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Instructional computers in high school mathematics reform: Its theory and practice

Kwak, Eunsoon, Ph.D.
The Ohio State University, 1994
INSTRUCTIONAL COMPUTERS IN HIGH SCHOOL MATHEMATICS
REFORM: ITS THEORY AND PRACTICE

Dissertation

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate School
of the Ohio State University

by
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* * * * *

The Ohio State University
1994

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CHAPTER I
THE PROBLEM AND RELEVANT LITERATURE

Research Problem

The purpose of this study was to describe and interpret the formation and implementation of a technology application project in one school district's high school math curriculum. The research problem encompassed these goals:

1) To identify influences from the district's community, history and organizational structure that affect the development and implementation of the project.

2) To describe the nature and effects of the implemented project as teachers experienced it.

This dissertation seeks to address these goals in their social context. Most research on technology application in schools has been based on its technological potentials. Educational computing is an example. Extensive research predicted the impact of computers' technological capabilities on instruction and that research became a factor in hastening adoption of computers in public schools. Indeed, the number of computers in U.S. schools has increased by nearly fifty fold, from fewer than fifty thousand to 2.4 million during the last decade (Becker, 1991). Still, few studies have tried to understand computers within the social and political relationships that prevail in an organization and that influence utilization of the computers (Kling, 1980, Becker, 1992). In this regard, this paper attempts to interpret the application of
computers in high school math curriculum through a social context. To do so, societal trends that promote computers in schools and math curriculum change will be examined. To understand the discrepancy and/or similarity between societal trend and actual activities practiced in schools, school structure will then be discussed.

Research for this study was conducted during 1991-93 school years in Bowling Green County. A case study approach was used to investigate the societal/organizational context that impinges on implementation of the technology application project.

The rest of this chapter discusses the societal drive demanding computers in schools and the school's organizational structure. In addition, a technology application project is described in Chapter I. Methodology, its theoretical relevancies and the actual research process, is discussed in Chapter II. Chapter III and Chapter IV describe local history and school policies that establish conditions within which teachers influence and "live" the implemented project. Chapter V will interpret such local interaction by placing it in the theoretical context.

**Societal Context**

For almost half a century, American schools have been under pressure to reform. The last decade was dominated by public concern about the quality of schooling. *Nation at Risk* (1983), prepared by the National Commission on Excellence in Education, was notable for its boldness in pointing out "the widespread public perception" of the U.S. educational system; the book became a starting point for several other reform movements. The Commission lamented the U.S. educational system's diminishing capacity:

Our nation is at risk, our once unchallenged pre-eminence in commerce, industry, science, and technical innovation is being overtaken by
competitors throughout the world. . . the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people (p. 5).

To improve the educational system, the Commission encouraged technology use and industry involvement. Because of its critical power in a technology-oriented society, technology has become an indispensable ingredient of several reform movements. The argument for technology is insistent:

Technology can revolutionize the way we teach our children and change the way they learn, just as profoundly as it has altered the American work place (Senators Bingaman, Kennedy, & Cochran, 1993, p. 6).

The U.S. economy is changing in ways that have sharply increased demand for education. We lack even an adequate vocabulary to describe the transformation underway. . . . These changes increase demand for education both by creating a need for more workers in job categories that have always required well-educated people and by redefining traditional occupations in ways that increase the need for education. Insurance clerks, machine operatives and farmers find themselves facing challenging intellectual tasks. The demand for people without basic mathematics and communication skills is shrinking fast. . . .The blunt fact remains that unless something is done to improve the quality and the productivity of the U.S. educational system, we will have great difficulty holding our own in international market (Kelly, 1990, p. 60).

Such arguments assume that current schooling fails to educate future workers. Schools, which provide formal education to children in order to move into the labor force, need to upgrade their curriculum. To do so, technological help is essential, especially in math and science, since future jobs lie in these areas.

The above arguments also assume that economic function is the backbone of education, and efficiency and productivity are important criteria in evaluating an educational system from a functionalistic perspective. Strikingly, all of these claims for reform converge in the same philosophical viewpoint voiced by the educational movement that followed "Sputnik Shock." Technological
functionalist theories prevail in today's reform movement, as they did in the 1960s and 1970s. Functionalist theories stress education's technical functions which emphasize efficient use of human resources, correlate educational investment with social reward systems, and view educated individuals as a form of capital (Karabel & Halsey, 1977).

Emphasis on schooling's economic competency invites business and industry to join the educational system (Hansen, 1983). Business and industry have influenced the educational system not only as mentors for schooling but as sponsors. Curriculum engineering movements in the 1960s and 1970s are examples (Bauchamp, 1975). To support research and development of various programs, business and industry have invested money and equipment in higher education and public schools. In the last decade, the pursuit of joint educational business/industry efforts has become more aggressive in terms of increasing intensity and breadth of interests in such a cooperation (Jungck, 1985). These coalitions often put their effort into creating a politically advantageous atmosphere for the educational market. President Bill Clinton solicited the help of the business community in restructuring Arkansas' educational system when he was governor, appointed business executives to the Department of Education, and recently proposed a plan that highlights the need for restructuring the educational system (The Conference Board, 1993).

When people in the business and industry sector enter the educational system, they usually bring technology with them, claiming it will reshape the system as it did business and industry. Computer industries are an example. Through partnership, they enter elementary and secondary schools to promote computer use in classrooms. Apple Computer Company has been the forerunner in investing in public schools. In the summer of 1983, Apple donated $21 million worth of equipment and software to California schools when lawmakers
in that state gave the company a requested tax benefit. Federal tax credits, on the other hand, were stalled in Congress when Ohio Democrat Howard Metzenbaum called them a "rip-off" (Elmer-DeWitt, 1984). Other computer companies began to compete in the educational market; their pursuit of schools was strategic rather than profitable:

The education market is not all that profitable, but it is highly strategic, says Clive Smith, an analyst at Boston Yankee Group, a market-research organization. School use turns out to be absolutely key to establishing brand loyalty. Moreover, school sales can generate home purchases. Students working on Apple, Commodore or Radio Shack computers in school often lobby parents to get the same brand of machine at home (Elmer-DeWitt, 1984, p. 62).

It would be like "killing two birds with one stone" for companies to donate about-to-be-outdated computers to schools. When investing in schools, companies usually donate equipment that is losing its profit-earning capability because of sharp competition and rapid advances in hardware. In addition, the companies receive tax credits. An advanced computer model is rarely provided to public school classrooms. Not long ago the IBM PCjr was considered "too sophisticated and too expensive for the classroom" (Eldmer-DeWitt, 1984). At that time IBM PCjr generated a big profit for the company as its leading model. Becker (1991b) notes that outdated hardware hinders instructional computer use in public schools; Apple II and other 8-bit computers constituted nearly 90% of elementary school computers and three-fifths of high school ones.

Proponents of functionalism also assume there will be rapid growth in jobs in technology and mathematics areas. However, this assumption has been challenged by economists Rumberger and Levin (1984). They projected employment growth in the 1990s by analyzing long term employment patterns based on information provided by the U.S. Bureau of Labor Statistics. According to their report, low-skill jobs will increase significantly. Building
custodians, cashiers, secretaries, office clerks, and waiters and waitresses will be among the most numerous occupations. High technology jobs will account only for 7% of the new jobs in the economy between 1980 and 1995 (Rumberger & Levin, 1984). In addition, statistics about computer-related jobs include jobs only remotely related to computer technology and not requiring considerable computer knowledge. Entire classes of skilled workers will be drastically reduced or will be removed as their jobs are replaced by computers or robotics (Levin & Rumberg, 1983). Recent reform movements' assumptions about the future job market are questionable because they are not based on careful analysis. Rather, they often arise from a common "fear" that the nation might lose its economic and military power in a high-tech society.

Taylor and Johnsen (1988) pinpointed how such "fear" is used by and for the privileged few. They criticized contemporary culture because it assumes that technological change will promise material affluence and, therefore, sees advanced technology as progress. The authors point out the aim of education in this culture and its danger in today's reform movements:

Why this continuing frenzy to press the latest technological innovations be they new methods of curriculum generation or microcomputers, onto school children? One major reason is that much of what is done in schools is done ultimately in the name of national defense and security. Several national reports on education, such as Nation at Risk, which calls on us to "re-arm," illustrate this phenomenon. In many ways our nation has been kept on a war footing, a state of perpetual crisis, since December 1941. That the security threat is real can be seen in the weaponry that both "sides" now aim at one another. But it is just as true, as Eisenhower warned the nation when leaving the presidency in 1960, that the security threat is maintained and manipulated by the military-industrial elites with their great pools of capital and hegemonic privileges (p. 5).
Jungck (1985) also presents a common criticism of the functionalist theory:

Theories assumed models of perfect competition within the market place, exaggerated worker characteristics as the determinant of wages, overemphasized the role of technology in general, lacked sufficient attention to the content or "black box" of education and did not account for class conflict and ideology (p. 7).

In spite of criticisms of the functionalistic perspective in education, it is more pervasive than ever before. The power of functionalism was revealed when Romberg analyzed the reform movements in secondary mathematics curriculum during the past decade (1992). Romberg summarizes rationales of current math reform movements into three factors: (1) the changing needs of business and industry; (2) student performance and enrollment; (3) comparisons of school math with other countries. All these rationales converge in one argument: producing a competitive future workforce.

To meet workplace demands of the 1990s, school math curriculum should focus on higher-order thinking skills. Romberg claims that all business sector workers, "from hotel clerks to secretaries, from automobile mechanics to travel agents," must learn analytical thinking skills to function in a highly computerized society. For the same reason, students' performance should be raised. Especially, minorities and women should be motivated to pursue math because they are under-represented populations. On average, black students completed approximately one less year of high school math than their white classmates. These under-represented populations should be encouraged to stay with four straight years of mathematics in secondary education. Finally, the U.S. math curriculum includes more time for teaching lower-level skills such as arithmetic when compared to the math curriculum in other countries, and fewer students are enrolled in higher math. To maintain the U.S. position in the international market, this discrepancy should be eradicated (Romberg, 1992).
In Reshaping School Math (1990), Mathematical Science Education Board members claim that computers should be used throughout the math community since students will live in a society dominated by technology and quantitative methods. Computers are emphasized in today's math education with expectations that they will solve the problems of today's outdated educational system. On the other hand, there are warnings against these views that overemphasize the technical power of machines (Kling, 1980; 1982). In Kling's article, Kenneth Laudon points out the importance of understanding computer use in its social and political context:

Computers (do not) act on society in the manner of a ship at sea colliding with another ship. Rather, new technologies are shaped by extant political forces, cultural variables, and long term social trends. It is thus fruitless to ask what are the social effects of computers without asking who is developing the technology, what interests it serves, whose values are preserved or destroyed, what costs it imposes and who pays (p. 31).

To understand the social and political context of educational computer use, the following three sections will review factors that enhance educational computing, discuss its theoretical background and equity concerns, and examine the impact of current research on top-down reform movements.


Computers represent rapidly changing technology; they are the most visible change in American public schools (Becker, 1991a). Every school—even the ones without air conditioning—have at least some computers (Winn & Coleman, 1989). Watson categorized attributes of computer growth into three factors: (1) growth of educational technology as a discipline; (2) growth of the computer industry; (3) federal government funding (Sperry, 1976). These three factors support each other. Advocates of educational technology try to distinguish the field from others by seeking its root in technology rather than
education and by claiming a "science" of instruction as opposed to "craftsmanship" of teaching (Finn, 1953; Heinich, 1970, 1984). They emphasize psychological aspects of learning and the technical power of diverse media on instruction (Kwak & Anglin, 1991). Such trends are reflected in research that will be discussed later. Educational technology has thus provided theoretical and philosophical justification for computers to enter the educational system.

In addition, governmental policies that support the development and dissemination of computer assisted instruction and a rapidly growing computer industry have generated a variety of funds for the use of computers in public schools and higher education (Sperry, 1976; Hall, 1982). The Elementary and Secondary Education Act of 1965, which supported the development of computer assisted instruction, and the U.S. Department of Education's investment of $77 million in computer projects are examples of governmental involvement in the field (Sperry, 1976; National Science Foundation, 1983). Private sector for-profit and not-for-profit organizations also generated considerable funds. For example, the University of Illinois was awarded more than $750 million from Control Data Cooperation (CDC) for development of PLATO in less than twenty years (Hall, 1982). Sponsorship by government and the private sector in the 1960s and 1970s established the tradition of computer aided/managed instruction in schools. A variety of federal and private-sector funding programs built sizable computer-based education centers in higher education for development and research of instructional computers, provided computers to public schools for implementation purposes, and generated considerable resources and activities for military training (Hall, 1982).

DeAcosta (1988) has similar viewpoints to Watson in analyzing the sectors that enhance rapid growth of computers in education. She claims that mass-media, federal and state government, educational journals, the computer
industry, and parents promote the use of instructional computers. The growth of educational technology as a discipline encourages more articles on educational computer use in academic journals. With the assistance of computer industries, a variety of commercial journals that advertise new products in educational computing are published. Also, mass-media are continuously relating school success to owning one's own computer, causing many parents to demand that school administrators have computers for their children's education. It is interesting to note the relationship between parents' educational level and their request to include computers in their children's education. DeAcosta (1988) points out that the higher the parents' educational level, the higher the demand for educational computing for their children.

**Trends in Research on Computers**

The rapid growth of computers in education generates ample research on computer use. The theoretical background of research on computers is worthy of notice because of the research's varying implications for proper use of computers in education.

**Comparison Studies**

Most early research provided comparison studies. To justify instructional computing, its effect on student performance on standardized tests was compared to the effect of the traditional lecture method. The instructional computing focus in these studies was on computer assisted instruction (CAI), which has its root in behavioral science. CAI was viewed as a sophisticated version of programmed instruction. Individual pace and frequent feedback were important features of CAI. Under this tradition, knowledge is defined as an external entity that can be broken into digestible pieces. Learners are viewed as
receivers of such knowledge. Later, these comparison studies were criticized because of flaws in research design.

**Cognitive Studies**

Cognitive science and the view of media as unique symbol systems have changed the direction of research. Cognitive science focuses on what goes on in each learner's mind and provides different viewpoints of learners and knowledge. Learners become builders of their own knowledge and their active participation in the learning process is required. Because knowledge is understood in relation to its inquiry process, the application of knowledge is emphasized over the acquisition of knowledge (Romberg, 1992).

Papert (1981) represents this new movement with his development and research on Logo. He insists that computers should be viewed as a new cultural element. Therefore, educational aims and curricula should be reconsidered to fit with this innovative cultural element. Papert's perspective on learning and learners has influenced current software development. Schwartz (1989), the author of *Geometric Supposer*, reflects Papert's views when he discusses the new learning opportunity that software can bring:

Suppose we grant that the essence of mathematical creativity is the making and exploring of mathematical conjectures. Why have such activities not been a serious part of mathematics teaching and learning in the schools? I believe they have not because such tools have begun to come into widespread use only very recently. If people lack tools that make the trouble associated with the making and exploring of conjectures manageable, they simply are not likely to be interested in doing so (p. 51).

**Symbol System Studies**

Proponents who view media as symbol systems criticized comparison studies because they tried to compare "apples and oranges." Different media bring unique impact on learning, and cannot be measured with standardized
evaluation mechanisms developed for printed media. Use of computers as "tool" and "tutee" is stressed in this new trend; this direction appears in current research on computers. Most studies from the last decade are empirical investigations of the impact of programming languages on other subjects (Becker, 1992).

Regardless of the different theoretical origins and implications for education, computer studies both in behavioral science and cognitive science support its educational use based on psychological aspects of learning. These studies often lend themselves to various computer-interested groups as justification for more computers in education.

Bredo (1989) claims that, although computer advocates point out the educational problems that should be addressed--such as active learning, and the communication aspect of a medium--the computer is overemphasized in dealing with them. Some other media also can address these problems if they interest teachers and students at the same time.

Computer advocates assume that all learners are interested in learning with computers; this assumption will become suspect as computers' novelty fades away in classrooms. Issues such as how to improve education if one's aim is to foster creativity, initiative, and adaptive intelligence among all students has been addressed in pragmatic and democratic traditions of education. Computer advocates for inquiry-oriented learning overemphasize computers in math and science: these issues are equally important in all areas of learning and they could be addressed without computers (Berdo, 1989).

Curriculum Studies

When applied to secondary school curriculum, such an overemphasis on computers often reduces or removes other elective courses. In a study of the impact of computer literacy in a school district curriculum, Jungck (1985) points
out its unplanned consequences. New computer literacy elective classes in secondary schools threaten the existence of other elective courses such as arts and music by reducing the numbers of students who would take those courses and by causing the teachers in these areas to feel insecure in their jobs.

Access Studies

It has also been argued that justification of computer use based on behavioral science and cognitive science fosters the status quo. According to some research, the accumulated effect of computers in education has "pernicious" side effects (Laboratory of Comparative Human Cognition, 1989; Sutton, 1991). Educational computing has reinforced and exacerbated previously existing inequalities of education across ethnic, gender, and socio-economic status (Sutton, 1991). Most studies on equity in computer use evaluate the issue in two respects: student access time and the kinds of activities students get involved in with computers (Sutton, 1991).

In elementary schools unequal access to computers by ethnicity, socio-economic status, and gender was more severe than in secondary schools. Through several nationwide surveys, Becker and Stering (1987) reveal that there is a difference in access to computers along racial and socio-economic lines, and these inequalities becomes worse in lower grades. In 1985, 94% of elementary schools with less than 4% Afro-American students owned computers, compared to 67% of schools with a majority of Afro-American students (Becker & Stering, 1987). Though not as dramatic as ethnicity, gender difference was found in computer use in elementary grades; girls used only forty-five percent of computer time (Sutton, 1991). The author points out that school policy and teachers play important roles in gender inequalities; 50% of girls were involved in computer-related activities when teachers and school policies encouraged
female participation while only 30% of them participated when such encouragement was absent (Sutton, 1992).

In secondary schools, inequality by gender, ethnicity and socio-economic status is related to actual activities with computers. It is also associated with computer-related activities being offered as elective courses for students. Surveys by Becker (1983, October) and the Office of Technology Assessment (1987) found that high socio-economic status students and predominantly white schools use computers for programming, while low socio-economic status students and predominantly minority schools use computers for drill and practice. To assure high-achieving students have greater access, many high schools require algebra I as a prerequisite to computer programming classes (Arias, 1990).

Differences in computer-related activities by gender also exist. Nationally, girls are over-represented in high school word-processing classes, while few girls were found in elective programming classes (Becker & Stering, 1987). Thus, a majority of girls and low socio-economic students, who are mostly Afro-American and Hispanic, learn practical computer application skills as office workers might use them, while high socio-economic students--mostly white male--learn problem-solving and analytical thinking skills through programming.

The case study done by Sheingold, Kane, and Endreweit (1983) shows different uses of computers based on school districts. They observed computer use in inner-city and suburban school systems. The inner-city school district used computers for drill and practice for below-level achieving students in order to raise student scores on state and national standardized tests. On the other hand, the suburban school district used computers to enrich the curriculum.
These studies highlight the tip of the iceberg that assumes hierarchical characteristics of learning. To learn high-order thinking skills, basic skills must be mastered first, and poor and minority students lack such skills (LCHC, 1989; Sutton, 1991). In addition, teacher attitudes hinder equal access to computers; they believe that better behaved students deserve more computer time, and that drill-and-practice programs are proper mostly for low-achieving students because such students can master basic skills through the programs (Sutton, 1991). Sutton's summary on unequal use of computers in education fairly represents the phenomenon:

The evidence indicates that computer use during the 1980s did not bring education closer to equal educational opportunity. Rather, it maintained and exaggerated existing inequities in education in input, processes of computer learning, and output. Poor, minority, and female students had less access to computers at home and, in addition, less access to computers at school... Computers were perceived as a male domain... computer literacy skills and positive attitudes towards computers were associated with experience, and middle-class White boys had more experience. Thus, children who were minority, poor, female, or low achieving were likely to be further behind after the introduction of computers into schools (Sutton, 1991, p. 494).

Impact of Current Research in Top-down Reform Movements

In general, equity issues in public education are addressed in setting policies, but not enough to persuade involved personnel of its importance (Cuban, 1990b). However, equity issues have become a factor in censoring a variety of funding applications (Lobman, 1992). By analyzing plausible styles that are more likely to result in awarding grants, Lobman (1992) lists common factors by which donors organize their support of schools. Servicing "particular types of children" was an attribute for awarding a variety of grants.

However, this attribute in many funding applications does not always guarantee benefits for that specific population. Subverted use of the federal
government's new Chapter 2 state block grant system is an example (Jungck, 1985). Chapter 2 funds were originally distributed via Categorical Aids Programs for exceptional educational needs such as desegregation plans, and for "high-cost" children who are mostly low-income, non-English speaking, minority, rurally isolated, or gifted children. Later, funds were distributed on the basis of local school district per capita counts. As a result, funds became available for a whole spectrum of schools in the nation at the expense of urban schools whose general population was "high-cost" students, and of small districts, most of whose students were isolated. Also, the size of grants became too small to establish any innovative educational program, and monies were spent mostly to buy books and computers. Use of the Chapter 2 system has been estimated to have reversed eighteen years of federal elementary and secondary school education assistance to poor and minority students (Jungck, 1985).

