on the other hand, cultural systems. Schemes always have a social part, and instrumental genesis always has individual and social aspects. In this sense, the notion of social scheme is very close to the notion of situated abstraction, defined by Noss and Hoyles ‘‘as a complex construction being a product of activity, context, history and culture’’ (p. 121).

Therefore an instrument is the result of a construction by a subject, in a community of practice, on a basis of a given artifact, through a process-the instrumental genesis. An instrument is a mixed entity, with a given component (an artifact, or the part of an artifact mobilized to realize a type of task) and a psychological component (the schemes organizing the activity of the subject). All schemes have individual and social aspects.

Hoyles, et al (2004) contend “A key challenge, then, for the integration of technology into classrooms and curricula is to understand and to devise ways to foster the process of instrumental genesis.” (p. 314). They suggest that Trouche (2003) recognizes the possibilities of reconciling the individual and social perspectives linked to the work of Piaget and Vygotsky, and make use of the notion of scheme for technology integration. On a theoretical level, they make use of the notion of scheme (schemes of instrumented action) “to map the important specificities of mathematical knowledge that are not necessarily part of the general psychological constructs which support ‘knowledge generation’ by individuals” (p. 314).

Hoyles et al. (2004) proposes that although schemes of instrumented action recognizes the shaping of the learner by interaction with tools in a general way, the notion of situated abstraction seeks to address the specific way mathematical knowledge might be developed. The
notion of situated abstraction provides a means to describe and validate an activity from a mathematical point of view, but without necessarily mapping it onto standard mathematical discourse. It works well in computational environments because the process of instrumental genesis, which involves the new representational infrastructure supported by the computer, will tend to produce individual understandings and ways of working that are divergent from standard mathematics.

Hoyles, et al. (2004) assert that there are discontinuities between computationally mediated mathematical abstraction and the norms of traditional mathematical curricula. They contend that it is the process of abstraction of mathematical properties and invariants that is important and is shaped by the tools being used, the users’ relationship to the tools—including whether the users judge them to be expressive of their developing mathematical meanings—and most importantly, whether these are valued and judged by the community (e.g., the classroom) to be mathematical.

Guin and Trouche (2002), present an example of how tools provided by Computer Algebra Systems (CAS) and graphical calculators shape the way in which a user solves two equations in two unknowns, and how one might interpret the meanings that the user constructs concerning equations and their solution. They followed with an example in which students attempt to find the limit of a function not directly computed by the CAS calculator. Trouche (2003) describes how learners build specific schemes and notes the differentiation among their behavior. He suggests that students will develop different conceptions of limit and that they are likely to develop different situated abstractions of the notion of mathematical limit that are intricately connected to their use of the tool. In moving from an individual to a social perspective, Trouche suggests that social schemes may be closely associated with situated
abstraction although the idea of social schemes and schemes of individual cognition do not in
themselves take any explicit epistemic focus.

Hoyles, et al. (2004) emphasize that it is important to understand the connections
between instrumental genesis, which occurs at the individual learner’s level, and orchestrating a
group of students learning in the classroom. They theorize that the mechanisms of “situated
abstractions are developed in and through the community, harnessing the discourse (shaped by
the tools at hand) as a means for student-student and student-teacher communication, as well as a
means for generating individual knowledge” (p. 7) They contend that an understanding of the
teacher’s role in computationally based environment would illuminate the nature mathematical
knowledge involved. This understanding would also help to clarify how the process of
integrating technologies productively into the mathematics might be facilitated.

**Instrumental Orchestration As a Guide for Instrumental Genesis**

Trouche (2004) introduced the term *instrumental orchestration* to point out the necessity
of external steering of students’ instrumental genesis. According to Trouche:

An instrumental orchestration is defined by “didactic configurations (i.e., the layout of
the artifacts available in the environment, with one layout for each stage of the
mathematical treatment) and by “exploitation modes” of these configurations. For each
orchestration, the “main object,” originating from the necessity of orchestration itself and
the secondary objects, linked to the chosen exploitation modes, should be distinguished.
The configurations and their exploitation modes produce “accounts of activity (i.e., to say
results of the activity which can be observed by persons other than the subject involved in
the activity). The socialization of these accounts (research reports, calculator screens,
etc.) is essential. (pp. 296–297)

Trouche (2004) proposes that instrumental orchestrations can act at three levels, each of
which corresponds to different types of artifacts. The first level is that of the artifact itself; the
second level, a psychological one, is of an instrument or set of instruments; and the third level, a
“meta” one, is the relationship of a subject with an instrument.
Guin, Ruthven, and Trouche (2004) give examples of the first and third levels:

The first level example concerns software issues (on a symbolic calculator); it is a matter of helping students in computing and, more to the point “understand” the limits of functions. It constitutes a particular answer to the question asked by Hoyles: “we need software where children have some freedom to express their own ideas, but “constrained” in ways so as to focus their attention on the mathematics (Hoyles, 2001). The third level example is a self-analysis device, which aims to provide students the ability to reflect on their own-instrumented activity by providing them with observable traces of it. (p. 297)

The Role of the Teacher in Technology-Enhanced Environments

The role of the teacher as a facilitator is seen as most important in a constructivist context (Richards, 1998; Witfelt, 2000). Within a constructivist classroom, the teacher engenders social and intellectual climates, where collaborative and cooperative learning methods are supported. In parallel, technology-enhanced classrooms tap constructivist strategies (Jonassen, 1999), arranging problem-based projects where students actively construct knowledge, linking knew knowledge with previous knowledge.

In non-traditional classrooms such as the open/global classroom (Witfelt, 2000), the role and responsibilities of the teacher have changed. The teacher, as an agent, has to constantly update information and technology for making learning authentic and relevant. With this transition in roles and responsibilities, Witfelt listed new teacher competencies in constructivist contexts that include supervisor qualifications, supporter and facilitator of students’ work, advisor and subject-matter expert, inspirer and encourager, arbiter at group discussions, critic in mobilizing greater effort when objectives are not being met, and evaluator to improve general learning capacities of students.

Leadership and Community Support

A high level of administrative participation and support is a key factor in technology integration (Marshall, 1999; Henriquez & Riconscente, 1998). One challenge regarding local and
district leadership is the pressure to meet school system standards for achievement on standardized tests. Because of this pressure, teachers may limit or avoid exploration and creative uses of technology (Henriquez & Riconscente, 1998; Marshall, 1999). According to Marshall, most decision-makers support technology in the classroom but are unwilling to restructure the traditional school experience so it can transform the way students learn. Marshall notes that relationships between the school and the community have been influential in technology efforts. Partnerships with businesses, local universities, and volunteer organizations have done a great deal toward advancing the use of technology in schools. Marshall suggests that a key to getting community support for these programs is to demonstrate students’ success using technology. He emphasizes, “If you can show kids being successful, other teachers will want to do it” (p. 3).

Burch (2007) in a case study of educational policy and practice of a district, found that for mathematics the district tended to rely on preexisting teacher leaders, such as curriculum specialists, paid for out of school budgets for implementation of reform. Burch noted, “Professional development in mathematics prioritized teachers’ mastery of content” (p. 87).

Bush (2007) contends that in mathematics, building teachers’ skills was framed as developing their conceptual knowledge of mathematics. Reflecting this perspective, a district administrator defined best practices in mathematics professional development as emphasizing content above all else. In interviews and in an analysis of materials made available to school and district staff members as part of the reforms, she found mathematics was understood mainly as a problem of teachers’ content knowledge; in contrast, literacy was understood mainly as a problem of teachers’ pedagogical knowledge.

Burch (2007) contends that this subject-specific view of professional development was not an explicit dimension of the district’s formal policy design. She noted that the district’s
blueprints for reform in mathematics articulated an overarching theory of action. She stated, “Appearing in key documents across the district, this theory of action included an emphasis on building teachers’ ability to engage students’ intellect and stimulate their interest in the subject matter (p. 88).”

According to Burch (2007), this emphasis on deep understanding of content mirrored state established standards in mathematics. “District office staff members identified the mathematics workshop emphasizing teachers’ mastery of content as best practice; in doing so, they contributed to perceptions of the effectiveness of this approach over others” (p. 88).

**Summary**

The aforementioned research has informed the field of mathematics education on the relationships among teachers’ and administrators’ conceptions of school policy and its effect on technology implementation in a number of ways. For example, Ernest (1988) claims that teachers' approaches to mathematics teaching depend basically on their systems of beliefs; in particular on their conceptions of the nature of mathematics, and on their mental models of teaching and learning mathematics. Pepin’s (1999) findings suggest that teachers’ conceptions are manifested in their practices and can be traced back to the educational trends of mathematics and mathematics education, as well as to personal constructions. The findings of Pepin’s research demonstrate that “teachers' classroom practices in the three countries [England, France, and Germany] reflected their beliefs and conceptions of mathematics and its teaching and learning” (p. 144).

The literature on teachers’ beliefs also reveals that although many researchers indicated that there is a strong relationship between teachers’ beliefs and instructional practices, many also indicated that teachers’ stated beliefs and their instructional practice are not always consistent.
Inconsistencies between teachers’ beliefs and practices are due to constraining forces out of a teachers’ control. Current approaches in mathematics education do not take these constraining forces into account (Nolder, 1990). Arvold and Albright (1995) emphasize:

Even teachers holding progressive beliefs find it difficult to render their ideas into practice because of mediating factors such as the pressure of examinations, administrative demands or policies, students’ and parents’ traditional expectations, as well as the lack of resources, the nature of textbooks, students’ behavior, demands for covering the syllabus, and supervisory style, among many others. (p. 54)

Teachers’ beliefs also effect the implementation of technology into teachers’ instructional practices. According to Newhouse (1998), the current nature of teachers’ beliefs is not favorable to adopting technology. Newhouse surveyed 60 Australian teachers and found that, even when the teachers had technical skills, they were reluctant to implement technology in their classrooms. Teachers were not convinced about the benefits of computers in education and supported very limited roles of technology in the classroom. The Newhouse concluded that one of the factors for such resistance was teachers’ preference for traditional methods of instruction.

The research literature discussed above provides strong evidence to suggest that teachers’ conceptions have an effect on their teaching practices. Adding to this research can help to improve educational opportunities for school children, which is the goal of teachers, school administrators, policy maker, parents, and other community members.
CHAPTER 3

Methodology

The aim of this study was to identify factors of policy understanding and implementation that facilitate or hinder teachers’ use of technology in their classrooms. The primary unit of analysis was the district officials’ and teachers’ responses to technology policy and patterns of implementation and impact. The study invested effort in capturing individual teachers’ responses to policy and paid attention to the context surrounding classrooms.

I collected data from individuals at various levels (e.g., district-level officials involved in creating the framework for implementation and district-level individuals with supervisory and subject-area responsibilities) to provide an interpretive background for making sense of each teacher’s practice.

My approach was from the theoretical perspective of an interpretivist. As Howe (1998) explained, “Interpretivists hold that human beings are self-creating. …It is not as if human beings are simply pushed to and fro by existing social arrangements and cultural norms. Instead, they actively shape and reshape these constraints on behavior” (p. 16). Teachers have been part of the “social arrangements” and “cultural norms,” of our education system for many years. They actively construct their beliefs based on their experiences within the system. Because of this observation, grounded theory seemed to have the flexibility to address my research questions.

The purpose of grounded theory is to develop a theory grounded in the experiences of the participants. Because I perceived a general lack of information about teachers’ conceptions about
teaching with technology, I wanted to develop a theory, grounded in the teachers’ experiences, of what those conceptions may be.

Grounded theory methodology is the intentional search for and development of theory. Strauss and Corbin (1998) noted, “Theory consists of plausible relationships proposed among concepts and sets of concepts” (p. 168). Specifying these concepts as conceptions (beliefs, views and preferences) provided a plausible restatement for the research objective of the present study. I wanted to posit plausible relationships among teachers’ and administrators’ conceptions of policy and its impact on teaching mathematics with technology. Grounded theory provided a framework for designing my study to meet this objective.

This study employed a qualitative research design, focusing on middle school mathematics teachers, their principal, and one assistant superintendent in Macon County School District. (pseudonym) I chose to utilize a qualitative research design because it allowed for in-depth understanding of teachers’ and administrators’ conceptions of school policy in middle school mathematics, particularly with regard to policy effect on technology implementation. A qualitative approach was selected for this study because the approach is well suited for examining educators’ experiences with an educational innovation (Merriam, 1998).

Research Site and Participants

Research Site

Macon County School District

I pursued access to three districts across Georgia, one urban district in Northeast Georgia, and two rural districts, one in the eastern and the other in the southwestern part of the state. My access to Macon County School District began through personal contacts. In my discussions with the district person whom I first contacted, it was clear that Macon County School District fit with
my requirements in several important ways. Macon County School District was acceptable because it contained a middle school that was implementing some new technology in the sixth-grade mathematics classrooms; it had plans to expand the new technology implementation to the mathematics classrooms at other grades, and eventually the whole school; and it is a fairly typical rural school district.

Macon County School District is a small district in a rural part of the state, with four elementary schools feeding two middle and two high schools. Georgia, like most other states, has opted to follow the mandates of the No Child Left Behind Act (NCLB), and has begun testing its students in the 3rd through 8th, and 11th grades with a Criterion Referenced Competency Test (CRCT). The state and the district failed to meet federal adequate yearly progress Annual Yearly Progress (AYP) in 2007 when measuring overall proficiency in mathematics, reading, and social studies; graduation rates, and attendance rates together (Standard & Poor's, 2007). However, Coffee Middle School (pseudonym) in Macon County met AYP in 2007 as well as at least the two years prior to 2007.

Macon School District is located in a high-poverty area of the state. Findings from the National Teaching, Learning, and Computing Studies (Ronnkvist, Dexter, & Anderson, 2000) suggest that teachers in high-poverty elementary and middle schools are more likely than others to select “remediation of skills” and “mastering skills just taught” as their primary objectives for student computer use. They also suggest that secondary teachers in poorer communities are more likely to see computers as valuable for teaching students to work independently rather than collaboratively. Though Coffee Middle School is located in a high-poverty school district, the sixth grade mathematics teachers at Coffee Middle School do not fit into the above category.
Coffee Middle school

Coffee Middle School has a total enrollment of 688 students. It is a Title I School having 430 students eligible for free lunch and 53 eligible for reduced lunch (MCD Public school data 2005-2006 school year). The school has 52 teachers with a teacher student ratio of 13:2.

Participants

The participants were mathematics teachers and school administrators who were involved with implementing technology policy in the teaching and learning of mathematics. These participants had some knowledge about technology and some degree of experience with it. They were working in a school environment in which technology policy had an impact on the teaching and learning of mathematics.

Teachers

The study focused on sixth grade mathematics teachers, because they had recently acquired new technology that encourages the use of the computer. There were three sixth grade mathematics teachers at the school. All of the sixth grade mathematics teachers were invited to participate in the study and all agreed. Seventh and eighth grade teachers were not invited to participate because I felt they would not add any additional insight. They had not yet acquired the new technology. According to Patton, “…qualitative sampling designs specify minimum samples based on expected reasonable coverage of the phenomenon given the purpose of the study and stakeholders interests” (p. 246). Each mathematics teacher was selected based on her willingness to participate in the study. The sample consisted of those teachers who were implementing the new technology.

The engagement of multiple participants provided multiple perspectives, thus producing multiple sources of data that were used to cross check and verify emergent themes, which
provided the basis for triangulation (Patton, 2002). Because I could not observe mathematics
teachers’ feelings or how they perceived and interpreted the impact of school policy on their
implementation of technology into instruction; interviewing them was necessary (Merriam,
1998).

The choice to study inservice mathematics teachers was based on a belief that teachers
need to have experience with school technology policy in order to have a view of how policy
impacts their classroom practice. I contend that one’s conception of policy is something that is
developed through experience, and that the relationship between a teacher’s conception of policy
and classroom practice is likely to be more apparent in experienced mathematics teachers who
have recently been involved in technology implementation.