Misuse of the Chapter 2 system shows the critical role of actual policies in resource distribution. Distribution policies that do not endorse original goals often direct funds to other uses. In addition, the actual application of Chapter 2 shows the difficulty in changing practice through top-down reform plans. A top-down plan is likely to fail when it ignores human factors (Wolcott, 1977, 1981). Through his study of the implementation of the Planning-Programming-Budget-System, Wolcott (1977) points out the importance of actor/actresses in transmitting ideas into practice. The donor's culture must make sense in terms of the recipient's culture in order to make actual changes.

For this reason, the role of teachers has been defined continuously in reform movements based on directions of the educational reform pendulum (Cuban, 1990). Teachers are often blamed because of their incompetence in meeting the nation's expectations for a future workforce (National Commission
on Excellence in Education, 1983) and they are sometimes praised because of their critical role in bringing changes into classrooms (Task Force on Teaching as a Profession, 1986). School reform through computer technology is not an exception in recasting teacher roles in the process of change. Their role has been redefined from knowledge transmitter to facilitator of student learning. A noticeable aspect of these different conceptions of teachers is that it is not teachers themselves who define or assess their role in school reform movements. This oversight indicates little consideration of teacher perspectives in current school reform movements.

Another aspect that is often ignored in reform movements is that teachers do not have the power or freedom to change their practice as dramatically as some reformers envision. In spite of the autonomy allowed in each classroom, teacher actions are largely constrained by school structure (Cuban, 1989; Dreeben, 1973; Romberg, 1992). School organizations have embedded notions about the nature of knowledge, how students should learn, and how teachers should teach (Cuban, 1989).

In Romberg's review of math reform movements, Kilpatrick insists that school systems work through the embedded routines such as allocation and organization of time, instructional materials, assessment procedures, and human resources to ensure education occurs in a socially acceptable way (Romberg, 1992). Any successful implementation of new instructional practices requires an adaptation between the proposed practice and the organizational setting (Berman, 1978). Organizational routine rarely changes, however (Sarason, 1971; Cuban, 1986).

Changing math curriculum through computer technology seems to be as difficult as other traditional subject area changes because of firmly established
classroom routines. Romberg (1992) illustrates the persistent math classroom routine by borrowing Welch's (1978) description:

In all classes I visited, the sequence of activities was the same. First, answers were given for the previous day's assignment. The more difficult problems were worked by the teacher or a student at the chalkboard. A brief explanation, sometimes not at all, was given of the new material, and problems were assigned for the next day. The remainder of the class was devoted to working on the homework while the teacher moved about the room answering questions. The most noticeable thing about math classes was the repetition of this routine (p. 792).

Becker (1991b) points out classrooms and teaching circumstances as main barriers to the integration of computers in schools. However, few studies on instructional computers have paid attention to how the context of instruction provides opportunities as well as limitations to teachers (Sarason, 1971; Cuban, 1986b). Teaching is considered the delivery of information in most of these studies. For this reason, an organizational context that affects teacher behavior will be discussed in the next section.

Context of Classrooms

Teacher culture is distinguished from student culture because it is an adult and occupational culture. It is influenced by local school culture. Boards of education and central administrations affect teacher culture by setting curriculum (DeAcosta, 1988). Not all teachers, having their own beliefs on education and different levels of commitment to their jobs, abide by the curriculum and philosophy set by a central administration. Teachers and students actually influence what goes on in schools. In addition, the local community influences schooling in two aspects: (1) funds, and (2) the community's values and beliefs (DeAcosta, 1988). An affluent community is
more able to generate funds for children's education. Values and beliefs mold the kinds of education community members want for their children.

Teacher culture is largely influenced by school structure (Cuban, 1987b, 1989; Dreeben, 1973; Goodman, 1982; Sarason, 1971). Schools' organizational features mold behavior of school personnel. In examining schools as a work place, Dreeben (1973) points to these features:

Organizational properties and special characteristics of classrooms pose certain problems for teachers and that the nature of their work can be construed in terms of adaptive responses to those problems (p. 470).

It is said that under today's public school structure teacher-centered instruction is dominant and stable teachers' choice no matter what kind of instructional changes are planned (Cuban, 1986a; Dreeben, 1973). Teacher-centered instruction is resistant to change not because it meets the best interests of students or because it has high instructional value, but because it is the one which works under today's school structure (Cuban, 1986a; 1986b; Dreeben, 1973).

Then, what is the distinctive nature of school settings in which teachers dwell? Dreeben (1973) indicates three attributes of school structure that influence its members in a unique way: (1) density of classroom; (2) non-bureaucratic nature of teaching; (3) solidarity of teaching. These aspects have been continuously mentioned in others' work because of their distinguishing characteristics and stableness (Cuban, 1986; Goodman, 1984; Jackson, 1968; Sarason, 1971). In the remaining section, these characteristics will be reviewed because of their impact on teacher behavior.

Besides school structures, the importance of teachers' beliefs and values are constantly mentioned in implementing reform plans. Teachers, regardless of limitations set by school structures, try innovative ideas when they consider them important for themselves and/or their students (Bliss, 1986; Cuban, 1990;
Lorty, 1973). Sheingold, Hawkins, and Char (1984) found that it was up to teachers to use a certain computer program in their classes and that individual values and beliefs influenced the decision. This finding indicates the importance of teacher perspectives about curriculum and students in carrying out innovation. Therefore, the role of teacher values and beliefs in changing classroom activities will be examined.

**Collective Nature of the Classroom**

School is one of the few public institutions which receive involuntary clients (Jackson, 1968). It is mandatory that children attend school for a required number of years, and during certain ages. The most distinguishing characteristic of an involuntary group is its diversity (Dreeben, 1973). Students, with a whole spectrum of different backgrounds, are required to stay in a confined space for a certain duration of time with a certain purpose (instruction). This restriction, coupled with their clients' involuntariness, causes managerial problems. These managerial problems cannot be separated from instructional aspects because teachers cannot lead instruction in chaos. No matter how talented or knowledgeable teachers are they cannot be good teachers unless they control their students (Dreeben, 1973).

Also, since teachers cannot expect high motivation in involuntary students, they have to find ways to gain student attention while they are teaching. Attention is the replacement of motivation whenever someone's clients are there regardless of their wills (Dreeben, 1973; Jackson, 1968; Sarason, 1971). Under this condition, student learning is an "ultimate" goal of teaching, unlike most reformers whose "primary" concern is instruction and student learning (Jackson, 1968). That is, a typical classroom situation does not allow teachers to pay attention to each student's learning process although individual learning is a main goal of teaching. Teachers must first control their
crowd in order to accomplish any instructional goal (Jackson, 1968). Because teachers have to deal with a crowd, they cannot expect diverse voluntary participation which, if not guided properly, will bring unexpected problems. A diverse crowd in a considerable amount of time in a confined place on a mandatory base itself foretells "unexpected problems" no matter what teachers do (Dreeben, 1973). All they can do is to minimize such problems.

Because of the involuntary and diverse characteristics of a classroom crowd, instructional elements of teaching and the managerial aspects of teaching exist in intertwined form (Dreeben, 1973; Jackson, 1968). Teacher-initiated "rapid flow of verbal exchanges" typically serve these double purposes. Therefore, teacher-centered instruction persists because it meets both needs of managing students and delivering instruction at the same time (Cuban, 1987b). Teacher-centered instruction seems practical, at least under current school structure. Alternatives to traditional teaching may work better than existing ones, but so far there is little empirical evidence which confirms superior effectiveness of a new technique of teaching over the traditional teacher-centered approach (Cuban, 1986a, 1986b; Dreeben, 1973). Also, a new instructional technique, such as instruction based on individual student needs and sophisticated materials, requires different managerial techniques which few people know how to use (Bliss, 1986). Most teachers do not want to invite unnecessary problems into their classrooms, especially if the benefits of such uncertainty caused by a new technique is in question (Cuban, 1986a). They know that traditional teacher-centered instruction works under given situations, but they do not know how new instructional techniques will work in their classrooms.

The use of instructional computers is not an exception. Specific directions are scarce in most research on educational computer use. For
example, when teachers encounter inquiry-oriented learning with computers, the questions are not about its instructional values. Rather, the question is often about how teachers can foster learning environments that give students room to teach themselves under given classroom structures (Berdo, 1989). Guidance on such a question is rare in spite of the popularity of such ideas in school reform movements.

**Non-bureaucratic Nature of Teaching**

Where work situations contain many unknowns and unpredictable exigencies, and where work entails significant loyalties to the needs of clients, work activities will be governed to a substantial degree according to the judgement of workers under the constraints of immediate situational demands (Dreeben, 1973, p. 453).

Teaching activities tend not to be defined in terms of "conformity to system wide rules" because of unpredictable occupational characteristics. In addition, there is no coherent body of public knowledge which can guide actual teaching activities (Dreeben, 1973; Lortie, 1973; Jackson, 1987). Until recently, little attention was paid to situational demands of teachers' work; this oversight leads to the absence of guidelines for teachers in judging the appropriateness of their conduct. The absence of professional knowledge and the collective nature of teaching leave much room for individual teacher action. These characteristics do not mean that teaching is a self-regulated occupation. Teaching is largely molded by organizational controls through embedded routines like centralized curriculum, and policies about evaluation, hiring, promotion, and dismissal of teachers.

However, teaching does not have strict "order lines" such as those in a military organization. Its non-bureaucratic nature reflects the diversity of its clients. Schooling is an enterprise which has to satisfy a diverse population. Specific guidelines are the price paid by a business that has to "please all and
not offend any" (Jackson, 1987). Under these circumstances it is natural that directions from the central office be general enough to allow many interpretations according to the diverse interests of clients.

Weick (1976) finds the reason for school resistance to any change situated in its organizational characteristics. He claims that rational models are ample in theories and reform plans but hardly find their instances in practice because school organization is loosely coupled. Its members, i.e. teachers and principals, are loosely coupled in the respect that their interests are different, or interests common to both of them are unimportant relative to other concerns. Initial intention and actual actions in a loosely coupled system rarely coincide. As a result, the organization hardly changes, and theories based on rational models cannot explain such persistence. A loosely coupled system generates flexibility for self-determined members, while giving headaches to those who try to control.

A loosely coupled system theory lends itself to explaining the difficulty in changing classroom activities by top-down reform movements. When innovative ideas enter the classroom floor, they fail to transfer from ideas of innovation to elements of everyday life in classrooms. Often reformers' ideas are found in formal plans, policies, or resolutions directing school officials to implement new policies, and circulated letters from administrators to their staffs, but they can hardly be found in classroom activities (Cuban, 1986a; Kerr, 1989). Moreover, school changes usually take the top-down route either in a strict mandatory form or in a loose optional form. These top-down changes rarely accomplish their intentions in classrooms. Cuban (1986b) expresses the difficulty in bringing changes through top-down routes:

After the local authorities have taken official action, teachers and principals will be left to do pretty much as they have always done. This familiar exercise of local discretion in the face of external mandates
leaves untouched the core practices on which teachers rely to cope with the daily demands of the classroom. Thus, teacher-centered instruction persists. (p. 9)

In short, the collective nature of classroom teaching, the absence of professional knowledge, the generality of policies to meet the needs of diverse populations, and the diverse interests of members characterize teaching as a non-bureaucratic occupation. Few studies on computers in schools have considered these characteristics. It is these ignored aspects which persistently reject changes projected by educators and various commissions. Another distinct characteristic of the teaching occupation is that it is solitary in nature, and this distinction affects the implementation of reform through educational computing.

Teaching as Solitary Work

Typically, teaching occurs simultaneously in places that are defined and separate. Usually, no adults other than teachers themselves are in classrooms. Each teacher teaches to a group of students. Teachers seldom discuss their teaching styles or problems with their colleagues. Kulleseid (1987) points out the lack of communication among school faculty:

Patterns of communication between teachers are invariably described as far from open. Teachers choose to talk about non-school themes with other teachers. They prefer to keep their distances as a way of preserving their autonomy in the unions. . . . Most of their informal communication is confined to complaining or joking about the workplace, usually at lunch or in the faculty room. Little talk or time is devoted to professional interaction about curricula or students (p. 158).

McCutcheon (1980) found that a reason for the lack of communication among teachers was related to school retention policies. Teachers were afraid of getting retention when they discussed difficulties with other school staff, especially with principals. In addition, schools' reward policies insure the solitude of teaching (Jackson, 1987; Lortie, 1973). A reward policy that
encourages teachers to collaborate with outsiders such as professors, rather than with their colleagues, reinforces the solitary nature of classroom teaching. (Lortie, 1973).

The isolation of teaching has contrary effects in bringing change to classrooms. Spending most of their time with their students, teachers seldom get involved in innovative plans that affect their daily lives. "Lack of time" is a common reason for little involvement of teachers in school reform plans. Teachers' scarce involvement enforces division of labor in implementing reform plans. Teachers often find themselves executing others' plans which do not necessarily reflect their own perspectives about schooling. On the other hand, teachers' isolation protects their autonomy in classrooms. Teacher autonomy protects their interests against outside intervention. Teachers quietly subvert plans and curricula in which they do not believe. Many of them are resentful (quietly, or with actions) when they hear a "list of do's and don'ts for teachers" in their job because they know what works at least in their classrooms (Kerr, 1989, 1991).

The solitary nature of teaching creates difficulties in implementing planned changes. There is a tendency for reform plans to become lists of do's and do-nots no matter how carefully the limitations of the studies and the conditions under which their findings apply are stated (Cuban, 1986b). Since most reform ideas are developed by outsiders, (i.e. legislatures, businessmen, and educators in universities), teachers are rarely excited when they hear of changes. Teachers' perspectives on innovation are hardly reflected.

The fact that most teachers are not the consumers of academic research explains their different perspectives and priorities (Wolcott, 1974). In addition, since teaching is isolated and its practical knowledge is not openly accumulated, it is hard to provide guidance when new ideas are planned for classrooms. For
example, few answers are given as to how to use one or two computers with a whole classroomful of students, although this drawback was a common reason for not using computers for instructional purposes. Whenever a new instructional technique is introduced, it requires new managerial methods and role changes (Dreeben, 1973). So far little is known about new managerial techniques for new methods. Teaching with new methods need open discussion among teachers, administrators, and researchers. However, the nature of teaching does not seem to permit such open communication.

**Teachers' Values and Beliefs**

In spite of school structures and the nature of teaching, teachers will try new ideas and methods if they are convinced of their merit for their students. However, little research is conducted in this area; this void points to the need for in-depth descriptive research. Lortie (1973) and Kerr (1991) claim a paucity of literature that explores the subjective world of teachers in terms of their conceptions of what is important, primary, and ultimate. Most research focusing on the role of teachers' values/beliefs in implementing reform ideas is based on survey methods using professionally-developed instruments. Lortie (1973) asserts the necessity of in-depth descriptive studies on this area:

> One does not object to the carefully targeted theoretically designed studies but given our general ignorance of the world view of teachers, we are not likely to interpret findings from such studies with the appropriate level of sophistication. We know too little of the general context to 'place' smaller findings. In my opinion we have put certain fashionable carts before immature horses; we need research on the world view of teachers with approaches (open-ended interviews, observation, analysis of personal documents, etc.) that make the researcher come to terms with the value hierarchies of teachers (p. 490).

When certain changes are planned for public schooling, teacher beliefs in the planned changes seem important, if not crucial. Yet it is very hard to find
Research dealing with teacher values and viewpoints useful for understanding the parameters of teacher acceptance and rejection of various schooling approaches.

The importance of teacher values influencing innovative ideas of technology is revealed in Cuban's *Teachers and Machines* (1986a) and Wolcott's follow-up study of the *Think about* program (1981). *Think about* is an ITV program with exceptional potential to teach problem-solving skills to intermediate grades. However, when the program was used on the classroom floor where teacher-centered instruction and standardized evaluation were dominant, it turned out to be just another program that teachers had to cover. Teachers tend to choose programs mostly by their schedules, although the program was produced as an integrated series. Teachers confined the locus of problem-solving in the classroom, while the producers' intentions were to extend problem-solving situations beyond classrooms. Also, most teachers did not believe that the program was useful in their classrooms because it was not produced by the people who work closely with children (Wolcott, 1981). Teachers believe that they understand their students in a way that outside professionals do not.

If a teacher strongly believes in the benefit of using a certain innovative technique, he or she tries it despite limitations from school structure. Bliss (1986) found that teachers used cooperative learning methods (as opposed to traditional teacher-centered instruction) even when they did not have strong administrative/collegial support, because they saw merit in using such methods to promote democratic ideas, values, and discussion skills.

**Technology Application Project**

A technology application project was funded through a grant from Private Sector Partnership of the National Science Foundation (NSF) program for three
years, starting in October 1990. The Private Sector Partnership program solicits the full involvement of businesses and industries in both planning and executing a project. The rationale is that two-thirds of the population of the nation's scientists, mathematicians, and engineers work in the private sector, and that three-quarters of all research and development is done by this sector (National Science Foundation, 1990). Through partnership efforts these resources can be used to enhance science and mathematics education. In addition, the Private Sector Partnership program promotes the involvement of traditionally under-represented students in math and science as well as personnel training. Dr. Perry, the district math coordinator and the principal investigator of the project, negotiated with the staff of the NSF that fifty percent of the funds be used for district teacher training to promote teacher familiarity with technology use in classrooms. The funds for hardware purchase were limited to ten percent of the grant.

The project goals and implementation plans reflected the requirements of the sponsoring agency. The project had two goals: "to develop teachers who know of specific applications of mathematics and are able to utilize available technology to teach these applications and mathematical problem solving to their high school students;" and, "to increase motivation of high school students, particularly females and minorities, by using technology and mathematical connections as a means of attracting and retaining them in mathematics/science."

Teacher training was the foremost factor emphasized throughout the project implementation. First, Dr. Perry planned to develop "leadership expertise" within each high school. Two teachers from each of the five high schools in the district were to be "peer coaches." These peer coaches were assumed to have an interest in technology use in instruction and were to receive intensive training at the beginning of the project. Then, the peer coaches would
be responsible for showing the use of technology in instruction to the rest of the math teachers in their schools. Second, the district math teachers were to visit businesses and industries: The business/industry sectors worked as "mentors" who could show the practical use of mathematics and technology to teachers. Through the visitations, district math teachers were supposed to collect problem solving questions that would be appropriate for their classrooms. These problem solving questions would be used in relation to future career plans of students. Minorities and girls would be encouraged to move into advanced mathematics by these practical problem solving skills. Third, one teacher in each high school would be selected to work with local business or industry personnel each summer. Business would provide teachers hands-on experience in the use of mathematics and technology. Fourth, the district math teachers were encouraged to observe other teachers' classrooms where technology and math application were used. Finally, Dr. Perry offered ample workshops\(^3\) on technology use in classrooms. The project also planned to support the use of teacher materials and classroom activities developed through Project EQUALS and Family Math.

For the project evaluation, the Comprehensive Test of Basic Skills (CTBS) and a standardized math attitude scale were to be administered to measure student gains and their attitudinal change about the subject matter. Enrollment of minorities and girls in advanced mathematics courses was to be traced also to see if the project accomplished that goal. CTBS was not administered for this purpose because the state education reform act changed its student evaluation system while the project was being implemented in the districts' high schools.

The project planned to emphasize the practicality of math and the use of technology especially for female and minority students. The district had few

\(^3\) A list of workshops offered through the project is attached in Appendix D.
minority students in the higher-level mathematics classes. Less than 5% of minority students were enrolled in advanced mathematics. In the previous three years (1987-1990) no Afro-American students had taken calculus in any of the districts' high schools. Unlike minority students in math, more than 50% of the students in higher-level math classes used to be girls. However, for the past several years the percentage had dropped to 40%. The project goal was to recover the female percentage and to have a minimum 10% of minority students in advanced math classes. The written project emphasized equity issues in the math curriculum. In order to reach all students, the project stressed mathematics as a "pump," not a "filter," for students in their future career development.

Although the written proposal and accompanying documents reflect the official intentions of the project, its actual implementation was massively influenced by the process of negotiation between teachers and the district math coordinator. According to Dr. Perry, this project was a response to the district high school math teachers' "over-due" demand for classroom computers. Because the teachers' main interest was receiving the machines, Dr. Perry had to persuade them to meet the requirements of the Private Sector Partnership program.

Additionally, the allocation of funds for teacher stipends made it harder to expect teacher cooperation. NSF guidelines restricted teacher stipends to $10 per hour, which was less than half of the minimum wage for teachers. As a compensation for such a low wage, Dr. Perry rewarded the computers to actively involved teachers based on their accumulated observation/intern hours. Few teachers joined the summer internship program because of the low stipend. Teachers who needed extra income taught in summer schools or summer camps where the pay was better. A majority of the teachers interviewed viewed the low teacher stipend as an example of how they were treated by their
administrators. Only one teacher thought that the wage was fair because teachers could improve their expertise through opportunities created by the project. He said that:

This is not the wage for the mechanical work you do mindlessly. This is like someone saying, "Hey, I'll give you a nice car free. Just stop by and get it" and it will be foolish if someone says "no" to this deal.

Teachers' lack of involvement caused the project to be terminated in the second year of its intended three year grant. Seventy-six percent of the district math teachers received classroom computers. According to the district math coordinator, Family Math and Project EQUALS did not affect the project implementation because their target population was elementary and middle school students.
CHAPTER II
METHODOLOGY

We must translate our ethical concerns, our frustration at failure to reform, our anger over injustice, into disciplined questions and ways to pursue them (Spindler, 1982, p. 5).