Administrators

School administrators work within the context of school districts, and are to some extent
beholden to the superintendents of those districts. District policies can influence instructional
reform (Elmore, Abelmann & Fuhrman, 1996; Spillane, 2004). District traditions, the
superintendent’s leadership styles, reform initiatives, and the demographic compositions of each
district will vary, and will influence the actions of the principals of schools differently.
Additionally, economic differences exist between regions that may lead principals and other
administrators to stress different skills in the academic training of their students (Oakes &
Guiton, 1995). To control for the influence of these variables, this study was situated in a single
district at a single school.

Data Collection

I collected data about teachers’ and administrators’ conceptions of school district policies
concerning the implementation and use of computing technology for teaching and learning
mathematics. Within this district, the 3 teachers from Grade 6 were chosen for interviews. I believed that data from this grade level would give a good picture of teachers’ views of technology policies and their implementation. I also interviewed the district curriculum coordinator and school principal.

The study drew together information from various sources: document collection of technology implementation and usage policy; interviews with administrators at the district and school levels; and interviews with teachers combined with observations of their teaching. Original data sources used in this study consisted of three 1-hour interviews with the school principal, one 1-hour interview with each of three teachers, one 45-minute interview with the district curriculum coordinator, and documentary material supplied by district officials upon request. Secondary data sources include transcriptions of those interviews, coded transcripts, thematic documents, and follow up communications, and memoranda about targeted and emergent topics. Each of these sources is discussed in more detail below.

Interview data were helpful because they allowed me to gain an insight into the conceptions about technology policy of the interviewees. According to Patton (2002), the purpose of the interview is “to enter into the other person’s perspective” (p. 341). The interview is conducted to find out what someone else is thinking or what their beliefs are. Because I am interested in teachers’ and administrators’ conceptions (beliefs, views, and preferences) of technology policy, the interview method was appropriate. There were initial interviews and follow-up interviews based on an analysis of the initial interviews. These interviews were semi-structured with open-ended interview questions.
Interviews

The interviews provided data for triangulation. All interviews were semi-structured; the protocol included time to probe answers.

There was less time for probing and discussion with teachers than with the principal. I piloted the protocol for the interviews with volunteers prior to using it with personnel in the district. I created separate interview protocols for teachers and school administrators. I used information gained in the early interviews to make slight modifications to the protocol that I followed in subsequent interviews. This information allowed me to follow interesting stories or modify my language to match that used by educators in this district.

Administrator Interviews

I conducted an ad hoc interview with the superintendent at the district office. This interview did not follow a protocol, and was not recorded or transcribed. In this discussion, which lasted roughly 10 minutes, we informally discussed the nature of the school district. Field notes were recorded immediately following the interview. I communicated with the district curriculum coordinator after data collection to confirm the demographics for the district; that data became part of the description and analysis.

At the school level, my first interview with the principal focused on his “road to the principal ship,” discussions about school level policy, and his descriptions of the school and the students they serve to establish the context within which his conception of policy operated. The second interview focused on “the details of experience” (Seidman, 2006, p.18), his opinions of policy, especially technology implementation policy, and his interpretation of and immediate response to specific parts of text from state technology implementation legislation. The third interview protocol was designed to probe conception about policy.
Each interview was recorded. I recorded field notes about observations and conversations that were outside of the interview protocol immediately after each interview. Each interview was transcribed as soon as possible after the interview was conducted, typically within 3 days.

**Teacher Interviews**

An interview protocol that included the targeted themes and topics, including questions about teachers’ perceptions of the principal’s views on policy and policymaking guided the teacher interviews. There were two purposes to these interviews as part of the original design: first, to provide triangulation of data among the interview participants; and second, to gain additional information about how district officials and the principal communicated their conceptions of policy. As new themes emerged during on going comparative analysis, I recognized that more teacher interviews were needed to provide helpful additional data concerning the implementation policy. There was a need to know more about what actually happens in the classrooms.

**Documentary Material**

Spillane, et al. (2002) argue that to understand policy agents’ understandings of policies or reforms, research has to go beyond descriptions of personally related or measured beliefs to examine the interactions of those beliefs with policy mandates. Research has to include evidence of the agents’ behaviors and decisions. The second additional data source beyond interview data and class observations is from analysis of archival records at the district office and school.

District level policy documents helped to detail the policy environment in which the schools were operating. I collected documentary material from the district office and from the school as available. I asked at both locations for policy handbooks, minutes from school and board meetings, and any other school-level documents that might be relevant to my topic. I
reviewed the entire district policy manual and copied pages that detailed policies related to technology implementation, curriculum, philosophy, and any other material I thought might be relevant. Board meetings minutes were readily available. Reports of the monthly and called board meeting are printed in the weekly newspaper. I reviewed the reports that covered the board meetings of the previous 12 months. I also reviewed the district and state websites for relevant information.

After the initial interviews, I examined school-level records related to policy choices the principal had made regarding instructional method, test preparation, and teachers’ professional development. When appropriate, I followed up with the principal in order to assess his reasoning concerning the decisions reflected in the archival records, specifically pertaining to how he thought his conception of technology policy might have guided him.

Data Analysis

The data were analyzed using the constant comparison method (Strauss & Corbin, 1998). Analyses associated with the grounded theory research tradition use the constant comparative method for ongoing data analysis during data collection and cross-case analysis to construct cases and to help find common themes across the data. These methods of coding and recoding data throughout the data collection and analysis process informed that process and lead to categories, themes, and eventually to a theory that helped describe and explain the investigated topic which was, in the present study, “teachers’ and administrators’ conceptions of school policy and its impact on technology implementation.” Through comparing and contrasting the teachers’ and administrators’ belief systems, I developed a theory about teachers’ and administrators’ conceptions of school policy and its impact on technology implementation.
After the initial interviews, I examined school-level records related to policy choices the principal has made regarding instructional method, test preparation, and teachers’ professional development. I followed up with the principal in order to assess his reasoning behind the decisions reflected in the archival record, specifically pertaining to how he felt his conception of district policy may have guided him.

After the interviews were completed, I approached the data again and began the process of identifying constructs, categories, and identifying where applicable the dimensions of categories. In order to analyze participants’ conceptions, I coded for categories around which the protocol had been designed, and looked for emergent categories.

I kept track of interesting comments or blocks of comments in the data by keeping memoranda that included the potential meaning of words and phrases, and the significance of particular policy choices. Interesting discussions about local policy decisions emerged additional categories as it became clear that certain incidents were salient to participants. Policy thematic documents also served to clarify policies, which schools followed but were not described thoroughly in the policy documents given to me by school and district personnel.

Data about each different category were then extracted to new documents for each. Within these documents, comments were then recoded. Statements about similar topics from each interview were also organized to create a profile of policy conception for each individual.

These individual-level profiles were then merged by topic and reanalyzed for consistency or variation between individuals. Secondary analysis on thematic documents and merged documents were in the form of color-coding, embedded comments, and memoranda.

Finally, I organized the data throughout the process into graphic representations as part of the analysis. I created charts and tables for each participant, and for each set of conceptions and
policy statements. I created matrices for each category that included the subcategories, evidence from the data supporting each, and comments about the relevance of the evidence. Grouping and regrouping the distilled data from the category documents was not a final stage, but an ongoing stage of analysis (Miles & Huberman, 1984), from which several new categories emerged. The transcriptions, thematic documents, embedded comments, memos, charts, matrices, and documentary material provided at the school and district levels are the data upon which my analysis is based.

The teachers were observed teaching mathematics lessons that they selected. The topics leant themselves to the use of computing technology to enhance mathematics instruction.

**Issues of Research Validity**

This study was primarily concerned with investigating participants’ conceptions of policy and how those conceptions are triggered by and interact with policy mandates and rhetoric. The main challenge to the validity of any research study is “the inaccuracy or incompleteness of the data,” and recordings and accurate transcriptions of these recordings “largely solve the problem” (Maxwell, 1996, p. 89). As the bulk of this dissertation presents participants’ conceptions about policy, validity is addressed by presenting the conceptions and reactions in the participants own words as much as possible. My interpretations and analyses of these conceptions are presented in language that distinguishes my own interpretations from the participants. For this reason, I sent synopses of the participants’ conceptions and policy statements to the participants as member-checks. On some occasions, I sought additional (beyond the member check) follow up information from some of the participants.

In this dissertation, chapters 4 and 5 provide descriptions of participants’ conceptions of policy and topics relevant to these conceptions. An analysis of these conceptions is included in
chapter 6. I used Lincoln and Guba's (1984, p. 283) audit trail to ensure the validity of my findings, as well as member checks. The audit trail includes: field notes of each interview, including context and notes on initial researcher understandings of the interview material; audi-tapes and complete transcriptions; coding; and the development of charts to organize and analyze data. Additionally, I closely followed Strauss and Corbin’s (1990) recommendations for maintaining “theoretical sensitivity” throughout the coding and analysis process as a means of strengthening the description of interactions between conceptions and policy mandates.

Maxwell (1996) identifies two other specific threats to validity in qualitative research bias and reactivity. Clarification of researcher bias is one of the procedures that is critical for trustworthiness. Reactivity is the potential for the researcher to influence the responses during an interview. As a check against these threats, I charted my assumptions about potential outcomes before the interviews began, and wrote oppositional assumptions in adjacent cells. Doing so allowed me to be attentive to my preexisting frameworks and potential biases as they came up in coding and analysis (Maxwell, 1996). Additionally, when I thought my assumptions were being confirmed during the interviews I tried to present the opportunity for the participant to provide alternative explanations, when doing so would not be disruptive to the flow of the conversation.

The “boilerplate” (Maxwell, 1996) check of validity in the study design is that I interviewed teachers and administrators and gathered school and district documents to triangulate among the participants’ statements about policy. These data became part of the analyses beyond being validity checks on participants’ statements.

The final question of validity concerns how valid the statements of the participants themselves are. Seidman (2006, see pp. 23-26 for a discussion) describes how the three-interview model is designed as a check against this threat. Conducting three interviews of the principal at
different times provides enough data for me to ensure that his comments across interviews presented consistent viewpoints that did not contradict one another. The teachers’ interviews acted as a check among teachers and as a check against the potential for the administrators to have been communicating different beliefs to me than they did to teachers. Ultimately, I was not specifically concerned with assessing the validity of the participants’ conceptions of policy, but in getting the participants to reflect on them; accurately describing them and interpreting their interaction.
CHAPTER 4

Results for Federal and State Policy and District Administrators

The purpose of this study was to investigate teachers’ and administrators’ conceptions of school policy and policy impact on technology implementation in the mathematics classroom. The study utilized self-report data through interviews and observations of classroom instruction as well as policy documents analysis. An analysis of Federal, State, and District technology policy was done to determine what those policies are. Results of the study are based on data on the perception of teachers and administrators gained through interviews with the assumption that teachers and administrators would respond, to indirect questions, in a way that would give an indication of their conceptions of school policy and its effect on technology implementation (see teachers’ and administrators’ interview protocols, Appendixes A and B). Teachers and administrators responses were compared to the analysis of policy documents to help answer the research questions. Further, observations were done to help give the investigator a better understanding of the context of the mathematics education process within the classroom and to provide additional data for analysis. Policy documents, interviews, and observations were analyzed to answer the questions which are restated below.

Research Questions

1. What is the policy of a Georgia school and its district concerning the use of technology in the teaching and learning of mathematics?

2. What do district officials think that policy is?
3. What are a school’s mathematics teachers’ conceptions of their school and district policy concerning the use of technology in the teaching and learning of mathematics?

4. What policy objectives do the teachers believe encourage or discourage them in their efforts to use computing technology in their mathematics teaching?

**Policy Analysis**

**Federal Policy**

In January 2002, President Bush signed the "The No Child Left Behind Act" (NCLB). This act contains the most sweeping changes in federal law regarding public schools since the Elementary and Secondary Education Act of 1965. NCLB includes significant new accountability measures for all public schools and is based on the ambitious goal that all children will be proficient in mathematics and reading by 2014. One aspect of NCLB that separates it from previous national policy mandates on education is the law’s emphasis on the integration of technology into classrooms to support and improve teaching and learning. The act requires state educational agencies to assist every student in crossing the “digital divide” and to ensure that every student, regardless of the student’s race, ethnicity, gender, family income, geographic location, or disability, is technologically literate by the time the student finishes the eighth grade.

The NCLB policy requires that state policy align with federal policy on the integration of technology into classrooms to support and improve teaching and learning. This mandate of federal law requires the implementation of technology for the support of teaching and learning, with a focus on mathematics. The state and district policy was implemented to align with federal policy.
State and Local Policy

In September 2001, the Georgia State Board of Education requested an audit of Georgia’s Quality Core Curriculum. The audit found that in several areas, the Quality Core Curriculum lacked rigor and was inadequate to guide teaching and to ensure common expectations for all students. Shallow standards forced our teachers to guess what they should teach and to hope that what they were teaching was what would be tested. Inevitably, teachers used the curriculum document not as a guide for quality instruction but as a reference to mention in lesson plans and then put back on the shelf (Georgia Technology Plan, 2003).

The State Board of Education requested the Georgia Department of Education to develop a plan for strengthening the Georgia curriculum. The Department was specifically asked to address the following concerns:

1. The curriculum needs to be rigorous—more than “a half an inch deep.”
2. The curriculum needs to be more focused—less than a “mile wide.”
3. The curriculum needs to be clearly understandable by teachers so they can effectively guide instruction. The curriculum standards need to specifically describe what the students are expected to know and be able to do.
4. Instruction needs to be student-centered rather than teacher-centered. Educators should focus on what students are learning (Georgia Technology Plan, 2003).

What resulted is the Georgia Performance Standards (GPS) for grades K–12. The Georgia standards are presented grade by grade, and there is a description of what a student should be able to do at the beginning of each grade level.

In Grade 6, the curriculum begins to address traditional topics from algebra and geometry, and from Grade 7 on, the curriculum has four content strands: number and operations,
geometry, algebra, and data analysis and probability. The implementation of this curriculum requires that mathematics classrooms at every grade level be student-focused rather than teacher-focused. Working individually or collaboratively, students should be actively engaged in inquiry and discovery related to real phenomena. Knowledge and procedural skills should be developed in this context. Multiple representations of mathematics, alternative approaches to problem solving, and the appropriate use of technology are all fundamental to achieving the specified goals of the curriculum.

The new performance standards make heavy demands on teachers of mathematics, and extensive professional development will be needed to support teachers in implementing the standards. Training for sixth-grade teachers began in fall 2004. Beginning at Grade 6 in fall 2005, the standards for Grades 6–12 are being implemented in the classroom one grade at a time.

On July 13, 2006, the Georgia State Board of Education approved revisions to the Mathematics Georgia Performance Standards. No revision was made in the GPS sixth grade standards.

**Georgia State Technology Plan**

*Purposes of the Georgia plan.*

The purposes of the Georgia plan are as follows:

- To establish how technology can contribute to statewide goals of improving student achievement in Georgia’s K–12 public schools.
- To publish common goals that will unite efforts of the Georgia Department of Education (GA DOE), other state-funded education agencies, local systems, and additional educational partners charged with improving education through technology.
- To describe the strategies that the GA DOE will deploy toward goal attainment.
• To outline an evaluation plan by which statewide progress toward common goals will be measured.

• To serve as required documentation to the United States Department of Education (US DOE) for federal technology funding.¹

State and local district policy document are consistent in their efforts to implement technology into classroom instruction. They emphasize that technology use in schools will be frequent, transparent, and diverse, using the full range of appropriate tools that can enhance learning appropriately integrated into all grade levels and content areas to support learning; focused on technology integration and core academic standards, especially in areas which promote higher-order thinking and problem solving. This use should be reflective of the way professionals and practitioners use technology in the field to pursue work in their disciplines, and should be central to the learning process.

Students will use technology to find, synthesize, analyze, represent, apply, and share information in new ways; collaborate and communicate with others for the purposes of learning; and connect to learning activities that are meaningful, interesting, relevant, and challenging to them. Educators will use technology to enable new ways of implementing instruction and assessing learning; develop instructional strategies targeted toward needs; and enhance their professional skills and knowledge. All school systems are to have a 3-5 year technology plan that meets State of Georgia Technology Planning guidelines. The Georgia plan emphasizes that 2006

¹ This document is an extension of the Consolidated Application for Funding already approved by the State Board of Education. It provides more detail about technology programs in the state and was submitted to the US DOE as a condition under the Elementary and Secondary Education Act, Title IID: Enhancing Education Through Technology (2002).
success indicators will be met for the 2003-2006. The state Plan and the local plan will be extended for another 3 years.

Researchers have established that “the success or failure of technology is more dependent on human and contextual factors than on hardware or software” (Valdez et al., 2000). According to a synthesis of several national frameworks (enGauge, 2000; Porter, 2002) technology programs most likely to improve student learning will require:

- to high-quality technology programs Effective instructional use;
- Effective administrative use;
- Adequate access to technology;
- Educators who are proficient in technology integration;
- Wide-spread commitment to a common vision;
- Adequate system support for technology; and
- Equitable access for all students, parents, and educators.
Supported by equity with student achievement as the underlying goal, the Georgia plan focuses on three main areas; access to Instructional Resources; Instructional Uses of Technology; and Educator Proficiency.

**Instructional Resources**

Students should have equitable access to computers across core content areas (mathematics, language arts, science, social science, special education, and English for speakers of other languages). At the State Department of Education, there are two major programs to
enhance the instructional resources available to teachers and students: The Georgia e-Learning initiative and GeorgiaLearning Connections. The Georgia e-Learning initiative delivers online courses to high school students and educators.

One purpose of providing online courses is to ensure equitable access to academic courses and professional learning opportunities across the state. The Georgia e-Learning program offers several courses that many schools cannot offer, such as courses in advanced math, and Advanced Placement (AP) courses. To encourage home connectivity, the Georgia Department of Education continually posts public information for parents, students, and educators via the World Wide Web. In addition to the Georgia Learning Connections and Georgia’s eLearning initiative, information including the School Report cards and results of all data collections are available online.

**Instructional Uses of Technology**

The chart in Figure 2 comes from the North Central Educational Laboratory’s enGauge (2000) project attempts to summarize some of these key findings surrounding effective deployment of instructional technology use in classrooms.

![Figure 2: Instructional Approach to Learning (Georgia Technology Plan, 2003)](image-url)
The \( y \)-axis describes the uses of technology best suited to supporting various levels of thinking skills as represented in Krathwohl, Bloom, and Masia’s (1984, pp. xv-xix) taxonomy. In this taxonomy, thinking skills are represented from the simple to the complex in the following order: Knowledge; Comprehension; Application; Synthesis; Analysis; and Evaluation. As represented in the chart, researchers have found most drill and practice and integrated learning systems target basic skill acquisition, whereas a range of other technology tools are better able to support higher-level thinking and problem solving (Georgia Technology Plan, 2003).

The \( x \)-axis illustrates how certain pedagogies create the most fruitful context for certain technology tools and thinking skills. Didactic pedagogies are characterized by lecture and use of tools (texts, software, etc.) that transmit information to students. Students in more constructive instructional settings have higher levels of engagement and experience with content, and they make more decisions about their learning (Georgia Technology Plan, 2003).

The states of Georgia’s goals in the area of instructional technology use are the following:

- To expand the current range of use to include available and emerging technologies which are not used often in schools, but offer great potential for promoting the state’s new curriculum process standards;
- To move technology use from the periphery of the learning process to a central, vital role across all grade levels and content areas; and
- To encourage technology uses that support: (1) student-centered learning, (2) the acquisition of higher-order thinking skills as represented in the new QCC Process Skills Standards; (3) the mastery of QCC Technology Integration Standards; and (4) relevant, meaningful tasks for students.
**Educator Proficiency**

Training educators to use technology effectively is a primary component of Georgia the K—12 Technology Plan.

- Inservice teachers must meet the Professional Standards Commission’s 2006 Technology Proficiency requirement for re-certification (Professional Standards Commission Information, March 2003);
- Instructional practices aligned to research-supported models for effective technology use that will best support the new QCC Process Skills Standards (State of Georgia Technology Plan, 2003)

**Administrators’ Interview Results**

**District Curriculum Coordinator**

Rhonda (pseudonym) was the district curriculum coordinator and has been working in education for more than 34 years. She spent 10 years as an elementary classroom teacher. She then left the classroom to become assistant principal at her school. After serving as assistant principal for many years, she was appointed principal when the principal retired. After many years as principal, she was promoted to assistant superintendent for curriculum development. At the time of the study, she worked with the schools in the district on curriculum implementation and development.

**Appropriate use of technology**

Rhonda thought that appropriate technology implementation is very important in education, especially in mathematics. She believed that technology allows students to have a hands-on interactive educational experience. She saw technology implementation as a way to “tap into” students’ everyday experiences with technology. She stated in the interview,
I think [technology] is another avenue for boys and girls to see the process at work. Graphic calculators, computers, SMARTBoards, all of those technologies allow boys and girls to have that hands on experience and allow them to be interactive in their learning. When I think about technology and I think about what it does for kids, it brings them back to the same fascination that they have when they are looking at television or if they are playing videos.

Rhonda believed traditional teaching methods in which the teacher stands in front of the room lecturing, with kids going to the board and working problems, still works but because of the advanced technologies that are in the homes and that our kids are constantly confronted with, “we have to do a better job of entertaining them, to keep them involved.” She explained:

We’ve seen such a difference with our at risk population and especially with math because that’s an area that we put a lot of emphasis on. When we moved from…we were doing computers with the FCD projector, and the teachers were using the transparency on the overhead projectors for interaction with math activities, keeping the kids involved. But when we moved last year to SmartBoards\(^2\) in math, and teachers were able to pull in the templates from the SmartBoards website and children were interacting with the computers and interacting with the items on the screen and going up and pointing and clicking and moving the graphics around and explaining their problem, we saw more participation, we saw kids on task, we saw kids say, “Oh, now, I understand it”, it brought it alive for them, it made it real to them.

The SmartBoard is a digital whiteboard that connects to the computer and allows teachers to display the computer screen on the screen of the SMARTBoard. Teachers and students can then interact with the computer on the board using their hand as the mouse to navigate, draw on the board with digital colored pens, or save their work as an image to review later. The SmartBoard allows for enhanced class participation by allowing students the chance to interact with the computer using the board. Notes that are made on the board can be saved for review during later classroom discussions. At Coffee Middle School, the computer SMARTBoard

\(^2\) SMARTBoard and ACTIVboard are brand names of the interactive whiteboard (IWB) technology.
configuration was setup in the classroom so that it all turns on with the click of a button and it was ready to be used in a few seconds.

Rhonda found that teachers were finding that their kids were paying attention; the teachers are finding that the kids are asking higher level questions when they teach with technology. She had the sixth-grade mathematics teachers do a demonstration for the Board of Education, because she wanted the Board of Education to see their SMARTBoard technology and understand why she and the teachers felt like it was so important to put it in the schools. So, she got the sixth grade teachers to do a presentation to the Board. The teachers had the board members participate in a lesson on prime numbers. Rhonda stated that one teacher who was participating in the presentation said, “This is the hardest concept I’ve had to try to get across to my kids” and just by sitting there and going through it with board members she saw that, “Ah, I understand it”. Rhonda explained, “So, it has cut down some barriers for our teachers and allowed them to really get in there and help the kids understand the concepts better than they ever had in the past.”

Using a short lesson on prime numbers during the teachers’ presentation, Alice, the lead sixth grade mathematics teacher demonstrated the power of the computer in combination with the SmartBoard technology. She discussed the notion of prime number using a rectangular array similar to the example in Figure 3. Figure 3 shows representations of 3 and 6. Each tile, which represents one unit, can be manipulated with other tiles to form rectangles for a given number. If only a single column or row can be formed using a particular number of tiles then the number is a prime number. Using the computer in unison with the SMARTBoard, ALICE was able to demonstrate the manipulative power and the interactivity of this technology.
Rhonda saw that it is appropriate to use technology in the classroom because it is helpful to all students in mathematics education. She thought:

[Technology] is benefiting our students, and when you say math education in general, I’m thinking all students. There is so much acceleration you can do for those gifted kids as well as remediation for those at risk kids. It has changed what is happening in our classrooms.

She has observed that teachers and students are more interactive in the class. She stated,

When I go and observe math classes now, it’s not, ‘I’m going to put fifty problems on the board and you sit at your desk and figure out those problems’, that’s not what I’m seeing anymore. Homework is different, too.

When asked how homework had changed, Rhonda explained that they had acquired a comprehensive school reform grant in the area of mathematics. They brought the “Lifespan” program into the schools. The program was implemented in the primary grades while Rhonda was principal at a primary school in the district. The program involved using Play Stations. Parents would check out the Play Stations and take them home to the students. The program contained mathematics programs on CDs that could run on the Play Stations. The programs were based on storybook characters and “it was as if they were working on addition, or whatever skills or concepts they were working on at that time.” There were specific programs that the students worked on. Rhonda reported that one parent commented, “I can’t get over my child sitting there with that joy stick playing that Play Station but he’s learning math.
Rhonda believed teachers have to be open to all avenues out there; any resources that are out there that are going to get the attention of kids. She said,

Our kids are in “a have it their way” mentality right now, they are used to having everything. …If it’s not jumping around or singing back to them or changing colors, it loses their attention. So, technology has allowed us to keep them excited about learning.

Rhonda saw that technology is changing a lot of what is happening in our classrooms. She thought it is changing what is happening in our homes as well.

**Leadership support**

When asked, "Does the leadership at this school promote any views concerning instruction? How about mathematics instruction?” and “Does the leadership at your school promote any view concerning technology use?” Rhonda responded this way:

Our leadership at this office here, we promote advances in technology in all subject areas, especially math. As you are aware, math is one of those areas that are part of the annual manageable objectives, our [Annual Yearly Progress] AYP reports. And it’s an area that we are constantly struggling with, meeting the needs of all of our kids. Because of the changes that the Georgia Performance Standards brought and we are looking at where we are as a nation in the area of mathematics, we have to retool our teachers. One of the ways we are retooling is helping teachers understand that it is not the same mathematics that we learned in school as teachers and as students.

Rhonda thought that educators have to stay abreast of what technology can do to help students understand concepts. She asserted that the leadership at the schools in the district is open to looking at how technology can help the classroom because their primary motivation is to increase students’ achievement. She stated, “If we have to have it flashing and blinking to do that, that’s what we want to do.”

Rhonda expressed that the leadership at her schools supported advancements in the use of technology. She expressed that the system had put a lot of dollars into computing technology. They had just upgraded their technology and improved the infrastructure that they had in place.
Their next step as a system was to make all their classrooms twenty-first century classrooms with SMARTBoards, laptops, and computers. She thought that this was a struggle that they faced as a school system next. She believed it was important to constantly bring the board members into the schools to see how the teachers were using the technology.

Rhonda supported her view with the following statement.

So, I can sincerely say that the leadership at our schools is one hundred percent for advancement of technology. We put a lot of dollars in technology in this system. We’ve just received a 2.1 million dollar grant to upgrade our technology. We have a top of the line fiber line. We can run all the video screening and there is not anything that we cannot do in the schools on Tiger Trail [The streets on which the schools are located] because of the technology, the infrastructure that we have now in place. So, that we know with the infrastructure that we have in place, that we can provide all those resources for our students and for our teachers. Now, the next thing that we’ve got to do as a system is that we are looking at making our classrooms a twenty-first century classroom with the SMARTBoards and with laptops and with the computers. That’s a struggle that we face as a school system next. That’s why it is so important that we bring our board members in to see what this technology is doing and that’s what we are constantly doing.

Conception of Mathematics Teachers’ Views

When asked, “Do you believe that mathematics teachers agree with this view?” Rhonda responded by saying,

But I can truthfully say that our teachers are going to be one of the number one promoters for increasing technology in the classroom. I’ve got those math teachers that didn’t get SMARTBoards who are constantly saying, “We’re ready for the additional training” because without training that technology is no good, if you put it in there and you don’t train those teachers. Those teachers are going to have to be comfortable with it; they’ve got to be masters of it. If they’re not comfortable with it, it’s not going to be used, it is going to become a babysitter and that’s not what you’re putting in there for. These teachers are actively using this technology one hundred percent in their instruction, it is in their plans. It is planned for and it is used and it is evaluated. So, I think I can honestly say that the concept of looking to and implementing technology in math in our system is one that is moving forward, we’re not there yet, but we’re making steps in that direction to get where we want to be. Did I answer your question [laugh]?
The Principal

John is the principal at Coffee Middle School. This was his 14th year in education, his eighth year as an administrator, and second year as a middle school principal. He spent 6 years teaching on the high school and middle school levels and 6 years as an elementary school administrator. At the time of the study he was back at the middle school level as a principal.

Appropriate use of technology

I asked John how technology had changed instruction over the years since he had been introduced to computers, calculators, SMARTBoard or any other technology. I also asked him “Has [technology] changed in any way what your teachers teach or do they basically teach the same way?” He responded: “They view this as an opportunity for them to combine technology [with] instruction and really bring in some more real life, real world experiences for their students in the math classrooms.”

Leadership support

John emphasized that the Board of Education and the district were pushing use of technology in the schools. When asked how he felt about that as far as policies coming down to him and how much he encouraged teachers or how much he was on board with the board policies, he indicated his strong support for technology in teaching.

John was a strong proponent of the use of technology in instruction. When he came to the district almost 2 years before he observed, “There was a struggle for textbooks and just in talking with some parents and parents viewing textbooks as…just the tools or the materials that students could use or would need to be successful in school.” He went on to state:

But I contend to propose to not only parents, but fellow educators as well, that technology affords us the opportunity to use the most current resources and it also enables us to engage our students more in the textbooks. In the long run, I also believe that using more technology in the classroom is a more efficient resource than textbooks
actually because they are interchangeable in many ways with many of the programs that come with the technology that we use. So, I’m a strong proponent of using technology, not only in math, but in the other disciplines as well.

In my interview with John, he expressed the following ideas. In looking at technology use- that is computers, calculators, and other technology, SMARTBoards, and the Internet in particular- most people use more technology than they realize such as telephones, cell phones, the Internet, email, as technology is moving forward. And then some teachers, don’t believe in using it, many believe in the traditional method of teaching. Most of them do because that’s the way they were taught. “So, that’s okay.” He saw a great move forward in the use of computers and other technology. He thought that his teachers perceive that school policy involves a push for the use of technology thereby having a positive effect on technology use in the classroom. So, he understood that his policy of support encouraged teachers to incorporate technology into their instruction. He could see if they liked to use it or not and what teachers saw were the administrations’ expectations of technology use and what they saw as the advantages or disadvantages of its use.

The principal believed that there should be a balance in instruction. It is important to teach the basic mathematical skills, but he also believed that our schools must become more technologically advanced to keep up with advances in the world. He puts it this way.