Research design
To explore the factors, processes, and dynamics of computer use in high school settings, a case study design was used. A case study approach is especially effective in studying educational innovations in two respects. First, it is a proper tool in projecting the perspective from the bottom up rather than from the top down. Thus, the case study method gives merit to understanding the actual implementation process of an innovation. Secondly, qualitative methods help us to understand "processes of events" and to "discover context characteristics that shed light on an issue or object" (Sanders, 1981). In qualitative studies, the emphasis is on insight, discovery, and interpretation in context in contrast to the experimental and correlational approaches which "isolate variables from context and overlook the all important dimensions of meaning in human behavior" (Spindler, 1982).

Inquiry employed in a case study begins by approaching the research sites with the general problems based on a theory. Then, the researcher gradually focuses the research based on the opportunities and the circumstances of the particular site available to him or her. Since the inquiry in a case study is intentionally flexible to study the natural phenomena as they occur, the
researcher should remain open to the situation in order to work with given opportunities and in order to compensate when chances are not available. In choosing the opportunities to work with, a theory provides the framework through which the researcher observes. The function of theory is analogous to Eisner's conception that sees theory as a templet which conceals some parts of the landscape just as it brings other parts to the attention (Eisner, 1984).

The theoretical framework guides the researcher's focus of the study by aiding in the selection of observation opportunities and elaborating them. The selective nature of a study is inevitable because a case study demands the researcher live in selected field sites enough to understand insiders views and because a researcher cannot present every detail that was observed. Any study is limited due to its selectivity, though not without merit or validity. Erickson (1977) compares the case study to graphic/literature caricature because of its selectivity in describing real life in order to reveal the truth in it. It is because of this selective nature that the researcher should provide the readers the information on how selections were made. The rationales for decision making during this study are addressed in the remaining sections.

**Sampling**

Since the purpose of the study is to look at the school's organizational structure and culture that influence the implementation of the project, a purposeful sampling method was used. Four high schools were visited initially out of five district high schools. Among them, two schools were chosen for an intensive case study. Bill Hank was chosen because it reflects the district's community history and values in a comprehensive way. Bill Hank was the first public high school established before the district was formulated into today's configuration. The researcher also gained easy access to the school as the new
principal opened the school to university researchers. Putnam was chosen because it contrasts with Bill Hank in its surrounding community and its student population. The researcher stayed at Bill Hank during the 1991-1992 school year and Putnam from May 1992 to January 1993. The visiting schedule is attached in the Appendix A.

**Focusing the Questions**

The research questions were stated in theoretical terms in Chapter I. Here, the questions are generated as the products of interactions of the researcher's general interests and the specific opportunities found in the field sites.

The initial question was how instructional computing was practiced under the high school structure. The principal at Bill Hank recommended the researcher contact Mr. Friend, a programming teacher after listening to her interest. He informed the researcher of a technology application project that became effective a few months ago. Mr. Friend introduced the researcher to the math faculty in a departmental meeting on the second visit. Many teachers were frustrated because of the "unrealistic" demand of the project. The project provided a well-confined opportunity to investigate the rationale behind the integration of instructional computing into the math curriculum. It also created a chance to observe teacher interpretation of the project. Thus, these questions focused the observations:

What is the rationale of the project and how does the existing school structure mold actual instructional computing activities?

Is there any difference in instructional computing based on the community and history of a school?
Since the inquiry method employed in the case study has as its hallmark a naturalistic character, often the researcher has to deal with the chances which are not available. These missing cases sometimes become strong evidence which confirm/disconfirm the researcher's working hypotheses. A following example illustrates the case of missing opportunity. Soon it was found out that most mathematics classroom activities were not changing according to the goals of the project. Instead, the salient issue was who would get computers and where they would place them. The following questions emerged from this missing opportunity:

Why are teachers interested in having the classroom computers despite their seldom use of the machines for instructional purposes?

What is the actual use of the project-generated computers?

There was a teacher who tried to incorporate computers into her instruction whenever she thought that they were relevant to the subject. Through this discrepant case the specific question became:

What makes the teacher different from the rest of their colleagues and what is the motivation to use computers in instruction?

The focusing questions were not intended to restrict the observations but to represent more site specific and relevant versions of the general research questions. These questions were evolving into more precise forms as the observation process went on. They served as guidelines to identify, describe, and interpret the insiders' point of view.

**Collecting Data**

In the interpretive paradigm, all data are value-laden. Data should be understood based on their context. Therefore a researcher should make the data collection process transparent to readers so that they can understand the use of
data based on the data gathering context. Since all data are situated, multiple
data gathering methods are critical to ease such a value-laden characteristic.
Any single source of data should be examined against other sources of data in
order to find the consistent themes throughout all the sources of data. Then, the
researcher can relate these themes to the existing theories (working hypotheses)
to confirm or to point out discrepancies.

Observations

The strategy of doing observations first and interviews later was
employed for the following reasons.

First, the inside governing rules should be understood because of the
researcher's position as "an outsider looking in". It had to be known how local
teachers acted and what they considered important in schooling, including
instructional computing. In the beginning, some teachers came to the researcher
and explained what they were doing. Before long, the teachers were concerned
little with the researcher's presence. This passive presence brought the benefit
of observing reasonably typical teacher behavior.

Secondly, the passive observations provided chances to elaborate the
kinds of questions the researcher should ask in each interview session.
Furthermore, the persistent presence of the observer helped in establishing a
certain level of rapport with most interviewees. A researcher in the interpretive
paradigm should respect each individual teacher's interpretation of schooling.
To do that, the interview sessions should have flexibility. In order to have
flexibility, the interviewer should be somewhat familiar with each interviewee's
daily life. Repeated observations also brought ample chances to talk with
participants informally.

During the observation period phase, an average of three full days a week
were spent in the schools. During a typical day, classroom observations
occupied the most time. These observations lasted from one to several hours a session and on many days more than one classroom was observed.

In Bill Hank, all math classes were observed. In order to learn the schools as they were, the researcher visited the schools and attended the teachers' classrooms like a student. In order to gain a general understanding of the instructional computing activities in Bill Hank, other subject matter teachers who used computers in their instruction were also observed. That included social studies, science, industrial art, special education, and business classes.

Often participants' innocent remarks and non-research related behavior bring an important insight to understanding unspoken rules that govern their behavior or understanding. The following instance was an example that revealed an aspect of the math faculty culture at Bill Hank. Mr. Friend, an informant teacher, told the researcher that she might feel more comfortable eating lunch with female teachers on the second day of the visit. Three out of five male math teachers ate lunch with science male teachers and they were jokingly called the "boys club." The above remark showed the contact limits between male and female math teachers and this was confirmed during the observation period. Unlike Putnam, informal contact among Bill Hank math teachers was limited. Many math teachers ate lunch alone or with other department teachers. The researcher ate lunch with a couple of female math teachers and their student teachers in a classroom. Occasionally Ms. Burt, a math teacher, joined the lunch. Lunch sessions were valuable observation opportunities for understanding untold regularities and the teachers' concern about their school life. The researcher tried to be there as often as possible and Ms. Sutton, who opened her room for lunch, suggested the researcher copy her classroom key so that the researcher could use her classroom during times when
she was not there. Such a remark indicated an establishment of a certain level of rapport that was important in gathering candid data.

All math teachers' classes at Putnam were observed. Unlike Bill Hank, the English and the special education departments were eager to use computers in instruction. Putnam is the first high school in the district that has a writing center. Additional observations therefore naturally occurred in the writing center, special education, and word-processing classes. Various subject matter teachers used the writing center. Writing across all the subjects in high school was under the spotlight because the state education reform act puts an emphasis on writing as a new evaluation method. Putnam established a new math lab in the 1992-1993 school year. The development and actual use of the new math lab was observed. The researcher also observed an extra curricular activity named "Mac User's Club" led by a special education teacher. Since most math teachers ate lunch together in the faculty lounge, their informal talk and relaxed behavior were easily observed. Faculty meetings in Putnam, and math departmental meetings in both schools were observed. The researcher also joined a business and industry visitation with a Bill Hank math teacher and one math in-service conference held in the capital city of the state.

While observing the sites, the researcher jotted down the teachers' sayings, events, and her thoughts in observation notes. All these notes were rewritten after school. Parentheses were used to separate the observed events and the interpretations about them. All notes were checked each week to find the repeated themes and to elaborate further questions.

**Semi-structured Interviews and Informal Conversation**

A semi-structured interview method\(^1\) was employed. Since teachers' own views about their school and the technology application project were focused,

\[^1\]The interview guideline is attached in the Appendix B.
the researcher tried to play a role of just breaking the ice. One time, a teacher did not want to talk about the technology application project. So, the researcher let her talk about what she wanted. It ended up with five hours of talking in her classroom so that her candid view was understood. The researcher was lucky with her. In another case, a teacher did not elaborate on most of the questions so little information was gathered in that interview.

Most interviews were held in each teacher's room for 30 to 50 minutes. The interviewed individuals were as follows:

- The district math coordinator.
- 13 out of 15 mathematics teachers at Bill Hank High School
- 11 out of 13 mathematics teachers at Putnam High School
- A chairman of Social Studies at Bill Hank High School
- A chairman of Industrial Arts at Bill Hank High School
- 2 out of 3 counsellors at Bill Hank High School
- An informal historian of Bill Hank High School
- Assistant principal at Putnam High School
- Assistant principal at Bill Hank High School
- A chairwoman of counselling at Putnam High School
- The director of the writing center at Putnam High School

Since an interpretative case study method demands contextualizing gathered resources and elaborating them continuously, several math teachers and the district math coordinator were interviewed repeatedly. Most of these interviews were tape-recorded. Immediate note taking was followed when interviewees were reluctant to be recorded. All taped interview records were transcribed for thorough review.

Informal conversation became a valuable data source because it happened naturally. The teachers were spontaneous and honest in expressing themselves.
Most informal conversation occurred in hallways, in faculty lounges, and before and after classes. Sometimes, 5 minutes' talk with a teacher during a break time brought an important insight in understanding his/her actions in the site.

To gain a valid understanding of insiders' views, interviews and observations were done repeatedly. Interviews become more focused and informed when they are based on observed behavior and observations become more knowledgeable about the participants and their perspectives.

Document Review

Since the study was about the implementation of the technology application project, all the project-related documents were scrutinized. These documents include:

- the request for the proposal
- formal proposal
- problem solving questions collected from businesses and industries
- annual reports and the final report of the project.
- business/industry handouts for teacher observations

To gain a general understanding the following documents were reviewed:

- the state math curriculum guide for K-12 programs
- the district public school newsletters and information booklet
- departmental meeting and the school faculty meeting minutes
- the professional newsletters for the mathematics teachers

Analyzing the Data

The observation notes and interview transcriptions were reviewed on a regular basis to find repeated themes and to categorize them. Some categories were from the project proposal and some were from existing theories about school organization, curriculum change, and instructional computing. This
theoretical background is needed to go beyond mere description of actors' behavior and to interpret and convey the meaning which might be salient to teachers or tacit to them.

Strengths and Limitations

All research is concerned with producing valid and reliable knowledge (Mirriam, 1988). A case study approach is no exception. The critical question to be asked in judging a case study is: to what extent can the reader trust the findings of the study? As mentioned in the research design any study is limited as well as strengthened by its selectivity. It is also true that a qualitative study may be weakened by oversimplification or by exaggeration of a situation. On the other hand, it is a particularly useful tool in investigating and understanding slices of real life.

Because the nature of qualitative study is interpretation rather than measurement as in traditional experimental research, some researchers argue that it should have a different conceptualization of validity and reliability from traditional scientific research (Erickson, 1984; Guba & Lincoln, 1981; Merriam, 1988). The traditional ways of assessing validity and reliability are often meaningless or inappropriate when applied to qualitative research (Ratcliffe, 1983). To assess the strength of a qualitative study, validity and reliability must be evaluated in ways that are consistent with the nature and goals of qualitative research.

Internal Validity

Interpretative qualitative research assumes that reality is holistic, multidimensional, and continuously changing. It is not "a single, fixed, objective phenomenon waiting to be discovered, observed, and measured" (Mirriam, 1988). What is being observed in a case study is participants'
constructions of reality - how they see and understand the world. Therefore, the critical question for assessing internal validity is whether the findings of a study represents the reality of the insiders. Internal validity thus reflects the extent to which a researcher captured a "more or less honest rendering of how informants actually view themselves and their experiences" (Taylor & Bogdan, 1984). A case study approach stresses the importance of understanding participants' perspective, the complexity of human behavior, and providing a holistic interpretation of what is happening (Mirriam, 1988). Internal validity was assessed on the basis of following criteria: triangulation; member checks and feedback; long-term observations; and peer-review (Mirriam, 1988).

**Triangulation.** Triangulation means using multiple investigators, multiple sources of data, or multiple methods to confirm the emerging findings (Denzin, 1970). The data sources must be sturdy, independent, and congruent (Miles & Huberman, 1984). In this study, data were collected and analyzed at three different levels--observations, interviews and conversations, and document analysis. The multiple data collection methods permitted the researcher to double-check findings with different sources for corroboration and verification. Using multiple data sources lessened the circumstances under which biased, misleading, or inaccurate information from any one source overly influenced findings and conclusions (Mirriam, 1988). Triangulation strengthened data collections, analysis, and validity of the study.

**Member checks and feedback.** Member checks and feedback refer to taking data and interpretations back to the participants for confirmation (Mirriam, 1988). In this study, a summery of the proposal was brought to participants and the field notes were open to them. Ensuring data accuracy was a difficult task because certain kinds of feedback can change participant attitudes and behavior or disrupt the study. The researcher met with participants during
and after each research period to obtain their comments on the collected data and to discuss the interpretations of the data. Member checks and feedback strengthened the plausibility of the study.

**Long-term observations.** Data were collected and analyzed over the period of a year, from November 1991, to January 1993. This enabled the researcher to conduct frequent visits and observations at each school, gathering additional data, comparing it against other data and findings for verification, and checking out alternative explanations (Mirriam, 1988). Collecting data over a period of time strengthened the validity by providing the observer the discernment for distinguishing routinely occurring events from idiosyncratic or atypical ones. In addition, prolonged observation reduced potential researcher effects on the sites.

**Peer review.** The description part of this study was reviewed by the three dissertation commission members. Their review and criticism pushed the researcher to search for more data, clearer description, and to look for alternative explanations. The descriptions and findings of the study were also brought to a fellow researcher who was doing a field study in the same school district. Her comments helped the researcher gain some insight for the interpretation of the data.

The researcher also stepped back from the study to adopt more objective and distant perspective on the study several times. The repeated reexamination of the data led to a more detailed and focused study of instructional computer use. The critical review and reinterpreted findings strengthen validity.

**Reliability**

Reliability refers to the dependability of the results obtained from the data. In qualitative research it does not mean achieving the same results, but concurring that the results are consistent and dependable (Mirriam, 1988). The
critical question for assessing the reliability of a qualitative study is: If the study is repeated, will it yield results that are consistent with our general understanding of the phenomenon, results that make sense?

Reliability and validity are inextricably linked. It is impossible to have internal validity without reliability. Therefore, insuring internal validity also insures reliability (Guba & Lincoln, 1981). Traditional views of reliability are not appropriate for qualitative research, as Mirriam (1988) explains:

Because what is being studied in education is assumed to be in flux, multifaceted, and highly contextual, because information gathered is a function of who gives it and how skilled the researcher is at getting it, and because the emergent design of a qualitative case study precludes a priori controls, achieving reliability in the traditional sense is not only fanciful, but impossible. Furthermore, . . . replication of qualitative study will not yield the same results. That fact, however, does not discredit the results of the original study (p. 171-172).

A case study approach is interested in describing and explaining the world through the perspectives of those it studies, not in identifying laws of human behavior. Plus, it assumes multiple realities and multiple perspectives. The clarification of a researcher's position, and triangulation are important in establishing reliability (Mirriam, 1988).

Roles of the researcher. The researcher took a participant observer's role based on the interpretive paradigm. In an interpretative qualitative research approach, a researcher is not an "objective" being detached from the researched group although he or she tries to bracket their subjectivity as much as possible. Instead, it is important to clarify a researcher's position to help readers' understanding of findings and interpretations of a study.

A researcher comes to the research sites with his/her own strengths as well as limitations. Being a foreign woman graduate student who speaks English as a second language became disadvantageous as well as advantageous;
different limitations and opportunities were given to the researcher. It would be exemplary of missed chances that few opportunities were given to observe male math teachers' behaviors outside the classrooms at Bill Hank. Also, it took a longer time to understand the routine work in American high-schools. Being a stranger also became a strength because the researcher was less biased by previous experiences in American school settings. In addition, the researcher could easily become a "non-threatening figure" to the site teachers. This gave the researcher freedom to observe diverse occasions in the sites as well as to watch the teachers' typical and less intervened behavior.

In the beginning, teachers perceived the researcher as a computer-advocate coming from the university. This image made them self-protective when asked a question regarding the use of classroom computers. It did not take a long time, however, to convince participants that the researcher was not a computer expert. Then, teachers did not understand why the researcher wanted to observe their classes where the computers were rarely used. By letters\(^2\) and conversation, the researcher had to persuade the participants that she wanted to see what they were typically doing in every day class.

As in any other situation of human relationships, some participants were easy to talk with and some kept their distance from the researcher. As a participant observer, the researcher consciously tried not to create a visible close rapport with any particular group because such rapport came with a price. Identification of an outside researcher with a certain group of insiders limits access to the diverse groups of people in the sites.

\(^2\)An example of the letters for informing teachers the purpose of observations was attached in the Appendix C.
Establishing a right degree of rapport, which is close enough to listen to insiders telling their candid viewpoints and distanced enough not to get involved in a conflicting situation, is a difficult task if not an impossible one. The researcher learned this through an interview with a male math teacher at Bill Hank, who was considered an outsider by the department faculty. While the researcher was asking questions about the school and the project, the teacher suddenly started asking her viewpoints about them. The researcher could not be candid with the teacher because of the danger of losing her "neutral" standpoint in the school, and because of the chance of influencing his viewpoint to a certain degree. This incident showed the possible paradox of the researcher's role in the interpretive paradigm: being detached about the researched issues for the objectivity of the work, and at the same time maintaining trustful relationships with the respondents in order to gain access to their honest viewpoints.

Spindler (1982) claims that skills of doing a field study can only be learned and refined through field experience. A qualitative researcher without field experience is "like a surgeon without experience in surgery or a clinical psychologist without experience in clinics" (Spindler, 1982). A veteran researcher would have the wisdom to lead delicate situations like the above one into another unique chance to understanding the insiders' view.

**Triangulation.** As discussed for internal validity, multiple data collection and analysis methods were used. This cross-checking and cross-verifying process strengthened both the internal validity and the reliability of the study.

**External Validity**

Ethnographers feel that an in-depth study that gives accurate knowledge of one setting not markedly dissimilar from other relevant settings is likely to be generalizable in substantial degree to these other settings.
Ethnographers also usually feel that it is better to have in-depth, accurate knowledge of one setting than superficial and possibly skewed or misleading information about isolated relationships in many settings (Spindler, 1982, p. 8).

Spindler's claim about the generalizability of ethnography can also be applied in justifying external validity of a case study approach if one agrees that both approaches share similarities in the respect that they are interested in representing an "emic" view (view from within the culture) through in-depth research. Generalizability of qualitative research should be reconceptualized based on its goals of theorizing and the nature of interpretative research. Erickson (1986) argues that generalizability is an inappropriate goal for a case study approach because:

... search is not for abstract universals arrived at by statistical generalizations from a sample to a population, but for concrete universals arrived at by studying a specific case in great detail and then comparing it with other cases studied in equally great detail (p. 130).

Thus, what one learns from a particular situation may be transferable to situations encountered later or to other similar circumstances.

The critical factor that affects external validity of a case study is having a sufficient amount of time which allows the researcher to submerge into the field sites to distinguish typical events from atypical or idiosyncratic happenings. Another factor is to compare or contrast data and findings between sites. In this study, data were gathered over a year. The collected data and findings were compared between the two high schools of the district in order to find similarities and differences between them.

Since the goal of theorizing in the interpretive paradigm is better understanding of social phenomena rather than controlling them by an accurate prediction, this case study should also bring a better understanding about the use
of instructional computers in high school settings, especially for traditional academic subjects like mathematics which is important to those whose aim is to go to selective colleges. Furthermore, it is the readers who should judge the generalizability of the study to their cases, not the researcher. For this reason, the research process should be presented as explicitly as possible to the readers through detailed descriptions.

The Significance of the Research

The significance of the research has two aspects. First, although there is ample research on instructional computing, relatively little research has been done in high school contexts. Cuban (1986) finds the reason for the scarcity of such research in high schools' structure to be that unlike elementary schools, high schools have a very rigid notion of what to teach and how to teach. Moreover, the teachers are in less control of their class activities because their students change classes hour by hour. In addition, since several teachers teach the same course in most cases, each teacher must pay attention to what the other teachers do. The limited control of their class activities and the stable notion of what to teach make high school curricula largely pre-set. Consequently, most high school teachers are less likely to integrate instructional computing into the curriculum.