I am absolutely in favor of—. …I understand that there should be a balance between maintaining some of the fundamental skills of computation and some of the basic math skills. …it’s important for students to have a foundation in that, but I also believe that in order for our students to be more competitive in this global society and for America, as a country to continue to be considered one of the world’s leaders, our teachers and our public schools can not afford not to move more towards becoming more technologically advanced. Because, if we don’t we truly will be left behind in the big scheme of things in the world society. That’s my opinion.
Conception of Mathematics Teachers' Views

John, the principal, expressed his beliefs about technology implementation and how he perceived his teachers’ conceptions of teaching and the use of technology. He thought they were open to using technology, but some did not believe in students’ use of calculators in middle school mathematics. However, the eighth grade teachers did use scientific calculators for the purpose of familiarizing students with them in preparation for high school mathematics. Though computers had been in each teacher’s classroom for many years, most teachers had not made effective use of them for classroom instruction. To take advantage of emerging technologies and increase instructional use of computers, the school has implemented a policy of providing the SMARTBoard or ACTIVboard\(^3\) technology for all of the teachers. The board of education approved this implementation process and started placing this technology in the school starting with the sixth grade mathematic teachers. The principal reflects on the process this way:

I believe my teachers are very eager and open to using technology. I think that some of them have—. … I don’t know if I’d want to say an old school mentality when it comes to the use of calculators if they think that that’s somewhat enabling students. I know that with the teachers, the teachers who work with the older age groups, they understand the importance of students learning how to use scientific calculators and the functions of using that technology as they get into the higher order thinking math and transitioning to high school. Regarding the SMARTBoards, my sixth grade math teachers have SmartBoards in their rooms and use them on a daily basis and we are in the process of purchasing SMARTBoards for all of our math teachers and eventually for all of our content area teachers.

John explained that in the mathematics classrooms at his school, the teachers used this technology in combination with class demonstrations and student interaction with the technology. The teachers used the technology for instruction, but the technology also had instruments that allowed students to go to the board and work practice problems. The teachers

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\(^3\) SMARTBoard and ACTIVboard are brand names of the interactive whiteboard (IWB) technology.
could access the Internet, play mathematics games with the class, and do engaging activities
using the SMARTBoards. So, it is a combination of both. The teachers used the technology for
initial instruction, and they also used it to allow students to practice and to demonstrate
mathematics skills and concepts as well.
CHAPTER 5

Results for Teachers

At Coffee Middle School each grade level has its own department person over each subject areas. They are called lead teachers, or content lead teachers. There is also a grade coordinator who is the spokesperson for the whole grade when they have meetings with the principal. There is also a group called the Better Seekers, which tries to implement different curriculum improvements for the school to help the school’s progress.

Jane

When Jane first graduated from high school and went off to college, she was a mathematics education major for a couple of years. She never actually finished the education program because she changed her degree objective. She worked in social work in the county Department of Family and Children Services (DFACS) for about 3 years. After working with DFACS she entered the Teacher Alternative Preparation Program (TAPP) for the state of Georgia and began teaching fifth grade in a neighboring district. She taught fifth grade for 5 years there prior to coming home and teaching sixth grade mathematics (in 2006).

Jane started out teaching reading and social studies, but when the mathematics teacher at her school passed away, she started teaching mathematics. The former mathematics teacher became sick in the middle of the year and passed away. She took his classes and taught fifth-grade mathematics for two and a half years.
The sixth-grade mathematics teachers at Coffee Middle School meet as a group. When they meet, they all make decisions about how best to implement the curriculum, what to add, and what to change, and what to eliminate because of time constraints. Jane summarized:

What to teach Monday, Tuesday, Wednesday, Thursday, and Friday. If we find a nice flip chart, you know, maybe you’ll want to do that on Monday or just discuss…pretty much we do our lesson plans for the week together so everybody is teaching the same thing at the same time. Everybody teaches the same objectives, we support each other that way.

When they [the sixth grade teachers] came back from preplanning in January 2007, they did lesson plans for the whole month of January. They did all of January planning during the first week of January and during the last week of January they finished the February planning. But they still meet every week to discuss what was going on, and if any one of them was not exactly on target or fell behind, then they that person, “Well, we’ll do this…” to make sufficient and similar progress by the time they gave a benchmark test. They gave a benchmark test once a month, but by the time they gave that benchmark test, everybody would have taught what they said they were going to teach within that timeframe. If someone did not make it there, then the group did not add that objective to the test “because it wouldn’t be fair for the other students.”

In teaching mathematics, Jane sees a continuation from fifth grade mathematics to sixth-grade mathematics. She reflected on her experience by saying, “Sixth-grade math and fifth-grade math is almost identical, with the exception of surface area and volume. Some of the geometry change, but the rest of it is pretty much the same.” Jane displayed a chart of geometric figures as did the other two mathematics teachers. See Figure 4 below which includes surface area and volume.
Figure 4: Jane’s Display Board

Jane also suggested that some of her students’ work would be helpful in understanding how she structured her classes. See Figure 5 which shows one of her student’s work. The student drew several geometric shapes and solved some problems involving the shapes. See Figure 5.
When asked, “In general, do you use technology; do you use calculators or computers in your teaching in any way?” Jane responded:

I don’t personally; a lot of students use calculators. Some of them are use to using it in the elementary school, but I feel like if they can do it on paper, then once we can accomplish it on paper, then I’ll allow them use calculators but not a whole lot. Now, technology, I use it in my classroom a lot. I use my ACTIVboard and a lot of times I’ll pull up different math sites and games and we’ll play them on my PowerPoint that I use through ACTIVboard. Really, anything that can be done on the computer, I’ll put it up on the ACTIVboard and we do it as a class because it allows all of the students to be able to participate instead of making sure I’ve got a computer for every single student.

She was able to pull up something through the computer and then show it on the screen. She had a pen, which allowed the students to go up to the screen. She said,

It’s as if they had their keyboard and they could tap and do the stuff with the pen. So I don’t worry about having a computer for every single student. We go to the computer lab, but that’s only to do some practice for our CRCT test online. But other than that, I use my ACTIVboard.
Jane had students involved, going up to the board and maybe answering something. She explained,

And I can even put up a blank sheet and if I have students on the whiteboard working out problems, I can also put them on the ACTIVboard…because you can write like a regular pen on the ACTIVboard. So, we use it a lot, really.

Her main use of technology was the ACTIVboard connected to the computer. She though that was the appropriate use of the technology that she had, and she thought that was the best way to get her students to learn. When asked if she could envision using it in some other way. Jane responded:

It can be used in other ways. … We’re hoping to be able to get what they call the little ACTIVboard, and that’s a little device that you assign to each student and say, like if I wanted to give a quiz, which I do, but the only difference is now, I can’t use the ACTIVboard. Now, if I give a quiz, I show it on the ACTIVboard and they will write the answers down on a sheet of paper and turn it in. But if we get the ACTIVboard, they’ll be able to press an answer A, B, C, D, and if they press the answer and I’ll never have to take up a sheet of paper. Then I can go back to the computer later and pull up and see what student answered what and give a grade for that. But they don’t have them here yet so…I’m trying to get them to get it.

RESEARCHER: So, you’re pushing for the ACTIVboard? So, what is the process of trying to acquire that?

JANE: Well, we had a meeting with the…right now, here, only the sixth grade math teachers have ACTIVboards. However, I had an ACTIVboard in my old school, I wrote a mini grant and was awarded an ACTIVboard at my old school and so I already knew about it. And that’s how they know about some of the other stuff, too, because I’ve told them. But, anyway, we had a meeting…

RESEARCHER: Well, go ahead and talk about that.

JANE: Well, just at my old school, they sent a flyer around about if you want an ACTIVboard and I wrote a mini grant, answered some questions and I was awarded an ACTIVboard at my school, along with some other stuff that goes with it. And I didn’t have a whole class set of the ACTIVboards but it was a little sample, I think it was eight, but it was wonderful because I could put a multiple choice quiz up there and they choose their answers. Then I log into the program and it will show me what student gave me what answer and pretty much give me the grade. And it eliminated all this paper trail. But anyway, we had a meeting with the board members to demonstrate the ACTIVboard. I
guess the county is in the process of trying to come up with some money to put them in all the classrooms and so we showed them the many different ways it can be used. And I kind of threw that plug in about the ACTIVboards. I know that they’re going to get the ACTIVboards for all the other math teachers and eventually get it for the science and social studies teachers and hopefully, it will just trickle down to the other teachers.

RESEARCHER: So, you were the one who was familiar with this more than any of the other teachers here?

JANE: Yeah. The other teachers went to a staff development on it but I guess because I had been working with it a little longer than they had, I knew other little stuff so…if I find a nice flip chart, I’ll e-mail to them or if I make up a little flip chart, which is like a PowerPoint but they call it a Flip Chart for the ACTIVboard. But, yeah, I knew a little more about it than the rest of them.

RESEARCHER: Do you do a lot of communication by e-mail within the school?

JANE: Yeah, they e-mail pretty good. Content area, we have meetings once a week. We meet with all the math teachers, science, social science studies, and language arts …and so we do most of our communication as far as content that way. Now, if we find something good, and somebody can use it, then a lot of times we’ll just e-mail it to them.

RESEARCHER: When you have content meetings, do you all talk about objectives? What do you talk about in content meetings?

JANE: During our content meetings the teachers discuss what is going to be taught the upcoming week and discuss some stuff that needs to be taken care of, trying to make sure that they are following the curriculum map that they designed for the mathematics for the school year and making sure they are getting all the objectives taught before time for the CRCT.

Jane gave to me a copy of the units that they have developed for the sixth grade and the curriculum map, which is actually a little different from what they normally have because they changed some things. “So, what I have is not…what we’re actually going by. It’s the units but not in the correct order because we changed some stuff, we moved some stuff around.”

Jane went to the copier and made a copy of the Curriculum Map that she was referring to.

The curriculum map is displayed. See Figure 6.
Notice, the curriculum map consist of 12 units covering 36 weeks. However, teachers focus on 24 weeks in preparing for the CRCT and thus rearrange the 12 units to cover the objectives of the CRCT before test time, which is during the 25\textsuperscript{th} week of the school year. They cover the remaining units after the CRCT is given.

RESEARCHER: You meet as a group of sixth grade teachers. How is the principal involved in this? Who sets this procedure up?

JANE: It was already in progress when I came. This was something that they were doing but I think they did that…for what I’ve been told, I think that was some school improvement plan that they implemented and so everybody…you meet as a content and then you meet as a total grade. And then you are supposed to meet as…we’ve got three different little teams and you meet as your three different teams, too.

At her previous school, Jane was the grade coordinator for four years and so she expressed, “I was hoping to get out of that kind of situation but…I wasn’t that fortunate but its fine.”
RESEARCHER: Okay. So, you do use manipulatives, you do use the computer in order to manipulate things, to make them active.

JANE: Uh huh.

RESEARCHER: Do you believe in that?

JANE: Yes, most of time. I love my ACTIVboard.

RESEARCHER: You love it?

JANE: Yes.

RESEARCHER: How long did it take you to get comfortable with that technology?

JANE: When I first got it, my first six weeks of using it was just trial and error. I went to a couple of staff development classes in my previous county and those classes really taught you a lot about it and just playing with it, you know, just having that time to sit there and play with it and read and see what all it had. I’d say a good nine weeks. By Christmas break, the first year I had it, I think I could do a whole lot with it but there is still some stuff I’m not sure exactly how to do.

RESEARCHER: But you feel comfortable enough with it to incorporate it in your instruction?

JANE: Oh, yes.

RESEARCHER: Do you use it most everyday or how often?

JANE: I use it almost every single day.

RESEARCHER: And when you’re not using that, then…

JANE: We’re testing (laughs) or reviewing for a test. Even when we are reviewing for a test, I use it.

RESEARCHER: How about the school overall? Is the school meeting the yearly progress?

JANE: I think, yes, they receive Title I, the single school, this upcoming school year.

RESEARCHER: They received it already?

JANE: Yeah, for the last school year.

RESEARCHER: Okay, Title I Distinguished Schools
JANE: Uh huh, so they’re doing pretty good with math in AYP.

RESEARCHER: Okay, that’s wonderful. The documentation that you were talking about, for instance, they received that award…the curriculum guide that you all use and that kind of stuff, is there any way I could have access to any of that?

Jane offered to give a copy of their curriculum map for sixth grade math to me. The Title I Distinguished school banner is hanging in the commons area.

JANE: I’m sure you could go on the State Board of Education website and pull it up.

RESEARCHER: Okay, I’ve been there and looked at your school already but…you know, sometimes it’s hard to navigate and it’s hard to find out the stuff that you need. I see where you all made AYP, like three years in a row. Maybe the high school may not have last year. But anyway, that was good. When you use…so individual students do not use the computer, but you all use it as a class?

JANE: As a class, yeah. Well, they may use it if they want to take an accelerated test, that’s on the computer. They have to do that individually and I know that in the other classes, they take them to computer lab to type papers or do a little research but…I haven’t personally in math taken my class as a whole yet to the computer lab.

RESEARCHER: Are they allowed to use the calculator on the CRCT test?

JANE: No.

RESEARCHER: Has that always been the case?

JANE: No, I think special education kids, if it is stipulated in their IEP, then they may but I think it’s a bunch of controversy going on with that now but no, regular education students don’t use calculators.

RESEARCHER: And they will not use a calculator on that?

JANE: Um uh (no).

RESEARCHER: So, does that motivate you, not to use a calculator in your teaching?
JANE: That’s why I don’t use it.

RESEARCHER: That’s the exact reason?

JANE: That’s the reason why I don’t because I don’t want them to be dependent upon the calculator and then they can’t use it on the test.

RESEARCHER: So, would you say that the main motivator at this school in the math department is being able to pass that test?

JANE: Uh huh. Yes, sir.

RESEARCHER: Is there a lot depending on that?

JANE: Well, you just always want to look good and you want your students to look good and excel so, I mean…if you don’t meet it, then they are looking at, “what can we do for sixth grade math to get their students to get that sixty-six point seven percent of them that need to pass the CRCT test? And you don’t want all that attention.

When asked if, “you had a choice to teach something…if that test wasn’t there, and you had the choice to teach other things, do you think you might include more technology in your teaching?” Jane said:

Yeah, I probably would allow my students, if they…knew how to correctly use a calculator, then I would allow them to use it. But in my past, I noticed that when you allow them to use it, a lot of them don’t know the correct way to even enter in the information to get the right answer. So, that was in my previous years…so that’s one reason why I didn’t mess with them.

Then I asked, “If you were going to allow students to use a calculator, how do you think that they would use them and what would be an advantage of using a calculator against not using a calculator?” at which time Jane answered; “I guess the advantage would be once they know how to actually solve that problem on paper, let’s say it’s a four or five digit multiplication problem, then it would eliminate that time from them multiplying…you know, we could get maybe some of the work done a lot faster.”
She indicated that she would use the calculator as a time saver after students had already learned the process to solve the problem. She didn’t think that she would ever let them use it when they are learning a new concept.

RESEARCHER: Does the leadership here at the school, principal, assistant principal, the people that come to you with the plans that you are supposed to implement; do they promote the use of technology and do they have any particular view about technology?

JANE: My assistant principal actually loves these ACTIVboards. She’s the main one, you know…saying, “We’ve got to get them for these teachers, we’ve got to get them” so, yes, yes, I’d say definitely because she’s really striving and working hard trying to eventually get ACTIVboards for every single teacher here at the school.

The assistant principle was a “big” advocate of that type of technology. She was recently out of the classroom. She taught eighth grade mathematics and that was why Jane thought the sixth grade mathematics teachers were the first to get the ACTIVboard technology. Jane said they used them on a daily basis and that was the main technology they used. It was adequate for her purposes.

RESEARCHER: And you’re saying that there is no need to use a calculator because the students are not allowed to use them on the CRCT test?

JANE: That’s my personal feeling. The other two teachers, especially the one on the end, she allows her students to use calculators just because it saves a lot of time but…I don’t. I just don’t want them to be handicapped by that calculator and then when it’s time and they actually perform, they can’t because they are so dependent upon the calculator.

When asked, “How has the technology that you use changed what you do in the classroom from how you taught before you had it?” Jane explained how her teaching has evolved because of the integration of technology into her instruction.
Before, I used my overhead projector all the time. Now, I probably don’t even touch it much. I mean, I still instruct from the board but a lot of my instruction comes from the ACTIVboard, it’s a time saver. Say, for example, if you did a lecture and we took notes, then if I put it on a flip chart, I wouldn’t have to write it four different times. I wouldn’t have to get up there and write it four different times, I’d have it on a flip chart on a page and I could just turn to that page and it would save me a lot of time. Whereas before, you know, if you wrote on the chalkboard, you wrote it, the kids copied, you had to erase it and work out problems and then the next class you had to write it again, you know? It eliminates all that.

RESEARCHER: Okay. Do you have any directives coming from the administration as to how you should teach in the classroom?

JANE: No.

RESEARCHER: You pretty much can teach how you want to?

JANE: Yeah, I mean it’s all about being an effective teacher. You know, they want you to be that effective teacher and as long as you’re doing what you need to do in the classroom, no, they do not come and say “I want you to do this, this, this and that with your students”.

**Calculator use**

The teachers at Coffee Middle School administer the CRCT at the school. The students are not allowed to use calculators. The fact that students cannot use calculators on the CRCT is a motivating factor for Jane to not let them use calculators in the classroom. She doesn’t want students to be dependent upon the calculator and then they are not able to use it on the test. She thinks that the main motivator at the school in the mathematics department is being able to pass that test. She said there was lot depending on CRCT test performance.

RESEARCHER: Are students allowed to use the calculator on the CRCT test?

JANE: No

RESEARCHER: Has that always been the case?

JANE: No, I think special education kids, if it is stipulated in their IEP, then they may, but I think it’s a bunch of controversy going on with that now. But no, regular education
students don’t use calculators. That’s the reason why I don’t [let students use calculators in class] because I don’t want them to be dependent upon the calculator and then they can’t use it on the test.

She indicated that she would use the calculator as a time saver after students had already learned the process to solve the problem. She didn’t think that she would ever let them use it when they are learning a new concept.

**Jane-Summary**

**Instructional uses**

Jane uses technology in her classroom every day. She uses her ACTIVboard to pull up different mathematics sites and games and she, along with the class will play mathematics games on her PowerPoint that she uses through ACTIVboard. Anything that can be done on the computer, Jane can put up on the ACTIVboard and do it with the whole class. The ACTIVboard allows all of the students to be able to participate instead of each student having a computer. Whatever was on the computer would show on the screen and there was a pen that allowed anyone to go to the screen and interact with it. Jane explains, “...it’s as if they had their keyboard and they could tap and do the stuff with the pen so I don’t worry about having a computer for every single student.” There were three computer labs within the school. Jane took her class to the lab once a week to do practice work for the CRCT, she explained: “We are going to the computer labs but that’s only to do some practice for their CRCT test online. But other than that, I use my ACTIVboard.”

If she needed to work with manipulatives, to use some base ten blocks or fraction strips, she could pull them up on the ACTIVboard. Jane: “…instead of getting them out and passing them out to ten or fifteen different students and they’re playing with them. So, they can actually go up there, move the manipulatives on the board to solve the problem instead of actually
passing out all of those manipulatives.” She further notes that the program has a lot of different resources. “I can pull up a coordinate grid, I can pull up a number line, I can pull up a ruler, a protractor, a compass, and any type of manipulative you can think of.”

**Educator’s Proficiency**

Jane gives a good explanation of the professional development involved in the implementation of technology at her school. She explains it this way.

Yeah. The other teachers went to a staff development on it but I guess because I had been working with it a little longer than they have, I knew other little stuff so…if I find a nice flip chart, I’ll email to them or if I make up a little flip chart, which is like a PowerPoint but they call it a Flip Chart for the ACTIVboard.

During our content meetings we discuss what is going to be taught the upcoming week and discuss some stuff that needs to be taken care of, trying to make sure that we’ve got…that we’re following the curriculum map that they designed for math for the school year and making sure we are getting everything in before CRCT time.

When I first got it, my first six weeks of using it was just trial and error. I went to a couple of staff development classes in my previous county and those classes really taught you a lot of about it and just playing with it, you know, just having that time to sit there and play with it and read and see what all it had. I’d say a good nine weeks. By Christmas break, the first year I had it, I think I could do a whole lot with it but there is still some stuff I’m not sure exactly how to do.

**System Support**

Jane talks about the support of the administration in the implementation of technology.

My assistant principal actually loves these ACTIVboards. She’s the main one, you know…saying, “We’ve got to get them for these teachers, we’ve got to get them” so, yes, yes, I’d say definitely because she’s really striving and working hard trying to eventually get ACTIVboards for every single teacher here at [Coffee Middle School]. My principal is very supportive. He makes sure you have got what you need especially my first year here. Where I came from, I didn’t see the principal this much, but you can always look out your door and you’ll see him.

**Alice**

Alice had extensive experience in teaching mathematics and also an educational background that qualified her to be an effective teacher of middle school mathematics. Alice
graduated from a University in Southeast Georgia many years ago. She had been teaching for twenty-four years. She taught social studies her first year and she has been teaching mathematics since then. She taught seventh grade the first year, but had been teaching sixth grade all the other years. She was highly qualified in mathematics. She actually went back to school for professional development where she took the Georgia Assessments for the Certification of Educators (GACE) and so she was highly qualified through the GACE and also the “old way” too. She had taught at this school her whole career. She taught mathematics throughout the day.

**Appropriate use of technology**

When I asked Alice, “In your teaching, what do you think is the appropriate use of technology?” she gave me insight into what her conception of why we should take advantage of emerging technology. Technology can provide ways to give students visual stimulation as well as help them to learn in a variety of ways. Alice realizes that we have to teach through technology because “these kids need the visual stimulation and so I want my class up to date with technology and I’m constantly asking the media specialist about sites I can go to or things I can do to make my class more up to date.” She uses a computer to access educational resources and uses and interactive board to involve the class with interactive activities. Alice gives an example of how she uses computer technology in the classroom.

If I want to go to just write on the board, I go to ActivStudio, the professional version of it and if I want a coordinate plane to use to teach maybe with the math lesson for that day, I can click on the coordinate plane tab and my whole board will be blue and white lines and it shows the x axis and y axis and I can teach using that and you can pull up your different backgrounds and things you need. It gives the kids another visual to use in the lesson. The old days, I would have to draw my x and y on the chart board and draw every line and you know, plot my coordinates and then the next step we had, I had a poster board with the blue and white things on it. But now, all I’ve got to do with the ACTIVboard is click a button and I’ve got my coordinate plane ready. And a ruler is on there, there’s even a protractor on there, that’s the seventh grade standard so I’m not using it that much but there’s a protractor, there are rulers, you can draw your angles in any shape you want. I mean, it’s endless what it can do. And I’m certainly no expert on
everything that it can do. I’m learning daily and the way you learn something is by using it and so I’m using it daily. And we use it everyday in this classroom.

RESEARCHER: When you use it, does the administration require that or expect that or is it a decision that you.

ALICE: Oh, I’m sure it’s a decision I’m making. I know that the administration and the Board members and the superintendent certainly would think that you were using it if they were spending that much money on it. For instance, this year sixth grade math teachers received it; we were the first ones to receive it. And so when you get a new toy everybody wants that new toy. And so everybody else wanted one and so the principal at this school asked me would I present a program to the board members and the superintendent to try to see if we could get funding for the science and social studies teachers to get one.

One evening the board of education had a meeting in Alice’s classroom. Alice along with the other sixth grade teachers presented some things on the ACTIVboard, not just that you could use for math but they wanted them to see what you could for science and social studies and things like that, too. So, they presented those kinds of things to them. The teachers were successful in their presentation that night because the Board decided to adopt the ACTIVboard for science and social studies for the next school year. The goal is for everybody to get one in the school.

…it speeds things up quickly and I mean…I see it as a great benefit to education. Now, I remember when we used to write on the chalkboard and then we got these whiteboards they call them and I thought that was an improvement but the ACTIVboard has really made things a lot faster and when I did the whiteboard, my kids were constantly coming and putting the problems on the board. Things haven’t changed with the ACTIVboard. They pick up the pen, “you go show us how you came to that answer on number 23” and so it is real kid friendly and there’s no reason to keep the children off of it. I believe the way you learn math is by doing math and so I’m making my kids constantly prove to me how they came up with that answer. And sometimes if one child came up with an answer one way, and another child came up with the same answer a different way, “well, let’s talk about these two different ways” and they can easily show that up there on that ACTIVboard.

I mean, they’re very interactive and the things about children, I mean, it’s kind of like they were born with technology in their brain because…they can get things a lot quicker than you can sometimes. I mean, they just really are technology wise and can pull things
up and find things a lot quicker than you can sometimes. So, yeah, my board is not off limits to my children and you can look at it and tell it probably needs cleaning right now. But that’s why it is up here, as a tool for my children and that’s what I use it for.

Alice expressed how the sixth grade teachers are able to use their computers along with the ACTIVboard to demonstrate lessons from the counselor during advisement. She explains how the computer can enhance communications with the counselor thus gaining administrative support. “Lessons come through the counselor and so if she has an activity she wants us to do during Advisor/Advisee she usually puts it on a worksheet… but the math teachers, all she has to do…all we have to do is open our email and it will show right up there and kids can see that it came from her and it’s not just these teachers telling us to do something else.” They can see that the counselor was the one who wanted to do this for a reason. She saw the computer as enhancing what she did in the classroom “you can see anything you do up there really and if she wants something private, she turns the remote control off so that the students can’t see the board and sometimes she has to do.” She gave an example of how the computer was helpful with efficient in giving progress reports. “This week we had progress reports to go home. Well, one child was leaving early and she needed her progress report right then and so she just turned the remote control on and went over and printed her progress report. Closed that program down and came back over to the computer and continued what she was doing with the class and that took all of two minutes. So, yes, I can do multiple tasks up there.” It’s on the computer. Alice went through a demonstration of what was available on her computer showing me how anything that was on her computer could be shown on the ACTIVboard. “Every one of those programs, all those icons that you see right there on that screen, there are about 38 icons showing right there, well, that’s 38 programs and I can click on any of those icons and then you can go to the Internet and it’s endless. But anything you see right there I can click and it will pull it up.”
Researcher: So, does the leadership of this school promote any views concerning [interruption] instruction? How about mathematics instruction?

Okay. Our school has made AYP for the past several years but one area of need is math with special needs children so yes, math is a high area for the administration to try to think of things that will work to make improvements and our assistant principal is wonderful, wonderful, and wonderful with technology. She’s always finding things for us to use in the classroom, sites that we can do. We have an achievement series that we have here that our kids are benchmarked every four and a half weeks, the skills to get them ready for the CRCT. And after the benchmark we can do an analysis sheet and find out what skills our kids did achieve on that benchmark, what they didn’t, what the grade did as a whole before we can go back for remediation. So, yes, our administration is very in tune with technology, they are expecting us to use it, they are investing the money, they’re looking for grants to get us the technology and we’re expected to use it and I see it as an improvement.

When asked if she believed that the teachers and the district administrators agree with her view of how technology should be used in the classroom, how it can help educators, she gave insight into how the technology was viewed in the school by teachers and administrators.

The sixth grade teachers are into it. I know that they agree with the way we use technology in the classroom. In fact, we have a meeting every week and we bring in sites and our ideas for the whole online thing that we use quite a bit in class, things that we can use in our classroom because one teacher can’t find everything to use. It’s going to take teachers working together and collaborating and using what they find together. Our sixth grade math teachers really work well together. Now, do we meet with the seventh and eighth graders and the other teachers at the school? No, not like we should but as far as meeting with our small group, we do. Now, the administrators, they are requesting that you turn in your content meeting sheets and concepts and the ideas that were discussed during that meeting so. …I think they are on top of it, too. We probably just need to meet as a school more.

When she used the technology, she used it through the computer basically and she felt that the students were more excited about learning, they could look at different views of a particular problem rather than if they just had the textbook.

The computer, the math series…they are more…they’ve already gotten the real life situations thought out and it’s not all left on me to think of how can I put this lesson or concept into a real life situation? And so, they’ve got it thought out and like, we were studying circumference today and they had a little picture drawn out and the kids can see it. And that’s good for the visual learner, the people that need to see that real life part of it
and they’ve got it thought out, so it’s not all up on my shoulders to think of, “Well, let’s think of a way I can use this in real life”. So, let technology think for you [laughs].

When asked if she allows calculator use in your math class she responded this way; she expressed her conception of how the calculator should be used in the mathematics classroom.

She also outlined how she disagrees with the State policy.

Now I’m going to tell you. Georgia doesn’t let our sixth grade students use calculators on the [CRCT] test unless they have an IEP statement that they can. I think that is wrong because not one part of our test is measuring computation. Our CRCT test is measuring concepts. If you understand the volume of a cylinder, if you understand how the find the surface area of a rectangular prism, okay? I can make sure my kids understand those concepts, but if I have a child that has a memory deficit and they can not remember those multiplication tables and if I don’t not allow them to use a calculator in this classroom it holds them back. I think that’s a mistake. I think the state of Georgia needs to let all sixth grade students start using calculators in the sixth grade. I can understand not using them in K—5, “let’s learn our basic facts, let’s learn how to multiply, subtract, add, do concept problems and word problems without the use of a calculator” but when they get to sixth grade, it’s time to pass out the calculators, allow every child to use the calculator and I think we can take math to new heights if the state would get away from the old way and say calculators are here, let’s put them in their hands, let’s go to new heights and let’s be the ones that break the water and make the headway there because calculators are here to stay.

Alice pointed out that when students went home and she went home, and there was mathematics to do, “…we’re not going to sit there and do it the old fashion way, we’re going to pull out a calculator to do it.” She thinks that all sixth grade students should have calculators. She expressed her disagreement with the calculator use policy by emphasizing, “Are we allowed to? No, but do I [use them in class] yes.”

Alice tried to make time in her classroom for students to use calculators because she thought it was important that they understood a calculator, especially before they get to high school and they are expected to know how to work a scientific calculator. It would be a handicap if they have never had practice with a regular calculator. She had an inclusion class that includes children that had accommodations. The IEP allowed them to use a calculator. She had students
that were on calculators and student that were not on calculators. The students using calculators had documentation stating they could use a calculator. It was not left to teachers which student could use calculators on the CRCT; it is not anything to do with the individual teacher so they do not question the policy. The students and teachers know who is allowed to use a calculator on the test “and it’s no big deal, nobody even notices them anymore. I had to say that one or two times and that’s was it, it was over with, it was not an issue.” She thought all students should use calculators and she tried to make time in her classroom for kids to use calculators during class time. In fact, she had a yellow bin and a white bin full of calculators for the whole class. She noted a problem, “this is one problem that I had that. …I mean, I have like twenty-five children in every classroom in and out and I see today I’ve got some missing now so…that’s one problem I have, I mean, it’s hard to keep up with them like I wish I could keep up with them. But they do put their hands on a calculator in my room, yes.”

When asked if she is a believer in calculator use in the mathematics classroom she expressed her belief in using that technology this way.

ALICE: I think it is outdated not to let them use a calculator. I think it’s outdated for a middle school child not to be able to use a calculator. I wished we could get that changed. I really think it’s outdated. I mean not one part of that test measures children on computation, not one part of it. Now, they are measuring them on adding and subtracting fractions which some people say, “well, that’s computation and multiplying and dividing fractions” but if you give these kids a standard calculator, they’re not going to be able to do their fractions on a standard calculator, I mean, they might have to use a standard calculator to multiply and add, so be it, use it. I mean, I really don’t have a problem with giving scientific calculators in sixth grade either, I think that’s the way of the future, I think that’s the way we need to change. If we really want to improve things and we really want our kids to learn more concepts and ideas and do more critical thinking in math, then we’re going to have to quit crippling them by keeping a calculator from them when they have a deficit of short-term memory where they can’t learn their multiplication tables. There are so many kids that are very bright, but when it comes to remembering those facts, they just can’t do it, they just can’t do it. And they depend on their little multiplication sheet, which is outdated, too. Why should I sit here and “look on the multiplication table sheet” when I can do 54 divided by 6 on a calculator and pull it up real quick. So, I think not letting children use calculators is outdated and should be changed.
Alice believed in students using calculators starting in the sixth grade. She thinks calculators enhance their understanding and learning of concepts. The fact that they are not allowed to use calculators on the CRCT is not a rational policy. She believed calculator use in the classroom will not have a negative impact on their test result. Alice does not think that they will be hindered by using a calculator in class and then at test time, they can’t use it. She gives a model of how she believed she used the calculator effectively in her instruction, which includes practice time without the use of a calculator.