Secondly, most research on instructional computing has been done from a scientific perspective. Extensive research has examined the computer's effectiveness in delivering instruction and in teaching programming languages. This trend was obviously shown when the researcher examined the dissertations regarding the use of instructional computers in the last decade. Few studies have focused on the social and political relationships that prevail in an organization and influence the utilization of computers (Kling, 1980). In this
regard, an attempt is made to understand instructional computing in its social context through an interpretive perspective. The study should add one more effort in examining the field of instructional computing with a variety of perspectives.
CHAPTER III

Instructional Computing in the Mathematics Department of Bill Hank High School

Bill Hank High School and its Community

Bill Hank High School is located in a historic and wealthy part of town. The school's tradition, the diversity of its student body, and its autonomy has deeply influenced schooling. The school was established in 1904, as the first public school for whites. The school received its name—that of a famous statesman from the city—in 1928. Bill Hank was known as "a great compromiser" who ran for the president of the United States against Abraham Lincoln. Hank's sisters asked the school system to name the school in his neighborhood after their brother, in memory of his work in the state and nation.

In 1977, because of the increasing student population, the school moved to its current location near the original site.

Until 1968, most students at Bill Hank were from wealthy families of the neighborhood and it had established a strong tradition as a good college preparatory school. According to the chief counselor and chairman of the mathematics department, the school had been among the top ten high schools in the nation and it was still considered an honor to be a faculty member at Bill Hank.

The desegregation law, however, brought profound changes to the school. Bill Hank had to admit Afro-American students who contrasted with the traditional student population in almost every aspect. The law resulted in a bi-
polar student body, resegregating the school population. This resegregation caused violence and discipline problems throughout the seventies. Recently, a retired school historian pointed out the difficulty of maintaining these two different student bodies:

... which makes a very difficult task for the school to try to blend these people who are so different. I mean it's not just they are black and white. It is that they are among the poorest of the black and the richest of the white.

The poorest people live generally [in the] downtown area as you know. And they [are] bused out and bused into the neighborhood so different from where they live and just being on the bus and looking at the surroundings of the school causes conflict within them to some extent because they feel so alienated from the community where they live ... homes where they don't have any real nice conveniences and they pass by the beautiful big houses with large lawns and gardens. I think it causes a lot of envy and, yes, when they get to school that envy turns into anger.

Although student violence problems were reduced in the eighties, segregation of the student body continues to be one of the school's headaches. According to Mr. Goodman, chief of the counseling department, the composition of PTSA (Parents, Teachers, and Students Association) and its activities are good indicators of the role of the socio-economic status of the student families. Most poor parents do not feel comfortable in visiting the school. Moreover, he thought, the majority of poor families do not care about schooling.

In addition, the nearby university and Toyota Company add more diversity to the student body. Bill Hank is the only school among the five high schools in the district that offers an ESL (English as a Second Language) program. The student body was approximately 76% caucasian, 19% afro-american, 3% oriental, and 2% other races in the 1991-1992 school year.
Eighty percent of the students went on to colleges; 13% were on the federal lunch program.

Diversity was not always welcomed by school personnel. Ms. Roberts, a math teacher, said that the general attitude of faculty members toward the diverse student body was that faculty refused to attend to the needs of foreign students and blacks because it was not the faculty who asked for such children. Dr. Ray, chairman of the social studies department, thought that the only criticism of the school would be that it over-services the top 40% of the students and, relatively speaking, neglects the rest. The diversity of the student body, because it earned little attention from school personnel, resulted in a resegregation of the school. Ms. Sutton, a math teacher and alumna who had two sons attending the school, said that the students were "cliquey." The teenagers in the school were bundled into ESL students, rich students, Afro-Americans, and honor class students. The groups rarely mingled.

Another factor that promotes resegregation of the student body is tracking. The school is known for tracking its students. The school staff took it for granted that tracking is the mechanism for preserving the school's social/academic tradition within a heterogeneous student population. Because of the absence of a "middle cushion" in the student body, tracking has an obvious effect at Bill Hank. There were "day and night" differences between advanced classes and the basic ones. Students preparing for colleges usually take four years of mathematics, science, U.S. history, and foreign languages. On the other hand, there are students looking for courses that provide them an easy way out. Mr. Adams, a math teacher with a master's degree in business and who had taught in the business department, said that it was not rare in a disciplinary school like Bill Hank to maintain some "dumping ground" classes. He said:

Have you heard the term "dumping ground?" It's a class where they dump bad kids because it's not likely and they can stick them in there
possibly. And business and music is that way, I think—and the art classes
to an extent.

The difference between the advanced and basic classes in mathematics is
more dramatic than the differences in other departments because of the
hierarchical characteristic of the subject matter. The absence of middle class
students results in a dramatic difference in the students enrolled in average and
above-average math classes, which will be discussed later.

The school's diverse student body and its resegregation are a concern of
the school district's central office. During the 1991-1992 school year, Bill Hank
had a new principal who had dealt with the segregation problem successfully at
a middle school in North Carolina. Unlike the previous principal, he wanted to
have a firm grasp on what was going on in each classroom; his supervision was
often met by teacher resistance. The teachers said that the new principal visited
their classrooms without notice, unlike the previous principal who usually hid in
his office. A math teacher also mentioned that the new principal was rude in
asking "when will so and so retire?" publicly if there was a principal/teacher
controversy.

Some teachers expressed their feelings about such a strong and decisive
new principal by ridiculing him behind his back. Moreover, the teacher and
principal conflicts highlight the difficulties associated with changing established
school traditions.

There was another change at Bill Hank that deeply influenced the school
in 1968 in addition to desegregation. The desegregation law brought a merger
of the city and county school systems. The 1968 desegregation order gave the
majority of central office positions to personnel from the county school system
since there were significantly fewer city school personnel many of whom were
about to retire. The composition of personnel in the central office encouraged
distrustful relationships between the school staff and central office personnel. Several teachers thought central office personnel were "jealous" of the school's good reputation and its wealthy community. A recently retired teacher interpreted the general discomfort of the teachers as an act to protect their own interests and not a consequence of unequal treatment by central office:

I thought proud. I probably was over jealous. And my feeling about the school--because I mellowed a lot. Now, I realize that other schools are very good, too. There was a time I wouldn't acknowledge that. But, I know that they are. And I feel with Bill Hank teachers up to a point. I realized [there] probably [was] some truth in the attitude that they feel but probably not as much as they feel. The central office is probably not out to get them like they feel. Probably a little paranoid about, a little protective of their interests.

To preserve the school's tradition, Bill Hank faculty tried to maintain the school's independence. For example, the Bill Hank's math faculty was the only math faculty who would not submit faculty meeting minutes to the district math coordinator. The teachers at Bill Hank also tried to be independent from local administrators and were autonomous. It was said that the previous principal respected the creativity of each faculty member and believed that such creativity would blossom under minimized intervention of any kind.

Dr. Ray, who let his honor class students invite diverse social group members (i.e. homeless people, homosexuals, professors, and psychologists) as class speakers, appreciated such autonomy because it allowed him to do things otherwise impossible. He also admitted that the autonomy of teachers did not always have positive effects on student learning. When confronted with unwanted change, the teachers often used their autonomy to protect their own interests. As the chief counselor admitted, faculty autonomy sometimes created a "don't care" attitude toward external interventions.
In summary, the tradition of "the school for the rich" had tremendous effect on the schooling at Bill Hank. Bill Hank resegregated the students by rigorous tracking and tried to keep its distance from the central office in order to preserve the academic and social tradition. Tracking was a way to keep the school's tradition in a pluralized school population. Such a policy supported the college preparatory students and neglected the students not in that accelerated track.

The school faculty, especially those with the most seniority, are nostalgic about the glory of the school's past. They consider any policy that threatens the old tradition of the school unfair. Most of the school staff, therefore, took for granted tracking and faculty autonomy. In this respect, the technology application project may provide a chance for the math teachers to reflect the filtering role of the math curriculum because the project claims the use of technology to motivate minorities and girls in advanced mathematics courses. However, throughout its implementation, the project instead showed how powerful the school culture was by following the existing pattern of tracking in the math curriculum.

Mathematics Department: its Excellency and the Divisiveness

The math department at Bill Hank reflects the school's history. The excellence and division of the math faculty emerges from academic and social tradition, student diversity, and autonomy of the faculty and the school. Bill Hank has earned fame for its strong math and science programs. The math department won first prize in the state math competition several times, most recently in 1991-1992.

Teachers are proud of their students' excellent work and the chairman gives credit to the department's long tradition of excellence and its faculty's
hard work. All math teachers have master's degrees, and several of them are rank one teachers with an average of 21 years teaching experience. According to the chair, Bill Hank's math department is the only one in the district where three teachers, not one, are capable of teaching several calculus classes. It also provides several honor classes and few low-level classes.

The diverse student population and the tracking system have a profound influence in the math curriculum because of the department's strong tradition and because of the hierarchical nature of the subject matter. The absence of middle range students results in a big difference between average and above average classes. Algebra, geometry, and applied math are below average classes at Bill Hank, although these classes are defined as average ones in the school curriculum. There was a "day and night" difference between these classes and the classes one level above the average ones, for example--topic math and advanced geometry.

The below average status of average math classes at Bill Hank is known to math teachers in other high schools of the district. The chairwoman of Putnam's math department confirmed this. Ms. Alley, who has been in Bill Hank for two years and whose classes are mostly algebra, said that algebra as taught at her previous school was like honor classes at Bill Hank.

The difference between average and above classes shows the filtering of the math curriculum in the school especially when the student body is polarized. Mr. Adams, whose highest classes are algebra and geometry, thinks that the mathematics faculty is more sensitive to the student body than other departmental faculties because of the hierarchical nature of the subject matter. He explained this sensitivity:

The school is segregated because we have extremes-- socially we have very low and upper and I'm not saying that they don't have [many of the] same problems or the same positive things. But, they are two
entirely different social structures I guess. And, yes, there is a lot of
segregation at the school. I know they try to overcome that by mixing
classes with students. But, math is very stratified in upper and middle
and low levels. So, math is unique that way. In social studies class you
can possibly mix a lower and upper average type of students. In math
you can't. That can't be done. So, when you do have lower classes in
math you have thirty below-achieving, unmotivated, destructive, poor
background, no family, you know, you have the whole smear of all these
problems. And in one particular class you have one or two students who
are unlike that. A majority of students have all combinations of these
difficulties. And, so, it's hard when you have that many in class. Even
teaching a basic concept, you are trying to control the class [the] whole
time, keeping them from killing each other or whatever. I know killing
is a strong word. But, keep them [from] interfering with each other, even
to be able to hear, listen to what I'm doing.

In addition, students are tracked in the mathematics curriculum based on
their socio-economic status. Although nobody interviewed admitted that the
staff intentionally tracked students based on their socio-economic status,
counselors in the school agreed that there is a pattern of students' taking math
classes based on the students' socio-economic status. The district math
coordinator and the school students also confirmed the filtering of math students
based on socio-economic classes. Janet, a Bill Hank graduate, said that the
counselor asked her father's occupation and whether she was planning to go to
college when the counsellor planned Janet's schedule. Janet did not have any
problem getting into four consecutive years of mathematics because her father
was an IBM engineer. This filtering based on the students' socio-economic
status results in the pattern of math classes by race. Most black students, poor
and not school smart, are in low-level math classes and are not encouraged to
take higher-level math courses.

The dramatic difference between the low and high-level math classes has
created a divided math faculty. In Bill Hank, there are not enough low-level
classes for each teacher to teach at least one. Low-level classes are usually
taught by teachers who always teach these courses. Math teachers whose highest classes are average-level classes thought that their reality was so different from the teachers in the higher-level classes that they could not understand each other. One math teacher summed up the problem this way:

I don't think even the people who are making decisions about the math department, whatever... when all they have all day are the kids who are actually motivated about what they are doing. They don't understand the problems existing in the lower [level] classes. I think there is a breakdown there. I can't speak for them because that's what they used to do and that's what they have seen when they are in the classes. So, they can't understand what I'm talking [about]. That's what's going on day by day. It's them and not the particular thing and I understand why it wouldn't be. Because they don't see it everyday and have to feel it.

In this atmosphere, it is natural that most teachers' main concern is focused on which classes they will teach during the school year. Mr. Reed was upset in the math faculty meeting when teachers were planning the coming year's schedule. He requested the criteria for distributing classes among the teachers. Mr. Reed is one of the teachers who has taught average and lower-level courses despite having higher faculty seniority. The department chairman had no criteria for the scheduling decisions except for saying that some other departments, such as English, had kept their schedule secret until the first day of the school year. Ms. Roberts agreed with Mr. Reed's concern, while the rest of the math teachers remained silent during the argument.

Another reason for the division of the math faculty seems to lie in the fact that the authority of the department has been under the control of one person for a long time. Mr. Keen, the chairman, started his teaching career at Bill Hank and has been the chairman over 17 years. The math teachers, content with the chair or not, agree that almost all department policies are under the chair's control. The school's policy of insuring faculty autonomy allows
centralization of authority on a person for a long time. Ms. Sutton, who had been teaching math for 17 years, acknowledged the tradition:

Mr. Keen has always, since I was here, been the head of the math department and pretty much takes care of the department. Now, we hire new teachers. Basically the principal makes decisions about hiring new teachers. Other than that, what we teach is all up to under Mr. Keen...all has got to do with Mr. Keen, you know, the curriculum and everything.

On the other hand, the chairman does not have enough power to back up his authority. The school's autonomous climate for each individual teacher made it hard for the chair to practice strict control over the math faculty. In particular, teachers who had been at Bill Hank longer than the chair had strong voices regarding policies that would influence their classes. For example, the chair believed that the teachers should rotate math courses to keep their math knowledge fresh. However, the chair could not take algebra II honor classes from teachers high on the seniority list. It was said that algebra II was popular among math teachers because it was easy enough for them not to prepare for the class. At the same time, algebra II was difficult enough to require students to study hard. The chair's inability to control certain math teachers boosted most teachers' view that department policies were not fairly established. These feelings of unfairness, along with the autonomous faculty culture, caused some teachers to remain in their classrooms, with minimum interaction with other math teachers.

The department's tradition and the autonomous faculty have a strong influence in times of outside intervention. The pride of the math faculty often results in an exclusive attitude toward any outside intervention. Their exclusive attitude was explicitly revealed in the recent integration of ninth graders as the district shifted to the middle school concept. The middle school concept caused uneasiness between existing math faculty members and the teachers who came
with the ninth grader. Ms. Alley said that the math teachers did not invite the ninth grader teachers to lunch even once. Such indifferent behavior hurt her feelings and she is extra cautious in adapting to the new environment. Ms. Alley thinks she is the replacement teacher for a favorite teacher on the faculty. Some math teachers projected their anger for such a loss onto her. Mr. Adams, another teacher who came with ninth graders, also expressed his uneasiness:

And when we came to the school from the junior high, when they incorporated junior high with senior high and formed the middle school, I was in the ninth grade and they talked about how we are supposed to be absorbed into the total curriculum of high school level which is not the case. And I understand why it hasn't [been] and we people over here we teach the same subject over three years and to work with an upper-level type of classes would be a very difficult thing to do. There is a lot of fairness involved. But, at the same time, I have felt that it's not fair if I have low classes all the time. It's really burning out very much. I--the whole routine of every day--calling people, going out, getting files, files full of suspensions, full of referrals, court actions, all the stuff and I have all these type kids.

Ms. Sutton was also uncomfortable with the new configuration:

I don't think that ninth graders are mature enough to be housed with tenth graders and upper. Besides, it is not our decision. It (the middle school concept) might work in some places, but not here.

The technology application project was not an exception in confronting the exclusive attitude of the Bill Hank's math teachers. It was this math faculty culture that had a major influence on the project's implementation. The individualistic and divided faculty culture made it hard to communicate about the project among the math teachers. No math teachers except one were informed that the project-generated resources were primarily for minorities and girls. One teacher did not even know that the project was available and would provide her a classroom computer and other resources.
The chairman's view, which considered teacher involvement an individual teacher's responsibility, also influenced delivering project information to the teachers. Unlike at Putnam, there was little encouragement from the chair. Despite such little communication and rare use of the project-generated computers for instruction, a controversy concerning the distribution of the initial five computers occurred that will be discussed later. In this sense, the math teachers at Bill Hank were more sensitive to control over resources than were math faculty at Putnam. The technology application project, regardless of its original intention, followed the existing filtered math curriculum instead of influencing the math faculty culture.

**Instructional Computing**

Mostly because of the similar high school structure, instructional computing at Bill Hank has much in common with the same program at Putnam. Yet, it also reflects the school's autonomous atmosphere and tracking philosophy. First, instructional computing occurs in a departmentalized fashion. The independence of each department leads to different uses of the computers. Little intervention by the local administrators in instructional computing is more apparent at Bill Hank than at Putnam. The school's autonomous climate causes the administrators to be concerned less about instructional computing in classes. For example, information on the number and kind of computers was not available until 1992-1993, when the state education agency requested such a count. Table 1 shows the distribution of the computers in the department. As at Putnam, the old computers were allocated according to the existing power structure of the department. All the Apple II computers in special education were moved from the math department programming lab as the central office replaced Apple II machines with the new IBM computers.
Table 1: Number of computers and staff in each department (May 1993)

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<tr>
<th>department</th>
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<th>location</th>
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</thead>
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<td>24</td>
<td>Tandy</td>
<td>business lab</td>
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<td>0</td>
<td></td>
<td></td>
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<tr>
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<td>0</td>
<td></td>
<td></td>
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<tr>
<td>fine arts</td>
<td>2</td>
<td>3</td>
<td>Apple IIe</td>
<td>classrooms</td>
</tr>
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<td></td>
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<td>Macintosh</td>
<td>classrooms</td>
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<tr>
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<td></td>
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<td>Amiga</td>
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<td>Macintosh</td>
<td>classroom</td>
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<td>industrial arts</td>
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<td>5</td>
<td>Tandy</td>
<td>classroom</td>
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| total number     | 97    | 136      |             |                |

* computers from the technology application project
Second, at Bill Hank computers are also integrated in the school curriculum as additional subjects. The math department offers programming classes and the business department offers word-processing/key-boarding classes. As at Putnam, the word-processing and the key-boarding classes show a gender bias: girls are the majority in these classes. There is no such gender pattern in the programming classes. Access to different kinds of computer knowledge based on gender also occurs at Bill Hank. In addition, there are race distinctions in these elective classes. There have been few black students in the programming courses. In 1991-1992, not a single black student was enrolled in the programming classes.

Mr. Friend, a programming teacher, thought that not all students wanted to take his classes because he demanded hard work. Ms. Derby, an advanced key-boarding teacher, said that most blacks in the school were from poor families and they were seeking an easy way out of the school. Therefore, most black students at Bill Hank did not take demanding elective courses such as programming. The pattern by race in taking elective courses was an example of the school's resegregation.

Besides the race and gender differences among these classes, teachers' notions about their students are different. Ms. Collins, a word-processing class teacher, thought that her students would not work unless she gave them step-by-step instruction for each day's work assignment. Ms. Derby, an advanced key-boarding class teacher, felt her students would not take programming classes because of Mr. Friend's demanding requirements. On the other hand, Mr. Friend said that his Quick BASIC class was more heterogeneous than the AP-Pascal class. The students in both classes were self-motivated after students who could not follow the Quick BASIC class dropped out.
The following episode reflects the teachers' different perceptions of students in the word-processing and programming classes. In March 1992, the computer virus Michelangelo spread quickly through the region. Mr. Friend was aware of the virus and checked all the computers in the programming lab and installed a new virus-protection program. Ms. Collins, however, thinking her students were not computer users outside the lab, did not bother with installing virus-protection program. Unlike Ms. Collins, Mr. Friend had to pay attention to external computer news because many of his students had computers at home. His students frequently talked about new versions of disk operating systems and exchanged programs with each other.

It was not only teachers who have different notions of student ability in these classes. Students are also aware of differences in these courses' work requirements. There were two white boys in the advanced key-boarding class. Daniel, a junior, knew the teacher personally. He said that he could get an A easily in this class, so he would raise his grade-point average. Luke, a senior, told me he was taking too many AP courses, so this class provided him a nice break.

The differences in gender, race, and teacher and student opinions on the word-processing/key-boarding classes and programming classes reflect the effects of the tracking system when these differences are considered in the context of the nature of the elective courses in high schools. Some elective courses receive high-level students, while others get low-level students. Business classes get lower-level students while foreign language and science classes usually receive higher-level ones.

Such a pattern also applies in the computer-integrated classes. Instructional computing experiences between the higher-level students and the lower-level students are very different. While the students in the programming
classes are learning how to develop computer programs, students in business
classes were learning how to use Word Perfect, a commercial word-processing
program, or how to type with accuracy and speed.

Unlike Putnam High School, leadership in instructional computing is
absent at Bill Hank. Instead, the autonomy of individual classrooms prevails.
At Bill Hank, the programming teacher and a couple of teachers in the math
department are the computer hackers. These experts, however, do not use the
computers for instructional purposes except in the programming classes. They
provide little support to other teachers as to how to incorporate computers in
classroom learning. It seemed that the strong tradition of excellence made most
teachers content with, if not proud of, existing instructional methods.

To understand the general atmosphere of instructional computing, the use
of computers in social studies, science, business, industrial arts, special
education, and math was observed. The language arts department had submitted
a proposal to the central office for the writing lab's establishment during 1992-
1993. When there were no pre-set obligations to use computers for instruction,
the computers were added to the class based on each teacher's different motive.