No, because I’m giving them practice time with a calculator and practice time without a calculator. Now, if I didn’t give them any practice time without a calculator, yeah, it might hinder them, but I know for a fact I’ve seen that my children can learn volume and surface area, the prisms, the cylinders and the columns that we have to learn, we can learn that. And the way I teach that is by putting a calculator in their hands and teaching the formula, plugging in the number where the formula is and of course, we look at the picture and pick out, well, which one is the radius? Which one is the height and so I’m doing my visual, we write our formula, what kind of solid is this? Write our formula, plug in our numbers, and sometimes “let’s work a couple without a calculator. Okay, let’s work 3 or 4 without a calculator. Now, let’s pick up and those are going to be with simpler numbers and let’s say our numbers are a little more difficult. Okay, let’s pass out calculators” and we can still do it. They understand it. The calculator didn’t hold them back, they passed their benchmark test without a calculator but they used a calculator in the classroom. I mean, our benchmark, we have benchmarks every four and a half weeks and it is preparing them for the CRCT and that’s my proof that hey, they learned this task with the calculator but they took this benchmark without a calculator and they still were able to do it. Does that kind of answer your question?

Alice has a chart on her classroom wall displaying some geometric shapes, which she spoke of in the quotation above. See Figure 7.
Alice finished the interview by expressing her desire for our children to exceed and to do well and she doesn’t think they should be held back by outdated things and that we need to make changes in trends and look for technology and whatever we can to do to give our kids every benefit possible. “So that we won’t just be thought of as a rural town, that we would have all these up to date things that a wealthier county might have.”

**Calculator use**

Alice tried to make time in her classroom for students to use calculators because she thought it was important that they understood a calculator, especially before they get to high school and they are expected to know how to work a scientific calculator. She thought all
students should use calculators and she tried to make time in her classroom for students to use calculators during class time.

She had an inclusion class that included children that had accommodations. The IEP allowed them to use a calculator. She had some children that used calculators on the CRCT and some who did not use calculators on the CRCT. The students using calculators had documentation stating they could use a calculator. It was not left to teachers which students could use calculators on the CRCT; “it is not anything to do with the individual teacher so they do not question the policy.”

Alice believed in students using calculators starting in the sixth grade. She thought calculators enhance their understanding and learning of concepts. The fact that they are not allowed to use calculators on the CRCT “is not a rational policy.” She believed calculator use in the classroom would not have a negative impact on their test result. Alice did not think that students would be hindered by using a calculator in class, and then at test time, they can’t use it? She gave a model of how she believed she used the calculator effectively in her instruction, which includes practice time without the use of a calculator

Alice-Summary

Instructional Uses

Alice uses the computer in combination with the ACTIVboard on a daily basis. She did not use her Whiteboard anymore because she used her ACTIVboard for her teaching and everything she wrote was on the ACTIVboard. She did mathematics on the Internet and in the computer lab with here students. Alice indicated that mathematics on the Internet and in the computer lab might be a form of play. She sometimes used the Internet and computer lab to reward students for good work. She also did activity days when she was ahead of the other sixth
grade teachers in her lessons. She stated, “We were doing math on the Internet and the computer lab really playing that day.” She also stated, “I try to use technology daily any way I can think of using it. …I realize that we have to teach through technology because these kids need the visual stimulation and so I want my class up to date with technology.”

Educators’ Proficiency

Alice constantly consults with her librarian because she believed the librarian was more up to date on the new technologies. Alice wanted to see what she could do to make her class more up to date. The sixth grade mathematics teachers had a meeting every week. In these meetings, they brought in Internet sites and there ideas. As Alice puts it, “In fact, we have a meeting every week and we bring in sites and our ideas for the whole online thing that we use quite a bit in class, …It’s going to take teachers working together and collaborating and using what they find together. Our sixth grade math teachers really work well together.”

System Support

Alice said that the administration, the Board members, and the superintendent believed that the sixth grade teachers were using the computers and ACTIVboard technology because they were spending a great deal of money on it. Consequently, the Board of Education had its meeting in Alice’s classroom so that the teachers could demonstrate the effectiveness of the technology. The Board adopted the ACTIVboard technology, so Alice believed that the sixth grade teachers were successful in demonstrating the effectiveness of the ACTIVboard technology when combined with the computer. Alice stated that that because of their successful demonstration The Board decided to purchase the technology for the seventh and eight grade mathematics teachers. She emphasized, “But that’s the goal—for everybody to get one in the school.”
Mary

Mary has been teaching thirteen years. She started teaching alternative school, taught there for one year, and now she has been teaching sixth grade mathematics for the other twelve years of her teaching career. She expressed to the researcher that she really enjoys teaching the kids.

RESEARCHER: So, let me ask another question about the test that students have to pass…they don’t have it in sixth grade, do they? Mary responded:

Sixth graders take the CRCT at the end of the year. They need to pass the reading, language arts, and the mathematic portion of the test. It’s not a requirement that they pass the science and social studies part of the CRCT. It’s not a requirement at the present time that they pass the science and social studies, but it is a must that they pass their reading and language arts and mathematics parts of the test in order to go on to the next grade.

Appropriate use of technology

Mary has a view on the appropriate technology implementation for mathematics education. She does not use calculators in her instruction in sixth grade because she thinks students are still learning the basics. But she believed calculators should be used in seventh and eighth grades even though they were not used on the CRCT test. Her reason for allowing calculators in the seventh and eighth grade was because to use the calculator to do a problem “you have to know the steps”. Another reason for allowing students to use them in the “higher levels” was to prepare them for high school where they use graphing calculators in some of the mathematics classes.

MARY: I think calculators are good. We don’t normally use calculators in sixth grade because students are still learning the basics, your addition, subtraction multiplication and division; we are still trying to work with them on that. We use them very little here in sixth grade. As far as seventh and eighth grade, I think they do need them even though they can’t use them on the test. You have to know the steps in order to use the calculator anyway. You have to know the steps to work on a problem before you can use the calculator, so I do believe in letting the higher-level students, seventh and eighth grade use them. And then, also, it gets them prepared for using them in high school. Other
things, computers, yeah, computers are good. A lot of the software that goes on the computer, they’re good for extra work and also this year is the first year with the SMARTBoard, the kids really enjoy the SMARTBoards.

Mary comments on how the new policy on testing has changed the emphasis on how she teaches mathematics since they implemented the CRCT test. She says it has changed her approach. The newly implemented Georgia Performance Standards (GPS) guides her instruction and is the focus of the CRCT.

MARY: Yes, it has. In the state of Georgia, we have what we call the GPS standards that we have to go by and those are the things that will be tested on during the test. And so we have to go by those standards to prepare the kids for the test.

RESEARCHER: Do you use the computer a lot?

MARY: Yes, I have mine on everyday, we do warm ups and everything on them and it gets the kids more involved.

RESEARCHER: So, it is more or less like demonstration?

MARY: Demonstration, yes, and then we got new textbooks this year and we’ve got programs to go along with them. The kids can get up and actually go to the SMARTBoard, they enjoy just touching it and seeing what happens, they enjoy the sound so it is real good for the kids to get involved.

RESEARCHER: Okay. And you don’t use the computers at all in the classroom?

MARY: Yes, when we have them do projects…more or less…playing games or if we find a good website…well, the computer actually ties into the SMARTBoard. We can bring things up on the computer and it shows up on the SMARTBoard and we can actually let them do work on the SMARTBoard from the computer. It works together.

RESEARCHER: Do you believe that technology is beneficial to the students?

MARY: Yes, right now, because this is just a different generation of kids now. I mean, they can’t sit still for two minutes and so this is a way of getting them up and moving them around, getting them involved. They like video games; the computer is more like a video game to them, that’s how they look at it. So, yes, computers and technology is very beneficial in a mathematics classroom.
RESEARCHER: Do the principal, vice principal, Board of Education…do they support technology in any way you can think of?

MARY: Oh, yes, oh, yes… right now they’re writing all kinds of grants trying to get the SMARTBoards in all the classrooms. Sixth grade got them this year; seventh grade math is going to get them next year. They started with the math department and they are going to go with the science next and then implement language arts and social studies. So, they’re trying to get all computers in all the rooms and SMARTBoards in all rooms. So, yeah, they are very supportive of the SMARTBoards and computers. We just got a new computer lab last year and so we’ve actually got three computer labs that we can actually have access to.

When asked about the other teachers at the school, whether they are enthusiastic about technology, computers, and if she hears negative or positive talk about using computers and calculators, Mary reported that she hears mostly positive comments about technology. She noted that the one negative was there are not enough computers in the classrooms. This was the only negative concern that she noted. This was what she said.

Yes; mostly positive things about computers. The only thing is maybe in a classroom, you know, we only have like two computers in a classroom, that was the only negative thing I see about it but like I said, they just got a new computer lab and so now you have access, there are 30 computers in there and so it is enough for a whole class.

Mary thinks that technology is the big thing now and it does help in the learning process and in middle school. She can see the difference in some of her students. She puts it this way, “because everybody just can’t do…a lot of them can’t do book work, they have to get up and actually work hands on and so I can see that technology is a big help.” She has some special education students that she has to let use the computer. Mary explains, “They actually know how to do the work but their problem solving or just regular computation, they can’t multiply or divide but if you give them a calculator, they know how to do it on the calculator and so that helps them out.” She thinks that technologies such as computers, SMARTBoards, and calculators are very important in a middle school setting.
Mary also has a chart on her classroom wall displaying some geometric shapes. See Figure 8.

![Figure 8: Mary’s Display Board](image)

**Calculator use**

Mary has a view on the appropriate technology implementation for mathematics education. She does not use calculators in her instruction in her sixth grade mathematics classroom because she thinks her students are still learning the basics. However, she did believe that calculator use is appropriate in middle school classrooms, but not appropriate in the sixth grade classrooms except in some special cases.

She had some special education students that she had to let use the calculator in the mathematics classroom. Mary explains, “They actually know how to do the work but their problem solving or just regular computation, they can’t multiply or divide but if you give them a calculator, they know how to do it on the calculator and so that helps them out.” She thought that
technology such as computers, SMARTBoards, and calculators was very important in a middle school setting.

**Mary-Summary**

**Instructional Uses**

Mary thought that technology was “the big thing” and it did help in the learning process in middle school. She saw the difference in some of her students. She said “…because everybody just can’t do…a lot of them can’t do book work, they have to get up and actually work hands on and so I can see that technology is a big help.” She had some special education students that she had to let use the computer. Mary explained,

> They actually know how to do the work but their problem solving or just regular computation, they can’t multiply or divide but if you give them a calculator, they know how to do it on the calculator and so that helps them out. So, yes, technology, all these computers, SmartBoards, calculators I think is very important in a middle school setting.

**Educators’ Proficiency**

Mary talked about how the computer and SMARTBoard worked in combination to engage the students. She explained,

> …if we find a good website…well, the computer actually ties into the SMARTBoard. We can bring things up on the computer and it shows up on the SMARTBoard and we can actually let them do work on the SMARTBoard from the computer. It works together.

**System Support**

Mary outlined how the school system supported and was implementing technology in her school. She explained:

> Yeah, we took inservice in Augusta. Oh, yes, oh, yes…right now they’re writing all kinds of grants trying to get the SmartBoards in all the classrooms. Sixth grade got them this year; seventh grade math is going to get them next year. They started with the math department and they are going to go with the science next and then implement language arts and social studies. So, they’re trying to get all computers in all the rooms.
CHAPTER 6

Cross-Case Analysis and Conclusions

The analysis of each research participant was organized according to three policy components, which are instructional use, educators’ proficiency, and system support for teachers’ learning, for students’ learning, and for teaching. Since my goal was to understand these teachers and administrators conceptions of policy, in this report I presented the data from the point of view of each research participant with as many of their own words as possible. The data have been presented, and now a cross-case analysis and my interpretation of how the participants made sense of each component of policy by using the sense-making framework of the study are presented below.

Cross-Case Analysis of the Administrators

The curriculum coordinator Rhonda, and the principal John promoted advances in technology in all subject areas, especially in mathematics. Mathematics is an area that is part of the annual manageable objectives reported in the Annual Yearly Progress (AYP) reports. It is an area where teachers are constantly seeking to meet the needs all of their students.

Because of the changes in the curriculum that the Georgia Performance Standards (GPS) require, they were looking more closely at where we were as a nation in the area of mathematics. They believed they had to retool teachers and help them understand that the mathematics requirements were not the same mathematics that we teachers learned in school as teachers and as students.
Mathematics teachers at Coffee Middle School were veterans and had a tendency to lean more towards the traditional teaching styles. They tended to be somewhat apprehensive about using technology; however, they were open to new strategies and understood that today’s generation of students tend to be a little more technically savvy. John believed that the teachers understood that by implementing new technology into their classrooms, they could, in fact, reach some of their students that they may not reach using traditional methods.

To take advantage of emerging technologies and increase instructional use of computers, the school had implemented a policy of providing the “SMARTBoard” or “ACTIVboard” technology for all the teachers. More specialized content software that tend to be associated with mathematics instruction were mentioned as needed by the principal—particularly programs designed for practice for the Criterion Referenced Competency Test (CRCT), but the focus for classroom instruction seemed to be on improving instruction using the ACTIVboard technology to enhance the interactive quality of the computer.

When asked about expanding the availability of tools in his school, the principal expressed interest, but noted that they hoped that currently available tools, which were being used effectively by sixth grade mathematics teachers, would be acquired for and utilized by seventh and eighth grade teachers before expanding. Both John and Rhonda also noted that teachers’ technology use and curriculum integration skills also played a role in their purchase request decisions. These decisions were made with the consideration of teachers’ input.

Apparently, the administrators felt that as teachers master the basics, new tools could be added. Additional plans, they felt, may overwhelm teachers and result in underutilization of expensive software titles. A third concern for the principal was cost. Investing in basic software tools that can be implemented across the school on every machine seemed to be his highest
priority. He noted that after costs for basic software titles were absorbed, there was sometimes little money left for other titles. A fourth concern for both was time to research available software and meet individual content needs.

In addition to computer use, both John and Rhonda believed that teachers should allow their students to use calculators during class time. Rhonda’s position on calculator use could be seen in her statement, “Graphic calculators, computers, SMARTBoards, all of those technologies that allow boys and girls to have hands-on experience and allow them to be interactive in their learning.” John, in expressing his thoughts on calculator use, stated that his teachers were open to using technology. However, some did not believe in students’ use of calculators in middle school mathematics.

**Cross-Case Analysis of the Teachers**

The sixth grade mathematics teachers at Coffee Middle School used the computer, in combination with the ACTIVboard daily. They did mathematics on the Internet and in the computer lab with their students. Anything that could be done on the computer could be placed on the ACTIVboard through the computer and teachers could thereby work with the entire class. The ACTIVboard allowed all students in the class to participate without each student using a computer individually. All three teachers used the computer in their classroom this way. They used it in their lectures and they let students come up to the board to demonstrate their understanding of concepts or to work problems. The teachers thought technology was the “big thing” and it did help in the learning process in middle school. The teachers thought that technology, computers, SMARTBoards, and calculators, were very important in a middle school setting.
Mary had a view on appropriate technology implementation for mathematics education. She did not use calculators in her sixth grade mathematics classroom because she thought her students were still learning the basics. However, she believed that calculator use was appropriate in middle school classrooms, but not appropriate in the sixth grade classrooms except in some special cases. She had some special education students that she had to let use the calculator. She said that the special education students knew how to do math on the calculator and so using the calculator helped them out with their math.