For example, Mr. Smith, a chemistry teacher, loaded Graphic Analyzer
III along with the Gas Law simulation program, into his two Apple IIGS
computers. Mr. Smith believed in the importance of visualization and common
sense in solving chemistry problems. The computer could provide graphic
animation which was impossible to supply with blackboard and chalk. He
wanted his students to visualize new problems and solve them through common
sense. In the class, Mr. Smith showed the movement of molecules based on
the temperature using the simulation program. Then, the students and the
teacher entered data for the graphics program. The students were to figure out
the relationship between volume and pressure.
Dr. Ray, chair of the social studies department, thought that the computers were good for students with low motivation; he especially believed in computer games which he felt easily capture students' attention. Dr. Ray divided his fundamental class students into two groups and let them play a computer game when the class was learning regions of nations in the Middle East and Africa. He did not need the computers for his advanced class where the students and the teacher worked more or less as intellectual equals and free discussion was the main channel in instruction.

Dr. Ray is not the only teacher who conceives the computer as an attention-gaining device. Ms. Jones, a special education teacher agrees with him. She let her "difficult boy" play Sticky Bear, a spelling game program, to keep him in the class and out of the hallways.

Mr. Harper integrated computers in his architectural drafting class in a unique way; he did it in the context of project-oriented classroom activities. Mr. Harper, chairman of the industrial arts department, was incorporating computers into classes to meet the needs of the job market. Auto CAD (Computer Aided Draft) is a common software package used in many industries and students have a hard time getting a job if they do not know how to use the program. Mr. Harper received an intensive five-day inservice about the program two years ago and continued to learn about the program by himself.

There were five Tandy computers with four graphic plotters and one printer in his room. Students need a strong mathematics background in order to take the drafting class. There were eleven male students with one Afro-American and two Asians. The class was project-oriented and individualized. On the day of my observation, three couples and one student were using the computers; the rest of the class members were doing their own work at their desks. One boy was preparing his blue-print to compete at the state fair. The
black student was renovating a teacher's house; he was converting the terrace into a room with windows. Two Asian students and a white student were brainstorming for their projects. Mr. Harper played the role of facilitator.

The students discussed problems with their partners or/and asked for help from the teacher. Mr. Harper said he had no discipline problems when he used computers in his instruction. Computers were integrated smoothly when class activities were project-driven, not lecture format. The project-oriented class lessened the collective nature of classroom learning. It provided flexibility so each student could do his own work rather than be occupied with whole class activities. When computers are considered as add-on instructional options, how they are added to the current curriculum depends on individual teacher values and subject matter characteristics.

In summary, instructional computing at Bill Hank not only shares many similarities with that at Putnam, but also reflects its faculty culture and the tracking philosophy. Instructional computing occurs in a departmentalized manner and it is integrated into the curriculum mainly as additional subjects to learn. The history of the school also plays a role. The tracking philosophy is evident in the type of experience students are given with computers. While more girls and blacks are found in word processing and advanced key-boarding classes, there is not a single black student in programming classes. The school staff, however, take these patterns for granted.

The autonomy of the individual teachers also influences general instructional computing in the school. There is not a teacher recognized as a leader in instructional computing. On the other hand, each teacher's personal values and the characteristics of the subject matter affect the practice of instructional computing. When teachers see the computer as a medium that enables concretization of abstract notions which is otherwise difficult or
impossible to do, it is used for such purposes. If a teacher regards the computer as a attention-maintaining device for difficult students, it is used accordingly. The tracking philosophy is also reflected in this varied integration of computers into instruction.

**Technology Application Project at Bill Hank High School**

The tradition works. So, why change?

Dr. Perry

The implemented project at Bill Hank influenced little of the math curriculum and reinforced the unequal distribution of computers among the departments. The math faculty culture and the firmly established textbook-centered math curriculum played major roles in the project's limited application. In the following section, project implementation at Bill Hank will be examined in three areas: (1) computer integration and emphasis on problem solving; (2) the math faculty culture that sets a unique tone for the implemented project; and (3) the discrepant teacher's effort to benefit from the project.

**Computer Integration and the Collective Nature of the Classroom Learning**

What are you going to do with thirty kids with one computer and with the software that you are not even familiar with?

Ms. Sutton

The project-generated computers were rarely used for instructional purposes. The absence of guidance in how to use classroom computers with the whole class was the main reason for most teachers not using the project-generated computers for instruction. The help that the teachers got was technical help from hackers in the department. Mr. Friend, a programming teacher, and Mr. Gorden, a peer-coach, were known as computer experts and they helped other math teachers. In-house training was mostly on how to use utility programs such as a word processor or a grading program.
The autonomous faculty culture seemed to prevail when math teachers asked for help from the computer experts. Often, such help was offered as expert teachers doing a favor for teachers who were relative computer illiterates. Mr. Friend, a programming teacher, complained that teachers wanted to use computers without putting in any personal effort. He himself learned all the computer knowledge, the programming languages and hardware configurations, alone. He thought that one should learn the computer by using it every day. It was impossible for him to teach everything in Word Perfect to all the math faculties.

On the other hand, most math teachers did not know what kind of program was loaded on their hard drives. Ms. Mayer was disappointed when Mr. Gorden loaded some programs on her computer without any explanation of how to use them. She also wanted to learn how to use Word Perfect, but none of the teacher inservice programs offered such a class. Ms. Mayer at least showed an interest in what was going on her computer. She was the only math teacher who tried to use the computer for instructional purposes. Most of the math teachers did not seem to care what was loaded on their hard drives as long as they could use the grade-keeping program.

Ms. Sutton turned on the computer for the first time when asked by the observer. The five programs were menu-driven: Geometric Supposer, MCAD, Green Globes, Graphing Equations, and Hardball. Ms. Sutton did not think of herself as a part of the computer generation. She questioned, "If I know so little about the computer, how can I use it for my students?" In addition, she did not like most programs. Geometric Supposer was too slow for her advanced geometry students, and the terminologies used in MCAD were too difficult for her students. In addition, Ms. Sutton thought that one computer with a printer, locked in the corner of the classroom for safety reasons, was almost useless for
instructional purposes. Ms. Sutton again asked, "What are you going to do with thirty kids with one computer and the software that you are not even familiar with?"

This question was typical to most math teachers at Bill Hank when they considered computer integration. Many of them did not think of themselves as the computer generation. Ms. Parker said that when she did her college preparation almost thirty years ago, computer technology was not available. She learned something in college, but it was nothing compared to today's technology. She needed to learn about new technology, but she could not find the time to do so.

Most instructional software purchased and loaded on the computers was ignored by most math teachers. They did not know what kinds of instructional programs and how many were in their computers. In general, the math teachers at Bill Hank appreciated on-site help despite the conflicts. The help offered from expert teachers, however, remained at a technical level like that at Putnam. None seemed to have an answer as to how to use one computer with so many students. This frustration became a common reason for the teachers' avoidance of instructional computing. The technology application project had little influence on instructional computing because the teachers received no meaningful training on using whole group instruction.

The avoidance of using classroom computers for instructional purposes revealed the power of the collective nature of the traditional lecture method. One computer with thirty students could rarely be used for instruction because of the assumption that students are supposed to be involved in the same activity, i.e., listening to the teacher. Unlike classes in writing, where project-oriented approaches are common, math has a relatively well-established procedure for classroom activities. According to Math Teacher's News, almost 98% of high
school math classes follow the established routine: review of homework, teacher explanation of new materials, and individual practice. Under these typical class activities students are supposed to be involved in the same activities: listening to the teacher or practicing what they have learned in the classroom.

Some math teachers, comfortable with the lecture method, do not pay attention to instructional computing even when they have access to hardware, software, and knowledge of computers. Often teachers want more computers and enough software for computer integration in their instruction. It was said that adequate hardware, software, and computer knowledge are preconditions for instructional computing. However, the tradition of classroom learning was so powerful that many teachers were reluctant to integrate computers into their teaching, even when such preconditions existed.

Teacher resistance to instructional computing was evident in the indifference of the "hacker" teachers to instructional computing. At Bill Hank, Mr. Keen, the chair, Mr. Friend, the programming teacher, and Mr. Gorden, a peer coach, all had the necessary preconditions for computer integration. The school staff considered them hackers. They all have computers at home and Mr. Friend and Mr. Gorden were responsible for helping the rest of the math faculty in setting up the project-generated classroom computers. Their classrooms were right next to, or across from, the programming lab which was idle three or more hours of the day.

Mr. Keen and Mr. Gorden were familiar with the math software because they selected it for the department. These three teachers had all the necessary conditions: the hardware, the software, and the knowledge of computers. Still, they rarely used the computers for instruction. During the observation period, the chair used the classroom computer only once in the calculus class. After finishing the lecture 10 minutes early, Mr. Keen showed the class how to use
Drive for the "gross part of the calculation." He thought that the proper use of the program was to check the students' answers. There were almost thirty students in the class and the program was hardly readable at the rear and one side of the class. Mr. Keen showed it briefly in the last minute of the class and he was little concerned with student complaints that they could not read the screen.

Mr. Keen thought that computer integration was a slow process that demanded teacher familiarity with the machine and personal extra effort. He made this argument:

Familiarity. Hopefully [the] longer they have [it], the more familiar [they will get] with [it]. I think that a lot of times that the teachers are hunting for a canned process of integrating things. I think that's what a lot of times we are looking [for]. Well, there is really no canned process out there. You can talk to a dozen different teachers that [they] used the technology in the classroom. And they probably used it in a dozen different ways. And what happened is that everybody's looking for something that will be easy for them to implement in their classroom. But, looking at what someone else's done, that doesn't mean that they are necessarily gonna work for them. So, the problem is that they've got to [come to] grips with how they can use this, when they can use this and be comfortable with that. Then, they are going to use it in the classroom. But, until then, and it may take a while in getting there. But, like I say, if you went back six years to Bill Hank and looked at the math staff as far as computers are concerned, most of them even didn't touch one. We [have] really come a long [in the] way as far as the staff [is] concerned. It may take another several years before we apply these in the classroom.

Although Mr. Keen realized computer integration demanded each teacher's endeavor, he would not find time to devote to it. Mr. Keen might need several more years to integrate the computers into his instruction. Mr. Friend, who taught programming courses and AP-calculus classes, did not consider computers useful in his calculus classes. He thought that, because of
more graphic applications, it might be easier for topic math and pre-calculus classes than AP-calculus to integrate computers into instruction.

The class procedure for these three teachers was typical: review previous learning by checking homework, lecture on new concepts, and require self-study for practice of the day's new learning. Questions students could not finish in self-study sessions became homework for the next class session. This procedure was repeated in almost every math class.

Mr. Keen, Mr. Friend, and Mr. Gorden were not benefiting from computer capability despite their considerable knowledge about computers, their proximity to the programming lab, and their involvement in purchasing software for the department. These teachers' attitudes contrasted strongly with Ms. Mayer's effort to integrate computers into her geometry classes. Although she was not knowledgeable about the computer itself, far from the programming lab, and familiar with only one program, she tried to diversify instruction by means of computers. These three teachers' and Ms. Mayer's cases brought into question the validity of the necessary and sufficient conditions for computer integration. Enough hardware, software, and familiarity with computers might be necessary conditions. These conditions, however, were not sufficient for computer integration. Teacher commitment to the value of instructional computing seemed critical.

The real stumbling block might be most teachers' dependence on the traditional lecture method of instruction. Mr. Perry, the math coordinator, agreed that math teachers at Bill Hank relied on traditional ideas about what to teach and how to teach. He thought that teachers at Bill Hank were higher in seniority and more inclined toward using traditional methods of teaching mathematics than were teachers at Putnam. Bill Hank's math teachers' adherence to the tradition of the department produced a strong resistance to any
change. As Dr. Perry commented, "The tradition works; so, why change?" reflects most teacher attitudes about outside initiations for reform.

Teachers did not recognize that their traditional teaching methods worked because of rigorous filtering. The traditional method that teachers are proud of was mostly for students in the advanced tracks leading to colleges and not for low-end students where the track does not consider college a post-high school option. Teachers take it for granted that this tracking of the math curriculum is appropriate instructional strategy. Also, the math department at Bill Hank is known for selecting math students for each track based on their social economic status, although not one math teacher admitted such a selection criterion.

According to Dr. Perry, math teachers at Bill Hank do not write recommendation letters for "poor" students beyond average math classes. Despite this discretion, the ideology the teachers adhered to was "ability"; others, such as "social economic status" and "race," were incidental ones and they can do little about them. The technology application project had little influence on traditional instructional methods and failed to address the ideologies underpinning the math curriculum. It neither questioned how the lecture method had worked nor presented how instructional computing would break the tracking foundation of the math curriculum.

**Teacher Priority: Textbook-Driven Curriculum or Math Application**

The project's goal of promoting the practicality of mathematics through teacher visitation to business and industries rarely altered the math curriculum. To understand the practicality of math in classrooms and in school structure, the meaning of math application to students and to teachers will be examined. In addition, teachers' view on the visitations and integration of such experience into their teaching will be discussed.
It seems that possibilities for math application rely on each student's interpretation of what he or she has learned in the classroom. Students, being a similar age group, often have similar ideas of what they consider practical. The interpretive nature of math application was revealed in Ms. Roberts' classroom. According to her, making math practical had been an issue inside and outside her classroom during her thirty-two years of teaching. She did not want to give her students the idea of math as something alien. Ms. Roberts saved one corner of the blackboard to present problem-solving questions to her students.

Ms. Roberts also believed that today's textbooks are more focused on practical problem solving. However, problems considered practical to the authors of textbooks are not considered practical by many teen-age students. For example, filling out tax forms or buying houses are not practical or real problems to many high school students. On the other hand, most students' eyes beam when the class talks about buying cars. Ms. Roberts asked the class to bring anything they wanted to measure for a lesson on measuring units. The boys brought pictures of girls and they enjoyed measuring them and converting their results to other measuring units.

As this extreme example depicts, the practicality of math is often a question how much a student can personalize the classroom learning. In this sense, making math meaningful to students is not so different from presenting other subjects in meaningful ways. The chairman of social studies said that, although he saw the need to make his teaching meaningful, he could not do this all the time because meaningful lessons demanded creativity and extra labor. One time Dr. Ray talked about the regions in the middle east and most of the students gave him the look that said, "Oh, sure. What does that have to do with me?" He got most students' attention by saying, "If you want to spend the rest of your life around Nicholasville Road, you don't have to bother learning this.
But if you plan to travel somewhere else in the future, this knowledge might come in handy for you." Dr. Ray admitted that such an effort "demanded" much of a teacher's mental and physical energy, and that he could not do it every time he saw the need.

Math application also requires students to attach personal meaning to classroom learning. Most teachers at Bill Hank, however, did not strive to accomplish this. Practical application of mathematics was not their priority. Rather, teachers attended to covering the textbooks. The characteristics of textbook-centered curriculum are strong in the math department of Bill Hank because of the school's emphasis on college preparation. Several teachers consider the textbook content to be "basic math" and their priority is to teach it. In this situation, it is not surprising that most math teachers at Bill Hank have a vague notion of the practicality of math. With math application being a secondary issue, teachers had ambiguous feelings about it.

During a lunch-time, Ms. Mayer shared her embarrassment when her teen-age daughter questioned the meaning of math in her life. Not having a persuasive answer to that, Ms. Mayer told her daughter, "You could help your daughter's homework, too." Although Ms. Mayer thought that her answer was not persuasive, she and other math teachers at this lunch could not come up with a better reason to learn math except for college preparation.

Such an episode, questioning the practicality of math, was not rare. Ms. Evans put a poster, listing the courses that the students should take based on their career plans, on her bulletin board because of students' frequent questioning of why they need to take math classes. Several students showed interest in the poster. A boy in algebra class said that he did not need to take the class because the poster did not list it for the lawyer he planned to be. Ms. Evans tried to persuade him that lawyers needed logical thinking and algebra
was helpful in learning it. The concept of logical thinking, although it has a critical value inside and outside the classroom, seemed too abstract for most students to understand.

Teacher visitations to business and industries might promote teachers’ awareness of practical math application. Teachers mentioned what they observed during business/industry visits when the students initiated the conversation. They, however, did not apply their learning from observation to classroom activities. Ms. Alley, who was second in the list of teacher visitation hours, made this admission:

I know I can tell them in general. But, I know that engineers might need to know this and this, whatever . . . I related back to my students. But, it’s not a concrete thing, may be. But, it’s intrinsic things, opposite to concrete.

The project goal of teacher visitations to business and industries confronted similar teacher resistance at both Bill Hank and Putnam. Although such visitations would give teachers an opportunity to learn how math was applied in the work force, teachers did not consider this learning as important. Many teachers thought that their job was to be in classrooms with their students rather than in business/industries learning about math applications. Teachers expressed their reluctance to leave their classrooms saying:

Going out during regular class times is ridiculous because it is our job to teach students.

Ms. Burt knew that many teachers at Bill Hank were not comfortable that they had to conduct project observations during the regular class times. She said that it was important for her to balance career and family life. Sometimes she had to take a day off because of family matters such as times when her children were sick. Ms. Burt wanted to save her possible absent days
for such a use. She did not want to leave her students to a substitute if she could avoid it.

Usually Ms. Burt did not know what kind of substitute she was going to get for her class. Sometimes the substitute did not know math. So, Ms. Burt let the substitute review the class. She often had to go back to the topic that the substitute had covered during her absence. She did not want to waste her students' time if it was not really necessary. Ms. Burt also talked about her colleague's devotion to the classroom teaching and the difficulty in leaving the classroom:

But, for others, like Susan, she was needed so much more here. She wouldn't go out shadowing even if she sees great benefit there. This morning, she threw up for thirty minutes before she came to school. But she was here in the school to give her kids practice for an AP exam tomorrow. To some teachers the shadowing refreshes the necessity of math and they learned the occupational use of math. It was refreshing. Susan's husband is a middle school teacher and it is easier for him to get a sub than Susan. So, he usually stays at home when their kids need a parent. She sees her needs here at the school [more] than out somewhere shadowing. Also, this year we adopted new textbooks that are lined up with New Standards; use more manipulatives, more problem solving, and integrated math. We are so busy learning the new textbooks. So, really we don't have much time for shadowing even if it is worthy to go.

Ms. Sutton, a peer coach of the school, also considered shadowing official rather than practical:

I'm not sure how much shadowing is going to bring as we are supposed to bring back to the math classes. Therefore, it is more official to me. I am more comfortable working here in school.

Although several teachers enjoyed the visitation, none of them transferred their observations to classroom activities. Mr. Friend was explicit in assessing his shadowing experience:

Once Mr. Gorden asked me to do shadowing together. Well, I had to do it anyway. So, we went out together. But, it turned out to be a good
experience. On the way back home, Mr. Gorden and I talked about how to use the computers in solving practical problems. But, in terms of applicability, like bringing problem solving questions to the class, it didn't happen. In this sense, shadowing accomplished nothing.

Like the teachers in Putnam, the 1991-1992 textbook adoption was the major reason teachers would not use shadowing experience in their classrooms. This reason reflects the power of a textbook-driven curriculum. Ms. Sutton was busy organizing the teacher association so that they could discuss what to cover or not to cover in a school year. Based on the discussion, the teachers would write the curriculum guide. Ms. Sutton was not alone in feeling she had no time for activities not related to the textbook. Other teachers were also occupied with the new textbooks and had no time to incorporate their observational learning into their teaching.

A textbook-driven curriculum demands teachers complete the textbook by the appointed time, leaving little 'extra' time for professional discretion. In this circumstance, the math application did not get most teachers' interests regardless of the intention of the technology application project.

Influence of the Divided, Individualistic Math Faculty Culture

It was the autonomous and individualistic math faculty culture that created the difference between Bill Hank and Putnam in implementation of the project. Faculty culture was shaped by a textbook-driven curriculum and the tradition of excellence in teaching textbook content.

Emphasis on covering the textbook also played a role in the division of faculty and in isolation of some math teachers. If teachers kept a slow pace, and if they did not make a fuss about who was going to be in their classrooms, they signaled to counselors that sending slow learners and problem children to them was okay.
Because of the polarized student population, and because of divided math faculties, resegregation of the department was apparent. The chair of the counseling department thought that it was the school's share of "bad" teachers who were with "bad" students. These teachers were the ones who were not involved in the project.

Ms. Roberts, the only black math teacher with 32 years of experience, was an example of such exclusion. She was alienated from the math faculty for various reasons. One reason is that Ms. Roberts does not cover the materials as others do. According to her, the counselors send her all the slow learners and problem students so that she can not speed up as much as she wants. Unlike the majority of the math teachers, Ms. Roberts believes that the important learning from her class is to learn general thinking skills so that students can apply them in various problem situations. Covering the textbook is not the primary concern for her. Ms. Roberts herself did not learn algebra II or calculus in her high school days. But, she did well in college because she knew how to approach problems. Her beliefs and personal experience are reflected in her classroom teaching. Ms. Roberts acknowledges various ways of approaching problem situations by thinking out loud. She said that although the SAT (Scholastic Aptitude Test) did not ask how to get an answer, students who can demonstrate the way to solve a problem will do well in college math.

The pressure to cover textbook materials is more severe than before. Ms. Roberts said that many authors of textbooks are not classroom teachers and they do not understand the compromised nature of the classroom. For example, the day that she was talking about the issue of covering books was prom day. Most of her seniors were gone and their absence affected the rest of the students. She could not pace her classes as she planned on days like this. School days contain several days such as prom day when students' minds are somewhere else.
Ms. Roberts also has a reputation among the district teachers for doing excellent work with at-risk students. She feels that she can easily approach a student when he or she was in her class and can let him/her talk about their problems. Ms. Roberts is "sick and tired" of her fame for being good with problem students. Until recently, when the scheduling was done by the computer, the counselors constantly sent her all sorts of problem students whom other math teachers were reluctant to take. Ms. Roberts thought that she did not have enough energy to deal with at-risk students all day long because she was getting old. She was one of the teachers at Bill Hank who stayed out of the project.

Ms. Roberts did not even know that there was a chance to earn the classroom computer. The exclusion of uninvolved teachers from the project was more apparent at Bill Hank than at Putnam because of Bill Hank's divided and individualistic math faculty culture. It was these excluded teachers who had taught the lower classes where the minorities, especially black students, were often found. Ms. Roberts's fundamental class was the only class at Bill Hank where the majority were black students. These teachers, however, remain outside the project benefit because they are not involved in the project implementation. As a result, the students in these teachers' classes have little chance to be exposed to classroom computers.

The individualistic nature of the faculty culture was shown in their attitudes about teachers not in the project. All the math faculties considered the distribution of the project-generated computers as fair. Therefore, blame for not having the computers should go to the uninvolved teachers. Most teachers agreed that they did not feel sorry for such teachers at all. Ms. Louis said that the computer distribution was fair because it was based on a criterion, not like the initial five computers that were distributed without criteria.
Ms. Mayer thought that the teachers who could not earn the computers were "jealous" of the teachers who earned them. She personally hates to visit other teacher's rooms and ask a favor to use the computer, especially when she wants to print out the materials. The noise that the printer produces interrupts the class.

The division in the department is deep enough for Ms. Roberts to know very little about the project. She had not heard about the project partly because she rarely had contact with other math teachers. She sometimes did not attend faculty meetings. Her isolation was severe enough that she asked, "If I visit business sites from now on, can I still get a computer?" after the computer distribution had been completed.

The divided math faculty culture had brought on the conflict regarding distribution of the first five computers. These five computers arrived in October 1991 at each high school in the district. They were given to teachers with a condition that teachers who earned classroom computers ahead of other teachers had to develop ideas for using them. They were supposed to show other teachers how computers might be used for instruction.

However, computer distribution at Bill Hank did not follow this procedure. The chair admitted that there was a conflict, although he would not elaborate on it. Mr. Adams remembered the conflict:

I know there is a lot of stink made by the teachers who got computers and there was a lot of fighting. That's what I heard and saw personally. There is a lot of [plans about] who got these five computers. Myself, I don't have to get involved because I don't even have my own room.

Although most math teachers did not agree with the distribution, their irritation was not powerful enough to alter it. Ms. Louis thought that the chair was unfair in giving the computers to some teachers without a clear explanation. Ms. Alley, who was the first in the project shadowing list in the district, had to
persuade other teachers that she was not angry just because she did not get a computer. As a recently transferred teacher, her priority was to get along with other math teachers. She did not want to make her acceptance by them any harder. Mr. Reed wondered why he did not get a computer when other teachers got one, but he decided not to pay any attention to that. Mr. Reed's attitude represented the rest of the math faculty who did not receive computers initially. The conflict in the distribution of the first five computers indicated the teachers' interests in the project. Although most math teachers did not care for the project's intentions, they wanted classroom computers; one computer in the classroom would be a convenience for the teacher.

In addition, the project-generated computers were a status symbol for math teachers. The competitive and individualistic faculty culture encouraged such a role. Most teachers were aware of this ramification. Mr. Adams said that:

If I have something that someone does not have, it's because I'm more important than they are. And it's a status symbol.

This awareness caused some teachers to want the classroom computers regardless of their instructional use. Mr. Reed, who was distanced from the rest of the faculty and not involved in the project, took the Apple II-GS computer—which was originally from Ms. Mayer's classroom—from Ms. Smith and placed it in his room. He admitted, however, that the computer was of little use because most software purchased, including the grade-keeping program, was for IBM and its compatibles. Teacher interest in control over the computers reflected their view of the project's benefits. Acquisition of classroom computers was an agreed-upon project advantage. The major project goal of increasing the opportunity for students from minority groups and for girls was not acknowledged by the teachers at Bill Hank.
The math teachers' protective attitude is evident when the central office tries to influence them. In the early phase of the project, the school's uncomfortable relationship with the central office brought misunderstanding. In the beginning, the math faculty was upset with the math coordinator because "the rules of the game" were not explained up front. They did not know that the project generated computers were to be awarded based on each teacher's shadowing hours. In addition, the math coordinator of the central office stated that teachers who had the project-generated computers first and had not done anything with them should return the computers to the central office so that other willing teachers would have them. This policy made some math teachers furious. Ms. Burt thought that this was another example of how the central office "sticks it to" the teachers at Bill Hank.

It so happened, however, that Bill Hank was not the only school that did not know the criteria for the computer distribution. What is more important, final distribution of the computers brought the satisfaction sought by most math teachers at Bill Hank. Seven more computers were awarded to the math department in March 1992, and all but three math teachers now have computers in their classrooms. The chair was content with the distribution. He thought that the math teachers somehow boosted themselves and did quite a good job. The teachers' attitude change regarding the computer distribution showed their protective behavior against policies that might hamper their interests.

Computer distribution in the department followed existing tracking patterns in math classes at Bill Hank. The original goal of the project—to release the filtering role of the math curriculum through technology and math application—was subverted. The project-generated computers were mostly placed in higher math classes that contained filtered students and were taught by powerful teachers.
Despite most teachers' indifference to the project other than gaining a classroom computer, there was a teacher who tried to integrate computers into her instruction. Ms. Mayer thought that it was her personality that made her different from other teachers.

Ms. Mayer: Her Initiative Personality to Pursue a New Method

Ms. Mayer had taught at Bill Hank for twelve years; she was second from the bottom on the seniority list of the department. Her classes were distributed evenly among higher and lower classes; pre-calculus was her highest class and fundamental math was the lowest. Ms. Mayer's zeal for instructional computing was well-recognized among other math teachers, although some teachers did not appreciate her effort. Her innovative attitude extended beyond the project implementation. Whenever there was a chance to make her class activity diverse for her students, she tried to do so. For example, before the project, Apple II-GS computers were available to Bill Hank teachers who submitted proposals on how they would use them for instruction. Ms. Mayer was the only math teacher who took advantage of this opportunity. Because the chairman valued her initiative, she had no problem in getting a project-generated computer.

Ms. Mayer tried to use the project-generated computers for instructional purposes. Sometimes her efforts brought her satisfaction, sometimes not. Using one computer with twenty-five or more students was a major challenge to her. First she arranged for her students to use the computer during free time: after the class or during a study hall hour. As a return, students got extra credit. This approach created a scheduling conflict. Students often came to the class when Ms. Mayer could not supervise them. Also, they came as a group, usually four or five, and they had a difficult time sharing the classroom computer. Providing computer experience in non-class time proved to be unmanageable
and afforded little benefit to students. Instead, she found a way to use computers in other teachers' classrooms and for display purposes.

Ms. Mayer was a regular user of Geometric Supposer in her Geometry class. She sometimes presented the program to the whole class by connecting the computer with the project-generated VCR with the 28" monitor. To do this, Ms. Mayer had to arrange the schedule with Mr. Gorden, a peer coach for the project, in order to swap classrooms since he had the necessary equipment. In the beginning of the class session, Ms. Mayer asked me to turn the front part of the classroom lights off. While she was exploring the characteristics of the isosceles triangle appearing on the monitor, her student teacher typed the keyboard following Ms. Mayer's cues. Ms. Mayer used the program for discovery learning. She let the computer discover the properties of the isosceles triangle for the class. Ms. Mayer said, "Let's check it out." "Let the computer do it." "If you wonder about something, let the computer find it for you."

During the class, Ms. Mayer encouraged her students to make guesses before the program presented any conclusions. She mentioned, "If that is perpendicular, give me some conclusions." There were readability problems when the program was used for the whole class instead of for individual instruction. It was hard to display the program to the whole class. Although the monitor was bigger than the regular computer monitor, it was still hard for the students in the back of the class to read. Some of these students lost interest and got involved other activities.

The program generated figures in random order. The placement of figures on the screen was not under a user's control. Sometimes an isosceles triangle appeared on the screen upside down. In this case some students had a hard time reading it. A student asked to have the triangle placed straight up, but that was not under Ms. Mayer's control. In addition, many times the figures
were not on the center of the screen but placed on the bottom or top. Such figure placements would not be a problem when the program is used individually. But, the random placement of figures affected the readability of the screen when Geometric Supposer was used for a large group of students. The program was not as versatile as a blackboard for assisting with unexpected students' requests.

One student asked the teacher to bisect the isosceles triangle from one of the equal angles to see if the bisector did not always produce a perpendicular angle. Since Ms. Mayer had already bisected the isosceles, the screen became too busy when she followed the student's request. Then, the student asked her to erase the previous bisector, but that was not possible. With a blackboard, Ms. Mayer could have easily erased the previous bisector and could have drawn the figures at the best spot where was the best spot for her students to see. Ms. Mayer's determination to try discovery learning with computers drove her to use the program continuously. She believed that, because Geometric Supposer offered unique learning experiences, it was beneficial for her class despite the difficulties. The more she used the program, the more she liked it.

Ms. Mayer also used Geometric Supposer for hands-on experience. A couple of times she tried to use the project-generated computers placed in other teachers' rooms. Before sending her students to other classrooms, Ms. Mayer distributed a memo that asked the teachers' permission:

On Monday, March 2, 1992 during 1st and 4th period, I would like to use your computer for an activity for my Geometry students. It is in conjunction with the Geometric Supposer. I would like to send 2 or 3 students to use the computer for about 25 minutes. If you prefer that we not use your computer please fill out the form below and return to me by the end of the day today.

teacher's name:_________________
Yes you may use it, considering it does belong to the school and not me!

No, it's all mine and no one else may use it so stay away. Thanks in advance for your cooperation.

In the memo Ms. Mayer emphasized that the classroom computers were to be used for instructional purposes by any teacher and they were not personal property. Mr. Gorden thought the memo was "cute" because it pointed out the teachers' false perception that the project-generated computers were their private possessions.

Ms. Mayer had to overcome managerial difficulties when she tried to use computers in other classrooms. Since the classroom computers were not networked, she and her student teacher had to move quickly from classroom to classroom to boot the program in a ten-minute break time. Such mobility was also needed during the class hour to provide the proper supervision with minimum interruption of other classes. Soon after, Ms. Mayer stopped trying to use the computers in other teachers' rooms mostly because it was too hard to prepare the class in several teachers' rooms.

The lack of other teachers' support was another reason for Ms. Mayer's discouragement. Although other math teachers did not express their reluctance openly, they made excuses for why their computers were not available except during planning hour. Teachers mostly mentioned that they also had to use the computers to pull out student grades when students asked for them. Mr. Friend thought that Ms. Mayer tried to use the computers to justify the fact that she was one of the teachers who gained computers in the first round of the distribution. A few teachers agreed with Mr. Friend; they viewed Ms. Mayer's efforts as justification of her "first turf" rather than for the sake of students.

Sometimes, Ms. Mayer used the programming lab. To use the programming lab, she had to check with Mr. Friend to avoid scheduling
conflicts. The programming lab is a two-room math teachers' workroom. These two rooms are right next to Mr. Friend's room and share the same entrance door. Also, there are big windows between the three rooms so that Mr. Friend can monitor the students in the lab while he is in his class. The physical configuration of the lab sets limitations on when Ms. Mayer uses the lab. She had to be extra careful so that her students do not interrupt Mr. Friend's class. When the class was small, Ms. Mayer preferred not to use the part of the lab that was right next to Mr. Friend's classroom. It was not comfortable for twenty or more people in the confined space. Ms. Mayer and her student teacher literally had to push the students to move around to provide the needed help.

Ms. Mayer's third hour geometry class was large; it had thirty-two students. This time Ms. Mayer had to use two rooms of the programming lab. Still, she fully used the lab that was one room down from the Mr. Friend's class and sent the rest of the students to the room that was right next to Mr. Friend's room. Ms. Mayer and her student teacher could not get out of the room that was one room down from Mr. Friend's classroom. She asked me to help the students in the lab right beside Mr. Friend's room. Ms. Mayer's extra caution reflects the ownership of the lab by the programming teacher, although few math teachers admitted that there were unstated regulations about using it.

The program Geometric Supposer was developed to give students a chance to explore conjectures. According to Dr. Bush, a director of the Math Education program at Limestone University and one of the advisors for the project, there are many things "given" and "proven" in math, especially in geometry. Geometric Supposer was developed to provide students the chance to explore conjectures. For example, if a line bisects an angle in an equilateral triangle, it also bisects the other side. This is not always true for other kinds of
triangles. Therefore, before the students prove anything, they should explore such characteristics and see if there is any rule to prove. This exploring step is what the mathematicians usually do and is a step that teachers do not have time to provide to their students.

In this regard, Geometric Supposer was made for discovery learning. It offers users intermediary steps such as what the students can prove in a given condition. The program is to motivate learners in an intrinsic sense by providing such an intermediate learning opportunity. The program is student-oriented, while the classroom is teacher-oriented.

The collective nature of classroom learning, however, modified the intentions of Geometric Supposer when it was used by Ms. Mayer. She incorporated the program into her geometry class to provide both cooperative and discovery learning experiences to the students. She used Geometric Supposer when she introduced "Pythagorean Theorem" in geometry class. Ms. Mayer was well prepared for the session. She wrote on the blackboard the materials to bring to the programming lab before the class. At first, Ms. Mayer introduced the theorem and explained the important concepts and terminologies. She emphasized that the class was going to discover the major characteristics of the Pythagorean Theorem through a lab activity. Cooperative learning was also pointed out: she told the students that they were going to help each other. Ms. Mayer handed out a lab activity sheet and homework sheet to the students. The students who finished the activity sheet within the allowed lab time were supposed to return to the classroom and work with the homework sheet. They worked in pairs in the lab.

Peer learning was accomplished in some of the pairs. A girl repeatedly and patiently explained geometric mean to her partner. In some pairs, one partner did most of the work and the other was busy copying the answers on the
activity sheet. One pair of boys finished the work early enough also to finish
the homework in the lab. A pair of girls sitting next to these boys became
frustrated when they could not follow the activity sheet. They were hesitant to
ask for help from Ms. Mayer and her student teacher because the teachers were
busy helping other classmates. The female couple could not finish the activity
sheet within the class time and left the lab in frustration. Ms. Mayer gathered
the activity sheets at the end of the session.

Ms. Mayer also used the same software for her third hour of geometry.
She asked me to a help because she and her student teacher were stuck in one
room of the programming lab and the students' demand for help was
overwhelming. The students who finished the lab activities early stopped
working with the program. Most of them were busy doing the homework.
Discovery learning did not seem to be a motivation for the students, although
the program was designed for such a purpose and the teacher tried to use it
accordingly. More important was that they, the teacher and the students, had to
finish the required work within the class time.

Later, Ms. Mayer agreed that the program would be better off when it
could be used in a relaxed atmosphere without pressure to complete a task in a
fixed time period. She said that discovery learning hardly happens in the
current school structure. Still, she could open the door for computer use for her
students: it was the first experience some of these students had using computers.
Ms. Mayer also hoped that she could be the role model to other math teachers
in integrating computers into instruction.

The satisfaction of knowing she provided new experience for her
students, and the recognition she received from her colleagues, were her reward
for all the effort she put into instructional computing. The reward was intrinsic
and informal. It was rarely official. Ms. Mayer thought that official rewards
are not for teachers like her who put "one hundred and ten percent" of their effort into classroom instruction.

Ms. Mayer was flattered when somebody in the department nominated her for the President's Award for Excellent Teachers. Upon reviewing the application form she was disappointed. The form asked for the number of extra hours she had stayed at the school and extra curricula activities in which she was involved. Ms. Mayer considers herself a devoted teacher, but she has other commitments to her family and it is not possible for her to stay at school late. In her mind, some teachers were more focused on outside classroom activities than on classroom teaching and they could easily get the administrators' attention. The outside criteria for evaluating excellent teachers were different from her conception of what it takes to be a good teacher.

Ms. Mayer's interest in diversifying her instruction went beyond the project implementation. Rather, it was part of her life. For example, she is a regular reader of The Mathematics Teacher. Whenever Ms. Mayer finds an interesting classroom activity she can use in her class, she stores the article in a folder for that lesson plan. How Ms. Mayer gained instructional video tapes also exemplifies her innovative efforts in classroom activities:

I have a satellite dish at home. One Saturday morning, I watched the College Algebra Program, I learned about it through TV Guide, and said to myself, "Why not videotape it 'cause it can be used at my classroom." So, I videotaped five of them in four weeks. But, about the end, the program said for more information call 1-800-LEARN. So, I called and found out that there are twenty-five tapes. I missed the rest of twenty tapes! I first asked Mr. Keen to purchase it. But, we are out of money and he suggested I talk to the librarian. I did and we purchased it. I informed other math teachers that the program was available for certain topics. But, so far, only one [has] asked for it.
Ms. Mayer's interest in new instructional methods would have continued with or without the project. Still, the technology application project provided her another chance.

On the other hand, by not explicitly showing relationships between the use of computers and changing the math curriculum from filtering traditionally under-represented students to encouraging them, the goals of the technology application project had little influence on Ms. Mayer's classroom. Ms. Mayer did not realize that the project-generated computers were intended to attract minorities and girls to higher math classes. She could not see the connection between the technology and motivating those students. In addition, race and gender problems were not teacher-oriented and little could be done because they were complicated problems.

In this regard, Ms. Mayer was not different from the rest of the math faculty. They believe that "ability" is the only criterion for higher-math classes. Ms. Mayer's case provides an example to display the project's missing link between computer integration and motivating minorities and girls to higher math courses. According to Dr. Perry, once he could provide computers for all math classes, honor classes as well as fundamental classes, minority and female students would also have a chance to use the computers. At Bill Hank the lower math classes did not have the project-generated computers because the teachers of these classes remained uninvolved in the project for one reason or another. The project's plan to emphasize math application for the recruitment of minorities and girls did not affect the existing math curriculum because the teachers paid no attention to it.

Ms. Mayer did not use computers in relation to real problem solving that she learned from businesses and industries. She was one of the few teachers
who enjoyed the shadowing experience. She thought that she learned real problem solving through shadowing:

I am interested in real estate appraising. I may become one in the future. Ms. Parker and I went shadowing together and it was really a good experience. We went to the court house to estimate the price of a house. You have to know when the owner purchased the house but we cannot find the purchase year. In the file, there was a picture of the house with the date printed. Jackie guessed that the date should be the purchase date. It turned out that she was right. It was real world problem solving. You have to use the cross reference and deeds. It was creative thinking. And I don't know whether we can teach such thinking in the school.

Ms. Mayer was not an exception; she talked to her class about her shadowing experience infrequently. She could not transfer her visiting experience into her classroom activities. She also had the problem of leaving the classroom to a substitute teacher. When her students complained that they could not understand what the substitute teacher had taught, Ms. Mayer had to review the session that the substitute teacher covered.

In summary, the technology application project provided Ms. Mayer another chance to diversify her instruction. Her use of instructional computing, however, was constrained by the prevailing school structure. The collective nature of classroom learning and the time limitations made it difficult for her to provide cooperative, and discovery learning to her students. Ms. Mayer could not benefit from the shadowing experience, either, because her priority remained with teaching the textbooks. She agreed with the rest of the math teachers that the minority and gender issues in the math curriculum were not teacher related. In addition, she could not understand how computers would be used to alleviate problems that are created outside school. In this regard, Ms. Mayer's case was similar to the discrepant teachers' cases in Putnam. Despite the discrepant teachers' values and efforts in instructional computing, the characteristics of the existing school structure overwhelmed their classroom teaching.
Summary

In this chapter, the implemented project at Bill Hank was examined. The project planned to change the district high school math curriculum from minorities and girls being eliminated from higher-level courses either by self selection or difficulty to one in which computer experiences increased motivation and understanding. Instead, established organizational routines and faculty culture massively influenced the degree to which instructional computer activities were implemented.

The math faculty culture at Bill Hank grew out of the history, community, and organizational routines of the school. Located in a prestigious part of the town, Bill Hank traditionally has done an excellent job in teaching college-track mathematics through the teacher lecture method to its middle and upper-middle class students. The school's affluent community has approved the traditional teaching methods. Parents always demand top performances from their children, and that expectation translates into educating them in the way their parents were educated. In this circumstance, computers have hardly been used for intended outcomes.