Alice tried to provide time in her classroom for students to use calculators because she believed it was important that they understood a calculator, especially before they get to high school when they are expected to know how to work a scientific calculator. She thought all students should use calculators and she tried to make time in her classroom for students to use calculators during class time. However, she spent time working on the basics during the first part of the school year at which time her students were not allowed to use calculators. Alice indicated that mathematics on the Internet and in the computer lab may be a form of play, but none of the other teachers mentioned the computer in that context. She sometimes used the Internet and computer lab to reward students for good work. She also did activity days when she was ahead of the other sixth grade mathematics teachers in her lessons.

Jane indicated that she would use the calculator as a time saver after students had learned the processes to solve the problems. She did not think that she would ever let students use the calculator when they are learning a new concept. The fact that students could not use calculators on the CRCT was a motivator for Jane to not let them use calculators in her classroom. She did not want students to become dependent upon the calculator and then not be able to use it on the CRCT.
The sixth grade mathematics teachers at Coffee Middle School use the computer in combination with the ACTIVboard daily. All three teachers in the study used the computer in their classroom this way. They used it in their lectures while letting students come up to the board to demonstrate their understanding of concepts or to work problems. The teachers thought that technology was an absolute necessity to aid students in the learning process in middle school.

As for calculator use, the teachers were divided on the issue of whether calculators should be used in the sixth grade mathematics classroom. Alice provided time in her classroom for students to use calculators because she believed it was important that they understood a calculator; especially before they get to high school when they will be expected to know how to work a scientific calculator. Jane did not allow her students to use calculators in the classroom. She did not think that she would ever let students use the calculator when they were learning a new concept. The fact that students could not use calculators on the CRCT was a motivator for Jane to not let them use calculators in her classroom. She did not use calculators in her sixth grade mathematics classroom because she thought her students were still learning the basics. However, she did believe that calculator use was appropriate in middle school classrooms, but not appropriate in the sixth grade classrooms except in some special cases. Mary did not use calculators in her sixth grade mathematics classroom because she thought her students were still learning the basics. However, she did believe that calculator use was appropriate in middle school classrooms, but not appropriate in the sixth grade classrooms except in some special cases.
Sense Making

The underlying assumption of my research was that policies impose voluntary or mandatory changes in practices through prescribed actions and objectives, yet policy actors bring in situated interpretations to the policy as they construct their own practices. In this framework, local agents are not passive recipients of an official language; rather, they are contributors to the change as they actively interpret educational policies (Mantilla, 2001; Schwab, 2001).

My theory of the process of technology implementation in a middle school mathematics department is that policy makers expect teachers to make changes in practices through prescribed actions and objectives, yet policy actors bring in individual interpretations of the policy as they construct their own practices. Consequently, technology implementation is an evolving process dependent on the individual teacher, school administration, available technology, and the situated circumstance.

Figure 9 illustrates the continuous process of technology implementation at Coffee Middle School. It has the components of Plan, Implement, Assess, and Improve, which revolve around the teachers and administrators. Teachers and administrators are involved in each of the components as they work to implement appropriate technology into the teaching and learning process.
Technology Implementation in the Mathematics Classroom: Documenting a continuous Improvement process

Figure 9: Continuous Improvement Process

The analysis presented here does not offer a policy implementation model or makes generalizations about the policy process in education. Rather, it presents an account of understanding the technology policy “always under construction” and applies sense-making perspectives to the study of technology policy as a process. The joint application of sense-making approach as a theoretical framework and the analytical tools of grounded theory are chosen because the former offers a relevant lens to understand the diversity of policy constructions in multiple settings. The latter provides process oriented sense-making tools necessary to understand technology policy in its entirety. Thus, it is an interpretive approach to
policy analysis aimed at understanding the underpinnings of the policy actors’ understanding and enactment of the technology policy objectives.

Pepin's (1999) findings suggest that teachers' conceptions are manifested in their practices and can be traced back to the educational trends of mathematics and mathematics education, as well as to personal constructions. The findings of this research demonstrate that teachers' classroom practices reflected their beliefs and conceptions of mathematics and its teaching and learning.

Based on the above analysis, I made the following assertions about the teachers in this study and how they made sense of their technology implementation experience.

1. The policies and goals of the school district shaped how the teachers made sense of their experiences using technology.

   The principal believed that his teachers perceived that school policy involved a push for the use of technology, thereby having a positive effect on technology use in the classroom. He understood that his policy of support encouraged teachers to incorporate technology into their instruction. He could determine the teachers who favored technology and the ones who did not. He could also determine what teachers viewed as the administrations’ expectations of technology use and what they saw as the advantages or disadvantages of its use.

   A major goal of the State, district and school was for their students to perform well on the Criterion Referenced Competency Test (CRCT). The teachers at Coffee Middle School administered the CRCT at the school. The students were not allowed to use calculators on the test.

   The fact that students could not use calculators on the CRCT was a motivator for Jane to not let them use calculators in the classroom. She did not want students to be dependent upon the
calculator and then not be able to use it on the test. She thought that the main motivator at the school in the mathematics department was for students to pass that test. She said there was a lot depending on CRCT performance.

Alice believed in students using calculators beginning in the sixth grade. She thought calculators enhanced their understanding and learning of concepts. The fact that they were not allowed to use calculators on the CRCT was not a rational policy. She believed calculator use in the classroom would not have a negative impact on their test result. Alice did not think that they would be hindered by using a calculator in class and then at test time, not be allowed to use it. She gave students practice time with calculators and practice time without calculators.

Mary did not use calculators in her instruction in sixth grade because she thought students were still learning the basics. However, she believed calculators should be used in seventh and eighth grades even though they were not used on the CRCT. Her reason for allowing calculators in the seventh and eighth grade was that to use the calculator to solve a problem “you must to know the steps”. Another reason for allowing students to use them in the “higher levels” was to prepare them for high school where they will use graphing calculators in some of the mathematics classes.

2. The mathematics of the adopted textbook greatly influenced the mathematics of which the teachers choose to make sense.

The teachers believed that technology afforded them the opportunity to use the most current resources and it also enabled them to engage their students more in the textbooks. Using more technology in the classroom was a more efficient resource than using textbooks alone because the textbooks were interchangeable in many ways with many of the programs that came with the technology that they used. They relied on textbooks and provided worksheets for
guidance. The mathematics textbooks that were used at the school were supplemented with lesson ideas, activities, and worksheets.

3. The teaching style used in the textbook content provided structure for teachers to make sense of their teaching of mathematics.

In the year of the study, the teachers began using new textbooks with computer programs to accompany them. The teachers commented that students could actually go to the SMARTBoard and manipulate figures on it. They enjoyed touching it and seeing what happened. They enjoyed the sounds it made. The teachers thought it was good for the students to get involved with hands-on experiences. Jane, Alice, and Mary used the technology in their instruction. Alice used calculator technology as well as the computer technology in her instruction.

When Jane, Alice, and Mary used the technology, they used it through the computer and they felt that the students were more excited about learning. The teacher and the students could look at different views of a particular problem which they could not do if using the textbook only.

4. Teachers considered student learning in making sense of technology for their own learning or for their teaching.

When the teachers used the technology, they used it through the computer basically and they felt that the students were more excited about learning and they could look at different views of a particular problem rather than if they just had the textbook.

5. Teachers’ perceived availability of technology in their schools and classrooms related to the way they made sense of the use of technology.
When asked about expanding the availability of tools in schools, the principal expressed interest, but noted that they hoped that currently available tools, which were being used effectively by sixth grade mathematics teachers, would be acquired for and utilized by seventh and eighth grade teachers before expanding. Both the curriculum coordinator and principal also noted that teachers’ technology use and curriculum integration skills also played a role in their purchase request decisions.

6. The teachers in this study reported willingness to incorporate technology in their teaching when they felt completely comfortable using the technology for themselves.

When Jane first got the ACTIVboard technology, her first six weeks of use was trial and error. She went to some staff development classes and learned much about it. It took her approximately nine weeks to become comfortable with the technology. She believed that she could be very successful with it, but there remained some aspects that she had to master.

7. Learning to use technology took more time than was allotted in the teachers’ daily schedules.

The sixth grade mathematics teachers at Coffee Middle School met as a group weekly. When they met, they all made decisions about how best to implement the curriculum-what to add, what to change, and what to eliminate because of time constraints. As Alice stated, “it is a demanding job to cover all of the required topics in a way that students retain the information.” With all of the planning and evaluation required, teachers did not have time to develop unique lessons every day. There was little time in the daily schedule to learn to use and plan to teach with technology. Jane gave insight into the time involved with technology implementation with the following statement.

When I first got it, my first six weeks of using it was just trial and error. I went to a couple of staff development classes in my previous county and those classes really taught
you a lot about it and just playing with it, you know, just having that time to sit there and play with it and read and see what all it had. I’d say a good nine weeks. By Christmas break, the first year I had it, I think I could do a whole lot with it but there is still some stuff I’m not sure exactly how to do.

**Conclusion**

I conducted this study in the quest to answer four research questions:

1. What is the policy of a Georgia school and its district concerning the use of technology in the teaching and learning of mathematics?
2. What do district officials think that policy is?
3. What are a school’s mathematics teachers’ conceptions of their school and district policy concerning the use of technology in the teaching and learning of mathematics?
4. What policy objectives do the teachers believe encourage or discourage them in their efforts to use computing technology in their mathematics teaching?

To answer the first research question, a document analysis was done to determine policy concerning the use of technology in the teaching and learning of mathematics. To answer questions two, three, and four, the analysis for each research participant was organized according to the three policy components of instructional use, educators’ proficiency, and system support for teachers’ learning, for their students’ learning, and then for teaching. These components were determined from the document analysis conducted by the researcher. Because my goal was to understand these teachers’ and administrators’ conceptions of policy and its effect on technology implementation, I presented the participant data from the point of view of each research participant with as many of their own words as possible.

This part of the study focused on understanding how five participants made sense of their experiences with implementing technology in the mathematics classroom. I believed that the participants had to make sense of their experiences for their own learning before making sense of
their experiences for their students learning. Only after making sense for their learning and for their students’ learning would participants make sense of their experiences for their teaching. This sense-making contributed to the participants’ conceptions of technology implementation policy and how relevant that policy was in their school situation.

The sixth grade teachers at Coffee Middle School considered themselves as part of a teaching with-technology community. Information and examples (e.g., textbooks, other teachers’ examples, and website information) were frequently collected and shared during lesson planning and material development. Peer feedback was employed to refine lesson details. When sharing feedback, participants talked about their products—clarifying activities and sequences and offering suggestions for improvement. Sharing dialogues about practices is typical in communities of practice (Lave & Wenger, 1991). When conversations emphasize practices for teaching with technology beyond basic technical functions, teachers may learn how to talk and how to negotiate using the socially shared conventions of the community (Brown et al., 1989).

The research questions of the study are addressed in turn below.

**Research Questions**

**Research question 1**

What is the policy of a Georgia school and its district concerning the use of technology in the teaching and learning of mathematics?

**Federal policy**

The United States Constitution delegates accountability for education to the states. Through advocacy, policy, information, and financial support, both nongovernmental educational organizations and governmental agencies at the state and local levels have provided
leadership in getting schools technologically equipped to deliver a “world-class” education to all students (Donnelly et al., 2002).

Currently, the U.S. Department of Education is interested in funding studies that involve understanding the best way to empower educators to use technology in providing students with the most benefits. It seems that there are many resources for teachers that help them learn to use technology and provide lessons and examples for them to use in the classroom. However, with the rapid advances in technology, many of these resources quickly become outdated or incomplete. There is a great deal more work to be done in this area to make technology work better for teachers and students in K-12 education.

State policy in Georgia

The States of Georgia provides leadership in implementing education reform. This leadership includes but is not limited to: setting academic standards, setting initial teacher certification and re-certification requirements, and setting technology-related standards for teachers. State-driven policies and standards have created demand for technology-related professional development at the local level because teachers may not be prepared to effectively teach with technology.

The state of Georgia has implemented technology standards to improve the quality of education for its school children (State of Georgia Technology Plan, 2003). The State Board of Education approved these standards on July 10, 2003. The State of Georgia K—12 technology standards include the following three objectives from among a total of seven:

1. Increase effective instructional uses of technology to address QCC learning standards in elementary and secondary schools.
4. Increase educators’ proficiency to use technology effectively to enhance student learning and business operations in elementary and secondary schools.

6. Increase the capacity of school systems to provide the high-quality system support necessary to realize effective technology use, especially in the areas of administrative support for effective instructional technology use; professional development; technical support for hardware, software, and network infrastructure; technology planning; and program evaluation. (p. 39)

In addition to implementing technology standards, Georgia is providing technology-related professional development opportunities for its teachers (Education Week, 2001). Technology-related professional development training is mandated for the certification and recertification of Georgia teachers. To ensure that technology-related professional development is available to all of its teachers, Georgia has adopted a professional development program developed at a state university and is providing it to teachers throughout the state (Education Week).

**District and school policy**

The school district plays an influential role in the local implementation of instructional reform (Berman & McLaughlin, 1977; Firestone, 1989; Spillane, 1996, 1999). This role involves the manner in which state and federal policy proposals are understood and disseminated by the district office. The manner in which instructional policy is understood influences their classroom implementation.

The Coffee County Board of Education adopts policy from the State of Georgia and approves local policy proposals consistent with State policy. These policies are implemented within the classroom. How they are implemented is a function of the classroom teacher’s conception of the policy.
In this study, district officials refers to those district administrators and curriculum specialists, and others who, because of their formal position or informal role, are actively involved in developing district policies about mathematics instruction and supporting teachers’ efforts to implement these policies. District officials decipher what a policy means and decide whether and how to adopt, adapt, or ignore policy proposals in local policies and practices (Spillane, 2002).

The sixth-grade teachers made use of computers accessorized with interactive whiteboard (IWB) technology in a high-needs rural middle school. The school was an ideal setting for this type of project because it was situated in a low-income area of the state and was considered a high-needs school. Eighty-six percent of the students were eligible for free or reduced lunch and many had difficult home lives. The school officials were interested in creative ways to teach this population of students, including the use of educational technologies such as computers, calculators, and SmartBoards to make learning more accessible to its students.

The SMARTBoard is a digital whiteboard that connects to the computer and allows teachers to display the computer screen on the screen of the SmartBoard. Teachers and students can then interact with the computer on the board using their hand as the mouse to navigate, draw on the board with digital colored pens, or save their work as an image to review later. The SMARTBoard allows for enhanced class participation by allowing students the chance to interact with the computer using the board. Notes that are made on the board can be saved for later review during later classroom discussions. At Coffee Middle School, the computer SMARTBoard configuration was set up in the classroom so that it all turns on with the click of a button. Then it was ready to use in a few seconds.
Smith, H. J., Higgins, S., Wall, K., & Miller, J. (2005) conducted a comprehensive literature review on the use of interactive whiteboards (IWB) as a tool for teaching and learning. Their analysis was divided into studies on the effectiveness of IWBs as teaching tools and their effectiveness as learning tools. They concluded that the interactive whiteboard presents seemingly more advantages to teachers as a teaching tool. These advantages include the ability for teachers to directly manipulate objects in real time for teaching geometry and other mathematics, efficiency in presenting a lesson, and support for planning and developing long-term, reusable resources.

Ways in which the IWB supports learning were listed as promoting motivation through the use of quickly changing screens and the use of color, high quality graphics, sound and video, and enhanced understanding of complex topics that involve movement such as physics and mathematics.