In addition, most math teachers at Bill Hank interpreted textbooks as "basic math" that must be covered within a school year and their priority was established according to this interpretation of the math curriculum. The intended computer use hardly received math teachers' attention because recruiting minorities and girls was not their primary concern. Moreover, intended computer activities for math application and problem solving demanded teachers' time to develop their own curriculum and lesson plans. Lack of time and absence of guidance on how to use a classroom computer for instruction also inhibited the accomplishment of the objective of the project.
CHAPTER IV

Instructional Computing in the Mathematics Department of Putnam High School

Community of Putnam High School

Putnam High School was established in 1958 as a rural school in the north end of the county. Historically the school has had a bad reputation; the school's location, the relatively low socio-economic status (SES) of the area, and its racial composition have influenced the school's public image. Ms. Beam, a math teacher, elaborated on the city's north and south divisions which have contributed to the school's image:

For some reason, people decide there is a certain part of the town they want to live in. And it happens to a lot of southerners because this weekend, my sister and I talked about the prestigious part of town and it is the south end of town. That's the way it is. I don't know why. But, people in Limestone think living in the south end of the town is the place to be.

The public's general notion of the north side's low social status was influenced by industry's movement during the sixties into the community's north end. Most enterprises in the county had located in the town's north end: Hughes Display Products, Lexmark, Square D, WABCO, Dixie Cup, and Proctor and Gamble etc. Although their presence was important to the town economically, the northern part of the town did not appeal to the public who sought a nice, quiet residential area.

The city's recent zoning ordinance also affected development of the community around the school. The ordinance restricted land use in the north
end to farming. The zoning ordinance and the intersecting interstate highways, which blocked the north end, encouraged development in the south and west parts of town. The city's development in a south and west direction brought the necessity of building new schools in those areas. Many school staff also mentioned the role of realtors in development of the schools. Realtors encouraged central office personnel to build new schools in that direction to compensate residents for high property taxes. Building a new high school in the county's south-west end to suit these moneyed interests resulted in redistricting.

Mr. Smith, the assistant principal, said:

There was redistricting three or four years ago and we did lose a couple of middle class black neighborhoods, off Georgetown Street and in that direction. They gave that neighborhood to Lawrence (the new school). We lost some black kids, middle and upper middle class and in return they shifted—we took some poor white neighbors. So, whereas we got fewer blacks, we got, I hate to say this—the quality of students was—we have more difficult students because their families are poor.

Putnam's loss of middle-class black students and increase in lower class white students intensified existing problems at the school.

The socio-economic status (SES) of the area also affected the school's reputation. Mr. Cochran—a business teacher involuntarily transferred to Putnam from Bill Hank eight years ago—mentioned that while many parents at Bill Hank were doctors and professors, parents at Putnam were mechanics and secretaries. Mr. Smith's comment revealed the socio-economic status of the community:

Most of the students are from the working class. Or, now to be called working poor. People are still at low or poverty levels and working a couple of jobs. Most of these families have a hard time. We have 30% of our students on free or reduced lunch programs. Maybe close to 40%. We do have some pockets of very nice neighborhoods, upper level middle class people. That population is down. It's not the primary group, we have the lower class economic groups.
In addition to serving working-class students, Putnam has historically been a school for the rural poor. School staff, in fact, talked about the history of the school:

It seems like an underdog kind of thing. Because when I first came here this was sort of out in the country and then they talked about Putnam being a farmer's school. They would joke and ask you "do your kids really drive tractors to school?"

When this school was first built, actually it was out in the country. A lot of farm area around here and a lot of kids from the north end are from the rural part of the country. So, they were less sophisticated, less wealthy, that kind of thing. As we have integrated, we've got more black students than other schools. We've got about 37% minority population. And other schools have 12 to 18, and 20%. So we have a far larger population.

The student families' low SES made it difficult for the school to attract middle and upper-middle class students. Most newcomers to the city wanted to settle in an area where their children could go to a good school. While I was visiting the school, my Bible class leader, a family doctor, bought a new house near the new high school (Lawrence) because he had heard that the principal of Lawrence hand-picked faculty members. This incident showed the interrelation between a school's reputation and the surrounding community.

As of the school year 1992-1993, the remaining minority population of the school was 41%. Although most black students at Putnam were from the neighborhood, not from the housing project, the large population of minority students also influenced the school's reputation negatively. The chair of the math department said about the public's image of the school:

When I first moved to Limestone, I was teaching at the University of Limestone (UL) as part-time [faculty] because there was no math opening 11 years ago. And when I applied to teach here, to teach in Bowling Green County, all the professors at UL said, "you don't want to teach at Putnam because of all the black students." So, the kids are mean. But, it
was the only opening they had that year. So, I got the job and so now, every time I go back to UL, every time I meet them, I tell them that it's ok to come here. We have a bad reputation. I don't know why. I think because there are so many black kids. And so, the general public always perceives blacks as bad and they are not. Some of my best students have been black.

The public see Putnam as "the blacks' school" and as a result expect it to have violence and discipline problems. Ms. Ellis, a math teacher, thought that the public's perception of the school was unfair because it was mostly based on the wrong image. Recently, one of her church members was going to visit the neighborhood to run an errand. So, Ms. Ellis invited her saying, "Why don't you stop by the school to see me?" And her friend questioned, "Oh, they are not going to stab me in the back?" Probably Ms. Blue's comment summed up the public's prejudice of the schools in the north end of the town:

When I first came here, I was very impressed. I don't know if you hear the rumors and things around the town about the schools in the north side. I was so excited when I got my first job at the junior high school near here. So, I told everybody, "I'm going to Williamson." And they say, "Oh, you poor thing." And they had me scared. They made me think that I was going to be frightened to turn my back cause somebody might pull a knife on me. But, that's the way the community talked about Williamson. When I came there and I thought, "This is just a school." You know, they were normal kids. And the kids here, too. I am really pleased with Putnam. And if my children decide that they want to come to high school here, they are supposed to go to Lost Creek, I think I'll let them come here instead of Lost Creek. The community doesn't see what really goes on here.

The school's bad reputation affected its schooling. First, it appeared to have a lack of community support. School staff agreed that, unlike other schools in the district, they could not secure financial support from local businesses and from parents. The assistant principal said that:
It seems that it is parents who are not equal. Some schools have parents who put extra money into school. So, there is quite a disparity. We are quite sensitive to that.

The lack of parental support influences the emphasis of schooling at Putnam: more time goes to parenting than to academics. Besides teaching, teachers have to help students overcome problems that they bring from outside the school.

Mr. Smith's comment made this point about schooling at Putnam:

Education is a small part of what we do. We're kind of a social service agency. We have the school nurse, we have counselors, we have a free lunch program. We recommend students go to the public health department if they are ill. We have 20 or 30 here at any one time who are pregnant and they are worrying about their child. We have 20 or 30 more who have a baby. So, that kind of difficulty. It is hard to tell the child to pay attention to subject matter when she has to worry about who's keeping her babies. So, it's all of these complicated factors in the whole—in the real world that they bring here and that distracts have them.

In this atmosphere, Putnam might not emphasize academics as much as the staff wishes. Among the district's high schools, the school had the lowest average on the state-wide new performance evaluation test. Unlike at Bill Hank, counselors at the school do not focus on sending students to prestigious colleges. Instead, they encourage their students to have more job training opportunities so that they can "function properly" in society. The chair of the counselling mentioned:

We don't think that the most important thing is to go to Harvard University. I think that we feel like that it is important for the students to have some kind of feel when they leave here, even to go to work, some type of vocational/ technical program or to go to colleges. Basically, we don't try to emphasize college over other things.

Approximately 60% of Putnam students move on to higher education, including technical programs.

The lack of parental concern about their children's school life affects math classrooms. Teachers have to spend more time controlling students than
teaching the subject. Often, teachers are distracted by non-academic issues and have less time to teach math. In addition, the public's negative image about Putnam perpetuates the status quo. Ms. Graham, the black woman principal, tries to change the school's image by emphasizing a traditional high school concept. So far, her efforts have not encouraged upper-middle class parents to send their children to Putnam.

As we have learned, the history of Putnam presents a sharp contrast to the history of Bill Hank. Recently, equality in the district's public schools has been questioned in relation to overcrowded classrooms in some schools (Ward, January 25, 1993). Parents were, however, not willing to move their children to less crowded schools. Instead, they insisted on "parent choice" which would jeopardize desegregation of public schools. Recent crowded classrooms suggest that the district has not monitored desegregation over its 20 years of implementation. As a result, some schools have over 50% black students while other schools have 5% or fewer minority population. If we believe that people's actions are worth a thousand words, this episode indicates the public's perception of equality among schools in the district.

How did the different history of Putnam affect the technology application project? First, the school's broad interpretation of academics allowed some math teachers to do more with the project. Math teachers at Putnam were less pressured to go over the textbooks thoroughly and competitively. Second, the project provided a chance to reflect on assumptions about the public's recognition of schools. It showed how often the public judged the school by the surrounding community and by the students' performance on the state-wide/nation-wide tests. In this regard, a few students who go to selective colleges improved the school's image even though they could by no means represent the whole student body.
It is common for the public to interpret academic excellence as high test scores. This interpretation influenced the implementation of the project by setting the tone of classroom teaching. Most teachers define subject matter knowledge narrowly on textbook content where most of the test items were focused. Ironically, the public demand for better education often calls for inclusion of technology in the curriculum. However, their interpretation of better education as assuring higher test scores ignores the innovative use of technology.

The technology application project was not an exception. It included computers and other technology to encourage changes in the mathematics curriculum. However, the strong teacher notion of what is proper mathematics in the classroom became one of the stumbling blocks in accomplishing the planned changes.

**Mathematics Department**

Putnam has well-united math faculty. There are thirteen math teachers, all certified in secondary math with an average of fourteen years or more of teaching. Seventy-seven percent have a master's degree, several have rank one and more.

The math teachers agreed that any disagreements or differences were accommodated through compromise. The chairwoman’s leadership and fair policies in student scheduling appear to provide an important basis for the harmonious nature of this faculty. Unlike Bill Hank, Putnam offers a substantial number of average and lower-level classes. The chair has a strict policy on teacher rotation into lower-level classes. In the 1992-93 school year, the chair had two lower level classes.
Sharing the lower level classes plays an important part in uniting the faculty in two respects. First, the class schedule is planned so that no one feels isolated or ignored. One of the primary concerns of the teachers is who was going to teach what in a school year. Second, lower-level classes provide a shared experience for math department faculty. Each knows what teaching lower classes entails. According to the observations at the both schools, when a certain group of teachers is constantly in charge of lower-level classes, the department becomes divided. Establishing a commonly shared reality provides the basis for meaningful communication among math teachers.

The recent integration of ninth graders into the high school program revealed the climate of the math department. The math department of Putnam had a high teacher turnover rate. Seven out of thirteen math teachers had been in the school less than three years. The new teachers were satisfied with their move to Putnam. Mr. and Mrs. Blue moved to Putnam with the 9th graders. Mrs. Blue felt welcomed when the 'old' faculty took her out to lunch and presented her with school materials displaying the school logo. Ms. Beam, who was a chairwoman at her previous school, also felt good about her transfer now with more mature students who were focused on their education. Mr. Ison was the least experienced transferred teacher. Although his classroom was a part of the former gymnasium, he felt that the math faculty was a team. He said that:

We all are different. Shana sticks to pen and paper method while Mike thinks that is obsolete and he advocates graphic calculators. Betty shows step-by-step procedures of doing math while I acknowledge different ways of solving problems. But, we all appreciate our differences as long as we can express our differences without threatening or hurting others.

Mr. Ison and Mike have frequent robust discussions in the math faculty lounge, and other math teachers do not hesitate to join the fray. A recent argument was about the L.A. riot and the Rodney King verdict.
There seemed to be agreement on what teachers would discuss. They would argue over nonschool matters and issues not related to teaching. Teacher style or philosophy of instruction was rarely discussed by the teachers. Solidarity of classroom teaching prevails in the math department of Putnam, just as it does at Bill Hank, although math teachers there hardly argue about anything.

The math faculty at Putnam relied little on help from the central office. A recent episode regarding the new math lab showed teacher distrust of central office personnel. The chairwoman and Ms. Vine wrote a proposal for the new math lab to serve as a resource to the technology application project. Not knowing what to do with the proposal, the chairwoman sent it to the educational technology coordinator at the central office as Dr. Perry recommended. The chair and Ms. Vine heard nothing further about their proposal. Instead, they received twenty-five IBM AT computers with five and a quarter-inch drives. The teachers said that the educational technology coordinator negotiated with the people in the IBM Company to "dump" the computers on Putnam's math department. These out-of-date computers had been stored in a warehouse since the company updated its office computers for employees. Eight of the computers did not work because they had been damaged during delivery; the rest of them were usable after the installation of graphic cards.

The chair's request for a full-time resource teacher and reduction in some teachers' class hours for management of the new math lab was not granted. Ms. Vine was upset because no explanation was given from the central office of how the proposal was used to get the hardware. She cited this episode as an example of how teachers' work is treated by central office administrators. Teachers are "underestimated" by the work they do and by the pay they get. She wanted to know what had happened to the proposal after it was sent to the
central office. This episode seemed to be relevant to discussion of the technology application project implementation because it shows the relationship between the central office personnel and classroom teachers. The lack of appreciation for each other's work made change difficult when one party wrote the plan and another party was supposed to execute it.

How did a unified math faculty affect the project? The chair successfully pushed most math teachers to visit businesses and industries. The math faculty was also well informed about the project. However, it is a different story as to whether or not the teachers carried out the project as planned. Before this paper examines the project as implemented in the math department, the school's general atmosphere of instructional computing will be discussed as to its influence on the project.

**Instructional Computers in Putnam**

Because of the high school structure, instructional computing at Putnam occurs in a departmentalized fashion. Subject matter as taught in the high school curriculum is specialized enough to be managed by departmental units. Each department is independent because the subject matter coordinators in the central office control funding for the departments and they set departmental policy, including policy on the use of instructional computers. Subject matter teachers are considered "semi-experts" in their areas. Under this structure, school administrators seldom intervene on issues such as computer integration into each department. Rather, as the assistant principal put it, the school administrators give as much freedom as possible to teachers so that teachers can try what has potential for their students.

Little intervention by school administrators is evident in the absence of any policy pertaining to instructional computers at the school-building level. At
best administrators checked the number of computers in the school building for insurance purposes. The lack of local administrators' intervention provides a window through which we can see the power among departments in controlling scarce resources such as computers. Unequal distribution of computers among departments could be an indicator of a department's status. The following is a table of the number of computers in each department.

Table 2 shows that computers are distributed mainly to the business, english, and math departments. The distribution pattern reflects the difference in funding for computers among the departments. It also points out the way that the computers were integrated into the school curriculum. Computers were mostly integrated as independent subject matter. Programming, word processing, and database were taught in high schools, and Putnam was no exception.

The knowledge taught through such subject areas was different, though the courses were about computers. While students in the programming classes were learning how to control the computer through programming, students in business classes learned how to use word-processing and database software. There is a pattern related to gender when these elective classes are examined against students' tendencies to take particular classes. At Putnam the ratio of girls and boys was almost even; it was 49 and 51. It was hard to tell whether there was a pattern by gender in students taking programming classes at Putnam. However, the assistant principal and the chair of the business department agreed that the girls were the dominant population in the business classes. My observations of the word processing and the database class supported their comments. Based on the teachers' comments and the observations, it was fair to say that there was a gender difference in levels of computer knowledge, as reflected in the composition of Putnam's classes.
Table 2: Number of computers and staff in each department (March 1993)

<table>
<thead>
<tr>
<th>department</th>
<th>staff</th>
<th>computer</th>
<th>brand</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>art</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>business</td>
<td>6</td>
<td>26</td>
<td>Tandy</td>
<td>business lab.</td>
</tr>
<tr>
<td>experience based</td>
<td>1</td>
<td>1</td>
<td>IBM</td>
<td>EBCE room</td>
</tr>
<tr>
<td>career Ed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>17</td>
<td>23</td>
<td>Macintosh</td>
<td>writing center</td>
</tr>
<tr>
<td>foreign language</td>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>home economics</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mathematics</td>
<td>13</td>
<td>20</td>
<td>IBM286</td>
<td>programming lab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>IBM-AT</td>
<td>math lab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13*</td>
<td>IBM286</td>
<td>classrooms</td>
</tr>
<tr>
<td>music</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE/health</td>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROTC</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>science</td>
<td>10</td>
<td>2</td>
<td>Macintosh</td>
<td></td>
</tr>
<tr>
<td>social studies</td>
<td>12</td>
<td>3</td>
<td>Apple II-GS</td>
<td>workrooms</td>
</tr>
<tr>
<td>special Ed</td>
<td>11</td>
<td>8</td>
<td>Macintosh</td>
<td>classrooms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>IBM compatible</td>
<td>classroom</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Apple IIc</td>
<td>classroom</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Apple IIe</td>
<td>classroom</td>
</tr>
<tr>
<td>technical education</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total number</td>
<td>90</td>
<td>118</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* computers from the technology application project
Besides the integration of computers as elective courses in the curriculum, Putnam was very active in instructional computing because of the contributing teachers. The director of the writing center and a special education teacher devoted their time and efforts in instructional computing. Their initiative earned recognition from school administrators and from other faculty members.

Putnam was the first school in the county to have a writing center. The center was located next to the library for students' convenience for research. The proper combination of funding and dedicated teachers seemed to be the key to the writing center's success. This combination helped the systematic planning and management of the center.

Unlike other computer labs in the school, the writing center started with a full-time director. The director had to justify the usefulness of the center to the school and to central office personnel because the use of computers in the writing was new to the high school curriculum. Initially, the director researched the most suitable equipment for the center by attending a technology conference and by visiting a neighboring county school. After the lab was established in 1990-1991, she advertised the center to faculty and kept a log of its use. Each school year, she developed a report of the total number of student users, the hours of the center's use, and results of a survey for further improvement. The full documentation was important for continued funding.

The lab has adequate human resources to meet student needs. Besides the director, the writing center had a class teacher, and a resource teacher. Resource teachers from the English department had an extra hour of released time. They willingly gave up their planning periods so they could help students in the center. The pro-activeness of the director and the resource teacher's dedication gained the other school staff's recognition. The chair of the
counseling department proudly commented that she could find students working in the writing center after the school:

It was yesterday afternoon, about four o'clock. I saw a light coming out of the writing center. There were almost twelve kids working with the computers with a teacher. I couldn't believe that kids were working at the writing center at that time! So, I really think strong teachers with more materials and more money will make the difference.

However, as the chairman of the social studies department at Bill Hank predicted, the director position was the first to be cut in times of tight budgets. All the resource teachers also had to return to their classrooms in the 1992-1993 school year. The school could not afford extra release time to support the center. Still, teachers' devotion to the center did keep two helpers in the center.

The cooperation of the English department's resource teachers is an example of the importance of teacher commitment to the integration of computers into the curriculum. They found a way to bypass school policy in order to run the center smoothly. The principal and other school administrators appreciated the teachers' willingness to give up their planning time in order to help students at the center. The dedication of the writing center staff seemed to influence other department teachers. It influenced the original configuration and justification for a new math lab.

Ms. North, a special education teacher, was also an active hacker at Putnam. She led an extracurricular activity called "Mac Users Group." Ms. North and another teacher in the department got a grant from a local computer store. The grant provided them with a training opportunity so that they could become certified to repair Apple II family computers.

Ms. North taught how to repair Apple II computers and accessories. The class was small. It had five boys and they were good at fixing computers. During my observation, they fixed a printer from the writing center and they
were working on two Apple II-GS computers. Two junior students would remain in the next year's class to help the teacher. Ms. North's class was responsible for fixing all the Apple II computers in the county. Although Ms. North questioned the usefulness of the old Apple II computers, she admitted that the county saved money through her class service.

The special education department was active in getting computers. They gathered Kroger receipts and sold candies to raise fund. Ms. North seemed to benefit from the fund raising partly because of her willingness and partly because of other teachers' indifference. She had one Apple II-c, one Apple II-e, one IBM compatible, two Mackintosh computers with the picture scanner and the extended hard drive, and two printers.

The way Ms. North earned the classroom computers reflects the flexibility of the central office and the department. The IBM compatible was her first computer. She got it by just one phone call to a lady at the central office. Recently that lady retired and nobody knew that Ms. North had the computer. One Mackintosh computer was borrowed for several months from a fellow teacher who has not asked for its return. In the near future, the department is to get a new Mackintosh computer. Mr. North said to the department chair, "Look, I know that I'm greedy. But, I've got to have that new one for my class." Ms. North thought that her "greediness" was accepted in the department because of her hard work. The faculty knew that she gave up her planning hour and she worked after school for computers to use in her class. Ms. North's case shows that teacher initiative can reap rewards, especially when other teachers are indifferent. Forwarding teachers' prestige was justified by their extra work.

In summary, instructional computing at Putnam was similar to that at Bill Hank. It occurred in a departmentalized fashion and the absence of school-wide
policy allowed for unequal distribution of computers among departments. Also, computers were not integrated to the school curriculum as much as added to new classes. Girls were apt to gain access to computers through word-processing and database classes.

On the other hand, Putnam had motivated teachers who put great effort into using computers in classroom instruction. It seems that their efforts went beyond their classrooms. Ms. Vinsand claimed substantial usefulness of computers in writing across the curriculum. Ms. North was involved in extracurricular activities to teach students how to develop simple instructional materials using Hypercard. In addition, she took the responsibility for repairing computers in the district. In this regard, their devotion was distinguishable from other teachers' efforts that remained within their classrooms. These initiatives by Putnam teachers influenced the general school atmosphere concerning the instructional computers. In a way it affected the math faculty trying to have their own computer lab as a source for the technology application project.