One of the sixth grade teachers, Alice, claimed that she felt that she was trying to use the technology because she knew that the equipment was expensive, but that she did not fully understand its pedagogical purpose. The computers in the sixth-grade teachers’ classrooms were connected to boards mounted on the walls, and they were used daily. The teachers used them as a display to do presentations and demonstrations. They talked about using the boards to surf the web in front of class and to show videos and presentations. They understood that these were things that could be done with a regular whiteboard or screen. However, they were also fully utilizing the functionality of the computer interfaced with the IWBs.

Teachers’ conceptions of these interfaces were that they were tools for learning and could somehow be utilized to help students learn difficult concepts. They first thought of them as tools for teaching but became very interested in suggestions about saving lessons and improving the
efficiency of the classroom. They talked about a lack of training and a need for an expert person in the school who they could consult about developing lessons and other ways to use the boards.

Curriculum requirements were obstacles to using IWBs. Teachers were expected to cover a certain curriculum during the school year. It was a demanding job to cover all of the required topics in a way that students retained the information. With all of the planning and evaluation required, teachers did not have the time to develop unique lessons every day so they relied on textbooks and provided worksheets. The mathematics textbooks that were used at the school were supplemented with lesson ideas, activities, and worksheets. The teachers explained that they found these lessons helpful and often used them. The lessons involved using the SmartBoards.

Research question 2

What do district officials think that policy is?

To take advantage of emerging technologies and increase instructional use of computers, the school had implemented a policy of providing the “SMARTBoard” or “ACTIVboard” technology for all of the teachers. The focus of district officials for classroom instruction seemed be on improving instruction using the ACTIVboard technology to display and enhance the interactive quality of the computer.

The administrators promoted advances in technology use in all subject areas, especially mathematics. They saw mathematics as one of the areas that is part of the annual manageable objectives, reported in the Annual Yearly Progress (AYP) reports. It is an area that they were constantly struggling with, trying to meet the needs of all of their students.

Because of changes in the Georgia Performance Standards (GPS), district officials were looking more closely at where they stood in the area of mathematics. They believed they had to
retool teachers and help them understand that the mathematics requirements are not the same mathematics that teachers learned in school as teachers and as students.

The principal expressed that the mathematics teachers at the school were veterans and had a tendency to lean more towards the traditional teaching styles, they tended to be somewhat apprehensive about using technology, but they were open to new strategies and understand today’s students and the fact that this generation of students tend to be a little more technically savvy. The principal of the school believed the teachers understood that by implementing this technology into their classrooms, they could reach some of their students that they may not reach using traditional methods.

When asked about expanding the availability of tools in schools, the principal expressed interest, but noted that they hoped that currently available tools, which were being used effectively by sixth grade mathematics teachers, would be acquired for and utilized by seventh and eighth grade teachers before expanding. Both the curriculum coordinator and principal also noted that teachers’ technology use and curriculum integration skills also played a role in their purchase request decisions. These decisions were made with the consideration of teacher input. Apparently, the administrators felt that as teachers mastered the basics, new tools could be added. Adding additional tools before the basic tools were mastered, they felt, could overwhelm teachers and result in underutilization of expensive software titles. A third concern for the principal was cost. Investing in basic software tools that could be implemented across the school on every machine seemed to be the highest priority, but after these costs were absorbed, there was sometimes little money left for other titles. Time to research available software and meet individual content needs was a fourth reason mentioned by both the principle and the curriculum coordinator.
Curriculum Coordinator

Rhonda thought that appropriate technology implementation was very important in education especially in mathematics education. Technology allows students to have a hands-on interactive educational experience. She saw technology implementation as a way to “tap into” students’ everyday experiences with technology. She stated, “I think it is another avenue for boys and girls to see the process at work. Graphic calculators, computers, SMARTBoards, all of those technologies allow boys and girls to have that hands-on experience and allow them to be interactive in their learning.”

She believed traditional teaching methods in which the teacher stands in front of the room lecturing and kids sometimes going to the board to work problems still worked, but because of the advanced technologies that are in the homes with which our kids are constantly confronted, “we have to do a better job of entertaining them to keep them involved. So, technology has allowed us to keep them excited about learning.” Rhonda understood that technology was changing a lot of what was happening in our classrooms. She thought it was changing what was happening in our homes as well.

Rhonda felt that we must to stay abreast with what technology can do to help our kids understand concepts. She asserted that the leadership at the schools in the district was open to looking at how technology can enhance learning in the classroom because their primary motivation is to increase students’ achievement. She stated:

If we have to have it flashing and blinking to do that, that’s what we want to do. Now, the next thing that we’ve got to do as a system is that we are looking at making our classrooms a twenty-first century classroom with the SMARTBoards and with laptops and with the computers. That’s a struggle that we face as a school system next. That’s why it is so important that we bring our board members in to see what this technology is doing and that’s what we are constantly doing. These teachers are actively using this technology one hundred percent in their instruction, it is in their plans. It is planned for and it is used and it is evaluated. So, I think I can
honestly say that the concept of looking to and implementing technology in math in our system is one that is moving forward, we’re not there yet, but we’re making steps in that direction to get where we want to be.

**Principal**

The principal at Coffee Middle School was a technology enthusiast and successfully applied for several technology grants. The school had a wealth of technology resources. The school had some problems integrating this technology in the past, and the teachers considered the technology underused because of the time and effort required to set up the hardware and find or create appropriate lessons. Teachers’ opinions of the usefulness of this technology range from enthusiasm to cynicism.

John emphasized that the local board of education was advocating use of technology in the schools. When asked how he felt about that as far as policies coming down to him and how much he encouraged teachers or how much he was on board with the board policies he indicated his strong support for technology in teaching.

He thought that his teachers perceived that school policy involved a push for the use of technology thereby having a positive effect on technology use in the classroom. He understood that his policy of support encouraged teachers to incorporate technology into their instruction. He could perceive their like or dislike of technology, what teachers saw as the administrations’ expectations of technology use, and what they saw as the advantages or disadvantages of its use. The principal believed there should be a balance in instruction. He believed it was important to teach the basic mathematical skills, but also believed that our schools must become more technologically advanced to keep up with advances in the world.
Research question 3

What are a school’s mathematics teachers’ conceptions of their school and district policy concerning the use of technology in the teaching and learning of mathematics?

Pepin's (1999) findings suggest that teachers' conceptions are manifested in their practices and can be traced back to the educational trends of mathematics and mathematics education, as well as to personal constructions. The findings of this research demonstrate that teachers' classroom practices reflected their beliefs and conceptions of mathematics and its teaching and learning.

Similarly, I believe that mathematics teachers’ conceptions of school district policy are manifested in their practice. With this in mind, and based on my analysis, I made the following assertions about the teachers in this study and how they made sense of their technology implementation experience.

1. The policies and goals of the school district shaped how the teachers made sense of their experiences in using technology.

2. The mathematics of the adopted textbook greatly influences the mathematics of which the teachers chose to make sense.

3. The teaching style used in the textbook content provided structure for teachers to make sense of their teaching of mathematics.

4. Teachers considered student learning in making sense of technology for their own learning or for their teaching.

5. Teachers’ perceived availability of technology in their schools and classrooms related to the way they made sense of the use of technology.

6. The teachers in this study reported willingness to incorporate technology in their teaching
when they felt completely comfortable using the technology for themselves.

7. Learning to use technology took more time than was allotted in the teachers’ daily schedule.

**Research question 4**

What policy objectives do the teachers believe encourage or discourage them in their efforts to use computing technology in their mathematics teaching?

The success of any educational reform approach depends in part on teachers’ belief in the reform effort and their will to implement the proposed changes (Handel, 2003). It also depends on district and school administrators and the development of teachers’ professional skills necessary to implement the reform (Roulet, 1998). Similarly, teachers’ conceptions of technology policy, relative to what that policy is, will have an impact on technology implementation (Knapp, 2002). The impact on the technology implementation is largely affected by how the policy encourages or discourages the teachers in their efforts to use computing technology (computers and calculators) in their mathematics teaching.

**Encourage**

The policy of technology implementation into the mathematics classroom by the school district was enacted to encourage teachers to be more effective in their mathematics instruction. Jane believed that it was all about being an effective teacher. She felt the administration wanted teachers to be effective. As long as they were doing what they needed to do in the classroom, administrators did not come in and say “I want you to do this, this, this, and that with your students.”

When asked if she believed that the teachers and the district administrators agreed with her view of how technology should be used in the classroom, how it could help educators, she
gave insight into how the technology was viewed in the school by teachers and administrators.

Jane stated:

The sixth grade teachers are into it. I know that they agree with the way we use technology in the classroom. In fact, we have a meeting every week and we bring in sites and our ideas for the whole online thing that we use quite a bit in class, things that we can use in our classroom because one teacher can’t find everything to use. It’s going to take teachers working together and collaborating and using what they find together.

Jane believed that the sixth grade math teachers really worked well together.

From these small group meetings, the administrators requested that the teachers submit their content meeting minutes that show concepts and ideas that were discussed during each meeting. Jane thinks that this showed that they were inspecting how well they were addressing their objectives.

**Discourage**

The fact that students cannot use calculators on the CRCT was a motivator for Jane to not allow students to use calculators in the classroom. She did not want her students to be dependent upon a calculator and not be able to use it on the test. She thought that the main motivator at the school in the mathematics department was for students to be able to pass that test. She said there is a lot depending on CRCT performance.

Alice believed that the policy of restricting calculator use on the CRCT was discouraging in her effects to use computing technology. She believed that the State of Georgia should allow all sixth grade students to use calculators in the sixth grade mathematics classroom. She understood not using calculators in grades K—5. She said, “let’s learn our basic facts, let’s learn how to multiply, subtract, add, do concept problems and word problems without the use of a calculator.” However, when students arrive to sixth grade, she thought it’s time to hand out the calculators, “allow every child to use the calculator and I think we can take math to new heights
if the State would get away from the old way and say calculators are here, let’s put them in their hands, let’s go to new heights and let’s be the ones that break the water and make the headway there, because calculators are here to stay.” She thought that all sixth grade students should use calculators in the mathematics classroom. She expressed her disagreement with the calculator use policy by emphasizing, “Are we allowed to [use calculators on the CRCT]? No, but do I [use them in class] yes.”

Alice believed in students using calculators starting in the sixth grade. She thought calculators enhanced their understanding and learning of concepts. The fact that they were not allowed to use calculators on the CRCT was not a rational policy. She believed calculator use in the classroom would not have a negative impact on their test result. Alice did not think that students would be hindered by using calculators in class and then at test time, not use it. She believed she used the calculator effectively in her instruction, which also included practice time without the use of a calculator.

**Findings**

The major findings of this study are that teachers’ and administrators’ conceptions of technology policy, relative to what that policy is, had an impact on technology implementation. The impact on technology implementation was largely affected by how the policy encouraged or discouraged the teachers in their efforts to use computing technology (computers and calculators) in their mathematics teaching.

Other findings indicate that participants’ conceptions and understanding of computing technology’s educational roles evolved from simple tools for productivity and motivation to diverse and advanced roles for learning concepts and developing thinking skills. They also developed critical concepts related to teaching with technology, including teachers’ roles,
students’ characteristics, and pedagogy. The findings of this study also indicate that the participants’ conceptions of technologies’ educational roles, which are supported by district policy, are as:

a. Simple tools for productivity and motivation
b. A medium through which concepts are learned and thinking skills are developed
c. Tools to help develop critical concepts related to teaching with technology, including teachers’ roles, pedagogy, and students’ characteristics

Implications

I propose future professional development and associated research that concentrates specifically on teachers who already have a commitment to technology use in their classrooms such as the teachers at Coffee Middle School. The focus of such programs would be one of augmentation rather than initiation. To this end, more effort should be put into effective use and integration of technology into the mathematics classroom.

In order for the benefit of new technological innovation to be realized, mathematics teachers need continuous and relevant training and support. As technology rapidly advances, this need will most likely continue. If teachers perceive that there is enough time for training or that the availability of technological resources is appropriate, they will make an effort to obtain the technology training they need and desire. Furthermore, there must be an obligation to plan and coordinate staff development in ways that will promote change in teacher practice.

Although much research has been documented on showing that teachers’ conceptions (attitudes, belief, and preferences) are important, more should be done on how to encourage mathematics teachers to integrate computing technology into their teaching. Training should
support the innovation of technology as a tool that makes teaching more efficient and not as just another layer in the curriculum.

A mentor-supported model could be used for professional development in technology to enable teachers to receive the additional support they need to facilitate change when implementing new strategies. Research needs to be conducted over a longer period of time to check sustainability, as well as to investigate the types of follow-up support needed by teachers. Effective mentor-supported professional development could be successful in increasing the integration of technology in the mathematics classroom when the training is relevant and encourages the integration of technology into the curriculum.

Venezky (1999) suggests that teachers need specific models to integrate technology into the classroom beyond the information provided in basic technology skills courses. Effective models provide information relative to technology and about changes in the traditional roles of teachers and students. He argues that few technology-in-education programs explicitly include organizational changes as one of the required elements for successful technology integration into the classroom.

Research such as that conducted by Oppong, (2002) should be continued. In his study, Oppong involved participants in posing technology-rich problems then solving them using technology in an effort to determine what technology-rich problems students pose say about their understanding of a mathematics concept. As ongoing advances in computing technology occur, the implementation of this technology should be studied in efforts to achieve continuous improvements in technology implementation policy and in mathematics education.

Administrators’ conceptions, attitudes, and beliefs play a key role in whether technology is used in the classroom. One way that administrators can show their support is by allowing and
encouraging release time for training. More research related to ways of improving administrators’ attitudes and beliefs in the area of computing technology implementation need to be conducted. Teachers should be made aware of the technologies and software tools that are available to them and their students through mentoring and support during and following professional development.

**Limitations**

This study was designed to gain insight into teachers’ and administrators’ conceptions of policy and its impact on technology implementation. It was a quest to determine what the policy is and to what extent the participants had embraced it. The analysis presented in this study did not offer a policy implementation model or make generalizations about the policy process or the technology implementation process in education. Neither did it explore the participants’ prior experiences that may have contributed to their conceptions. The study did not investigate the process of choosing hardware or software titles, the appropriateness of software titles, the teachers’ level of technology use ability or the teachers’ technology pedagogical knowledge for teaching mathematics. Rather, it presented an account of the understanding of technology policy “always under construction” and applied sense-making perspectives to the study of technology policy as a process.
REFERENCES


Appendix A

Teachers’ Interview Protocol

Conceptions of Technology Policy and Considerations of the Context of Teachers’ Interpretation of Policy Requirements and Implementation of Local Policy

1. What do you think is appropriate technology implementation in mathematics education? There is no right answer; even the experts widely disagree.

2. Do you believe that computing technology is beneficial for all students, for some students, for mathematics education in general?

3. How has computing technology changed what happens in your classroom?

4. Does the leadership at this school promote any views concerning instruction? How about mathematics instruction?

5. Does the leadership at your school promote any view concerning technology use?

6. Do you believe that other teachers and district administrators agree with this view?

7. Is there anything else you would like to tell me?

Thanks very much for your time.
Appendix B

Administrators’ Interview Protocol

Conceptions of Technology Policy and Considerations of the Context of Administrators’ Interpretation of Policy Requirements and Implementation of Local Policy

1. Do the mathematics teachers at your school promote any views concerning instruction? How about mathematics instruction using computing technology?

2. What do you think is appropriate technology implementation in Mathematics education? There is no right answer; even the experts widely disagree.

3. Do you believe that computing technology is beneficial for all students, for some students, for mathematics education in general?

4. How has computing technology changed what happens in mathematics classrooms at your school district?

5. Does the leadership at your school promote any view concerning technology use?

6. Do you believe that mathematics teachers agree with this view?

7. Is there anything else you would like to tell me?

Thanks very much for your time.