**Technology Application Project at Putnam High School**

The implemented technology application project at Putnam and Bill Hank shared much in common because of similar school structures. At the same time, the project at each school reflected the climate of the mathematics department and the school.

The district math coordinator had high regard for math teachers at Putnam because of their cooperation. They were in the top 50% of teachers on the shadowing list. The math department chairwoman's leadership played a key role in teachers' cooperation. In addition, the school's interpretation of curriculum as more than preparation for colleges allowed some math teachers to
risk innovative instructional techniques. The loose boundary of what to teach in the class gave a few teachers a little more latitude.

The school's proactive atmosphere toward instructional computing and the chairperson's efforts also contributed to establishing a mathematics lab in 1992-1993. One of the goals of the lab was its use as a source for the technology application project. The teachers' use of the lab provided valuable data in discussing the conditions sufficient for computer integration into the mathematics curriculum.

There were many similarities between Putnam and Bill Hank in how teachers interpreted the project. The project influenced little in most teachers' classroom activities. On the other hand, we can learn from the project's small success by examining its assumptions. We can see what aspect the project emphasized and what it undermined to bring changes to math classrooms.

The project assumed that instructional computing would be practiced once teachers had classroom computers. The teachers also would emphasize math applications when they saw how mathematics was used by today's job force. The emphasis on math application and instructional computing as a way to diversify teaching would motivate minority students and girls to pursue higher math. As a result, the filtering role of math curriculum by gender and race would weaken.

These assumptions reveal that the project viewed changes in math curriculum only as a matter of providing necessary resources and information. Although these might be necessary conditions, they are not sufficient to bring changes in high school math classes. Instead, the assumptions of the project ignored the organizational structure in which the project was to be executed. By ignoring the school structure, the district math coordinator failed to contextualize instructional computing and math application within high school structures. The
decontextualized issues gain little of teacher interest. Teachers interpreted the project based on the school structure, while Dr. Perry's main interest was to manage the project as planned.

Conflicting interests between Dr. Perry and local teachers became apparent during implementation of the project. Teachers at Putnam did not believe the district math coordinator understood their classroom life. They said that:

The math coordinator doesn't understand classroom problems because he's so far away from the school. He just came for an hour and he thinks that he can solve the problems.

He (math coordinator) stayed with 7th and 8th grades. I've heard that while he was a teacher, he did not impact on students. He had discipline problems. He won't understand the problems. But, he's nice. He always brings new things that we should do. But, he also has so many things to do. He has to cover the middle and elementary schools as well. These days he's busy with performance evaluation in elementary and middle schools. But I don't think that he has solutions. He was here in my 5th hour. He walked around the class and helped the students. But, he could not control the kids.

Unlike at Bill Hank, the teachers' general attitude toward the math coordinator was not hostile. The chair valued the math coordinator's hard work and his inclination not to boast about his own work. It was the general tendency, however, for teachers to disregard the changes planned by outsiders. Such an attitude was expressed in the following teacher comments:

All changes were planned by the state and "experts and legislators" who do not have teaching experience and who have little time to come here and understand what we are doing. Experts from universities and researchers don't understand what we are doing here. So, such movement is unreasonable to us and we expect little from such movement.
Central office people come up with ideas and solutions for places in which they don't have a feel for what's going on.

This chapter will examine the teachers' viewpoints regarding project goals and policies. Then, discrepant teachers' cases and the factors that made them different from the typical teachers will be discussed. Finally, the project's ramifications will be examined.

Issues in the math class: The gender and race pattern vs. apathy

The project's main goal was to alleviate —by math application and by technology— the gender and race pattern in higher mathematics classes. Though most math teachers at Putnam mentioned the gender and race issue as project goals, they did not attach much significance to them. The math teachers unanimously mentioned that they did not notice a pattern of students taking math by gender. The chair, who had taught calculus for years, said that girls were the majority as well as the leaders in the class.

However, regardless of this fact, many teachers believed that boys were more discovery-oriented and inquisitive, while girls were more organized and task-oriented. The chair said she noticed boys performed math adequately in industries even when they had not taken calculus in high school or in universities. Boys could do math because they had "curious minds." Mr. Flack thought that boys were better off in dealing with three-dimensional matters because historically, men had to make sense out of such matters to conquer nature. From teacher comments, one can infer that gender differences exist in most math teachers' minds, even though teachers do not notice a pattern of mathematics by gender.

Minorities, especially blacks, were noticeable in the lower-level classes. There were few blacks in the higher-level math classes. Most teachers, however, did not consider this a pattern based on race. Rather, they considered
the minority issue a complicated problem. It was intertwined with the social economic status (SES) of student families and home environment. Therefore, it was hard to tell that there was a pattern based solely on race in the mathematics classes. The math teachers agreed unanimously, though, that there was a pattern in the math classes based on SES.

In addition, the home environment was important for children to move on to higher math. If parents themselves had never learned algebra and thought their children taking such a course itself was amazing, or if they put no value on learning algebra, it became hard for the teachers to push students into higher math. The teachers said that middle-class blacks could do math as well as any race. If SES and home environment were such important factors for the students to move into higher math and if there were more blacks in the low classes than in higher ones, it can be inferred that many blacks were from low SES with poor home environments and were not "school-smart."

Recent redistricting may have affected math classes. The school's staff thought that they had lost good black student leaders and this loss affected the school climate. The loss of middle-class black students may also influence the racial mix of students in math classes.

The project goal failed to gain the teachers' attention because most teachers did not believe that there was a pattern to math classes by gender and race. However, many teachers perceived that boys had better minds than girls for higher math. In addition, there were more black students in lower classes than higher ones. Teachers did not pay attention to racial pattern because it was a complicated problem. Gender and race bias was not acknowledged as a classroom problem, although such biases existed in teachers' minds and were reflected in classroom enrollments.
Did the math coordinator see the race and gender issue as important in the district high school mathematics curriculum? According to him, the gender and race issue was mentioned as a project goal primarily because of the criteria for National Science Foundation funding. The gender and race issues were "gatekeepers" for awarding the grant and these agenda had to be spelled out in the written project regardless of the real intention of the project. It would not be surprising, then, that the project brought little change regarding gender and race patterns in the high school math curriculum.

On the other hand, it would be worthwhile to examine the issues raised by teachers because such issues reveal the characteristics of the school organization. Most math teachers named "apathy" as the uppermost problem in their classes. Some said "lack of time," "discipline" was the uppermost problem, while "apathy" was the math teachers' common problem. Mr. Allen, who had taught at Putnam for 28 years, said that:

The project is a waste of money because it is not related to the problems here. The biggest problem is apathy, the kids' attitude toward schooling, and huge paper work in every day. I can deal with the drug, family, teenage pregnancy problems. But, I can do nothing about the "don't care" attitude and I can't stand it.

The chair thought that student apathy was the general attitude problem that made teaching so hard. Apathy was not a specific problem related only to the lower-level math classes and to Putnam. It was a general school climate problem that could be found in all classes including her calculus class. It was discouraging to the chair to see that only two girls in the calculus class took notes.

The worst aspect of the "real" problem was that teachers did not believe there was a cure. Some thought that apathy is never treated in top-down projects like the technology application project because state and central office
personnel do not have the solution, either. Some believed that high school education should not be compulsory. Some math teachers thought that high school entry examinations might alleviate the problem. Others thought that a different curriculum, e.g., job skills, should be available for lower-level students. Most math teachers did not believe that all students could do algebra. The chair said:

I used to think that everybody can do math if they want to. But, I have learned that not everybody can. Simply they don't have the ability to do it. I know that the academic people say that anybody can do math in the articles and I don't believe them.

Ms. Vinsand's comment described the student attitude toward schooling:

Most students don't connect education with their future. All, even the low end, want to have a bright future with marriage with nice jobs. But, they don't correlate their future with education. Nobody wants to be garbage men even [though] their pay is good. But, they don't understand that they have to work hard in order to have a nice job. They don't understand that they should work at certain levels in order to go to college.

In summary, apathy was the general and chronic problem which made most math teachers feel helpless. Teachers did not believe that math application and instructional computing would change students' attitude in mathematics classes. Even the dissenting teacher, Mr. Flack, who had earned a reputation for diverse teaching in math application, felt his teaching suffered from such indifferent student attitudes. Apathy reflected the involuntary nature of schooling. The indifferent attitude of the high school students seemed to be hard to deal with because many students considered themselves adults who need little guidance from teachers. In classes where teachers had to wrestle with students' "I don't care" attitude, the gender and race issue rarely received teachers' attention.
Low Math Classes and Math Application

Since the project goal was to encourage low-level class students to move into higher math through math application and diverse teaching, it is important to look at the characteristics of the low math classes at Putnam.

A noticeable aspect of the low math classes was the teacher's different notions of students. Mr. Owen jokingly said that they were a different breed of animal. In the math faculty lounge, teachers agreed that they could not allow different ways of doing math for fundamental class students because innovative techniques would confuse students. Instead, teachers had to repeatedly show specific ways of solving problems. It was common for Mr. Owen to repeat the page number for the day's work four or five times. Students did not listen to him and later complained that they did not know which page they should be on. The substitute teacher told me that it was hard to work with students who did not have their own work ethics. It often made her angry because they did not consider it their responsibility to learn something in the class. She often negotiated with the students by having them study for 20 minutes and then letting them talk to each other as long as they did not interrupt the rest of the class.

Mr. Ison's fundamental class had the largest number of students. He had 32 students but usually one third of them were absent for various reasons. His style was not straightforward because, according to him, it did not fit with his personality. He allowed his students to chew gum in classes and he tried to encourage various ways of doing math as often as possible in all the classes. He was upset, however, when a student refused to work because he or she did not bring the book or a piece of paper. Such an episode was common in low-level classes.
Often students in low-level classes asked for personal attention that was impossible or exhausting for the teachers. Teachers said that they could not pay personal attention whenever asked because they had to deal with a group of students. The problems in low-level math classes were intertwined with social problems and, if dealt to any effect, it could not be defined solely in terms of technical issue. Many students in such classes had personal problems as well as discipline problems. Ms. Ellis, who voluntarily remained with the low-level classes, said that:

My kids are from the low socio economic class and their parents are not supportive. In my pre-algebra class eight out of 20 students are from single parent families. Also, these kids live with a mom, aunt, or grandma, are rude to them, and treat their teachers in the same way when they come to school.

Ms. Judd, who has been teaching at Putnam for 17 years, has similar opinions. She said:

Some kids are from single parent families. For example, the mom has two jobs and she is not available to kids because she is too busy. Father, who knows where. Moms are not around their kids because they are intimidated by their kids. All such problems come back to class.

It was common for teachers and students to have difficult relationships in the low-level classes. It may be more important for teachers to be creative and sensitive to students' needs because of their low motivation toward learning. However, because teachers deal with 25 students' needs at a time, they have little time to think about math application and different methods of teaching to motivate such students. Instead, these teachers were primarily concerned with managing the students as a group. The attitudes of these teachers influence instructional computer use that will be discussed in a later section.
Some teachers mentioned that the project was not for low-level class students because low-level class students learned arithmetic, not mathematics. Mathematics ideas start in algebra. But in the low-level classes such as fundamental math, consumer math, general math, applied math, and pre-algebra, students mostly study arithmetic. Students in these classes were not the target group for the project. Computers and other technology, such as the graphic calculators, were better used with mathematics concepts than with arithmetic concepts. In addition, most industries observed for math application used higher math ideas.

Along with the content of class work, managerial difficulty in the low-level math classes rendered issues such as "math application," or "instructional computing" trivial. The project's benefit was greater in higher math classes where students were disciplined enough to try diverse methods, where contents were sophisticated enough for computers and graphic calculators, and where teachers were powerful enough to bring new resources into their classrooms.

In summary, teachers were not interested in the project's stated goals. They felt those goals were not related to their classrooms' circumstances which were mostly shaped by the school culture. The density of the classroom and involuntary nature of public schooling made it hard for math teachers to realize the goals of the project. Instead, the teachers' indifference showed the ideological difference between the district math coordinator and the local teachers. The different interpretations of the project became evident after Dr. Perry started asking for teacher involvement. In the next section, teacher interpretation of the implemented project will be examined.
Peer Coaching and Lack of Guidance in the Use of Classroom Computers

The technology application project had two distinctive aspects. One was teacher training so that the teachers could be competent to use computers and graphic calculators in the classroom. The other aspect was the emphasis on math application by observing the use of mathematics in business and industry.

Peer coaching was a major strategy for training teachers to be technology competent. Plus, teacher inservice was conducted by the district central office. The aim of peer coaching was to train intensively two teachers from each high school so that they could be role models for integrating technology into classrooms. At Putnam, Mr. Johnson and another teacher who transferred to the new district high school volunteered to participate in the training. Ms. Beam later replaced the transferred teacher. These teachers volunteered in an effort to help their over-burdened department chair.

This school year, both volunteers were responsible for other projects. They were not especially interested in integrating technology into classroom instruction. It was not surprising, then, that the actual role of the peer coaches was insignificant throughout the project implementation.

What appeared more important than the motivations of the volunteer teachers was the lack of knowledge. There was no specific guidance regarding the integration of computers into classroom instruction. Mr. Johnson showed faculty how to use graphic calculators a couple of times after school hours. He became an advocate for graphic calculator use in the algebra II class. Yet, there was no specific training on how to use project-generated computers in classroom instruction.

Most help regarding the use of the computers was from Mr. Owen, a programming teacher. The help remained on a technical and personal level. It was technical because teachers asked how to use the computer itself--how to
install and run a program. Help was personal because individual teachers went to the programming teacher for assistance. The absence of guidance became the most common reason not to use classroom computers for instructional purposes. The chair said that it was the teachers who benefitted most when there was one computer in the classroom. The computer was mainly used for grade keeping purposes.

The lack of guidance was shown clearly in the use of project funds for inservice. Originally the biggest chunk of funds was allocated for inservice. However, it was actually used generally for any inservice offered in the math department rather than specifically for inservice on project goals. Under-use of inservice funds was the reason for the project's termination during its second year.

In summary, peer coaching did not work as planned partly because of leader teachers' lack of interest and because of the absence of guidance on how to use classroom computers in instruction. The lack of guidance and teachers' indifference became more salient in the math application.

Shadowing and Math Application

Teachers were to visit industry and business sites so that they might emphasize math application in their teaching. It was this plan that aggravated most teachers at Putnam. As with peer coaching, most teachers expected little from the idea. However, unlike peer coaching, the pressure to participate in shadowing could not be ignored. Classroom computers were awarded according to teacher shadowing hours. This requirement and insufficient computer funds required district teachers to compete for classroom computers.

At Putnam the chair wanted classroom computers and encouraged all the math teachers, except the programming teacher, who lived in the computer lab, and the new teacher, to earn project-generated computers. Teachers had to go
out to business and industry sites whether they liked it or not, and they did not hesitate to express their views about these visitations.

The most uneasiness about shadowing was generated by the necessity of teacher leaving their classrooms:

It is hard to make out lesson plans ahead of time, have them (substitute teachers) followed while you're gone. When you come back you pick up where you left off. When I'm not in my room, I don't know what they are understanding or not understanding. If I'm in my room, I don't care what's in my lesson plan book. If they have trouble with something, then I give them some more problems of the same stuff. If the sub comes in and writes the page numbers on the board, p.350, p.351, p.352, and p.1-25, the students sit there. They are quiet and the substitutes they don't worry about. There is no interaction, very little. When you get back, you've got to go back two days and pick out where you left off. And a lot of teachers don't like to do that.

But, the problem rests on sub teachers. We can use 10 days' absences per year. I use it for private, urgent things. I can't leave the class as often as the project asked. You can't let your students learn nothing while you learn something.

When you go out to shadow, it's nice to see how math is used and come back and tell the kids. But, again you have to leave your class. Regarding substitute teachers, no matter how good they are--I actually know one sub who is a really good math teacher--the kids complain about the sub and have to go back to cover that day's work. So, more work to do.

Ms. Ellis transferred to Putnam with the ninth graders when the middle school concept became effective. In her 27 years of teaching, she used only four sick days. She strongly believed that a teacher should stay in the classroom with her students. She became resentful when she had to go out to shadow just because the chair said so. Ms. Ellis thought such experience was "absolutely" useless because the math used in the business and industries was too advanced for her students.
Not all math teachers thought that shadowing was of little benefit, even though this evaluation was the most prevalent view. Ms. Beam thought that it was a worthy effort, though she was uncomfortable leaving the students with a substitute teacher. She said that:

I don't know what to do with the sub situation except have he just bite bullets . . . because I think something is a worthy effort. Now, some people don't agree with me. They don't leave their classroom for anything. I think that the students are better off if I'm in the classroom on a day to day basis. But, in the long run, they may be better off because I'm out somewhere else, putting in my time so that all the computers and software and all the materials are available. They have to weigh pros and cons, you know. I won't give up my Saturdays. My family has to come first with me.

Still, Ms. Beam's interpretation of the benefit of shadowing was material reward, rather than learning how math was used in the real world. Material gain was the common interpretation of the project's benefit even when teachers were resistant to visiting businesses and industries. Teacher reluctance to leave the classrooms was too pervasive to blame that they were apt to do the minimum work for their job. Instead, their hesitation was rooted in the classroom structure. The intertwined managerial and instructional character of classroom teaching made teachers reluctant to leave classrooms at any cost. The instantaneous nature of classroom teaching, where unexpected happenings frequently occur, was distinctive in high school classes where teachers had to deal with involuntary teenage groups.

In addition, most teachers' attitude toward shadowing reflected the characteristics of the high school math curriculum. The curriculum was driven by textbooks, so math application was treated as a peripheral issue. The textbook-oriented math curriculum was reflected in teachers' priorities and their difficulty in using the shadowing experiences. In 1991-1992 the state adopted
new textbooks for high school mathematics. This new textbook added to the reasons for teacher reluctance to go out and shadow. Teachers said:

The experience of visiting business has been nice. I don't know that we have used that information wisely. It has been a hard issue because of all the new textbooks. You're trying to get through your textbook. So, many of us teach the book instead of the curriculum. It's textbook-driven curriculum instead of the curriculum-driven instruction.

This is the first year for this textbook. First, we taught out of this book. And it takes a year to know what to anticipate, which direction the book is going to go, how I'm going to present this material. Do I change my approach or do I follow what the book says. Sometimes my ways are better than theirs. I'm not tied to the ways the book does things. But, if students have the book and if they can understand what the book says, then, I think that that's a good way to go. It's like that they got someone in front of them. But, what happens many times is that the students can't read the math book and understand it. So, a lot of times I go by the book and explain what they are trying to say.

Teachers did not have time to incorporate shadowing experiences into classroom activities when their priority was to go over the textbooks. In such circumstances promoting math application out of shadowing experience sounded nice, but practicing it was difficult.

Promoting the practicality of mathematics includes more than visiting industries and business sites. Observing how math is used in a real world was one thing, but applying those observations in the classroom was another. There was no direct transferability between the two places because the notion of practicality was context-bounded: it had a different meaning to each individual student. For example, geometry has applicability in architecture but that applicability means little to students whose prime interests have little to do with architecture. In this sense, promoting applicability of mathematics does not have cookbook-like procedures so that the teachers could follow mindlessly.
Instead, math application requires each teacher's creativity and sensitivity to their students as well as to subject matter. Therefore, it should be dealt within its specific context. The context-bounded character of math application emerged in the different interpretations of the district math coordinator and local teachers. To Dr. Perry, math application was problem solving, in contrast to drill and practice, and rote memorization. Therefore, he wanted teachers to generate problem-solving questions based on their shadowing experience. The questions, however, remained in paper work and were rarely used in math classes.

On the other hand, the meaning of math application was vague to most mathematics teachers, and they had different opinions regarding the issue. They said that:

I don't know. I do blow up the cartoons that involve scaling, and measuring. And I also make wrapping papers so it can be matched when you wrap materials. It relates to symmetry.

When it's done right, it's good. But, it takes time and [it is] different based on the situation.

Math is not practical. Arithmetic is practical and it is not math. Algebra and geometry are not practical but the path to learn Calculus that has a lot of practical application. Most problem solving questions are wording questions and they are not practical at all. Look at the speed word problems. If you want to know in what time two trains coming from the opposite directions with different speeds meet, use the speedometer.

To some teachers, math application meant hands-on experience. It implied hard work and was different because it was based on varying situation. To other teachers, math was not practical at all. It was the path to learn calculus.

Among teacher views about the practicality of math, Ms. Beam's notion reflected the ambiguity of most math teachers at Putnam:
They often ask "When am I gonna use this?" "Why do I do this." And it's hard to give them a reason that they are able to comprehend. They don't understand the need for education. To me, this is a part of your education regardless of whether you ever use it in life or not. To be an educated person, you should know something about geometry. You should know something about equations and pre-algebra, and algebra and whatever. That's a part of getting a high school diploma. They don't question so much about English . . . "Why do I need this?" except they may have to know why do I have to . . . But, they always want to know "Where am I ever gonna use this." And that's not a question I can answer. I don't know. You may never use it. But, if I let you out of here without teaching it to you, then I'm not doing my job. That is, trying to give them education.

When teachers have a vague notion of math application and when such a notion is not a priority, application remain in documents and are rarely practiced. Teachers' vague notions on math applications should be considered in relation to the existing math curriculum and the character of mathematics as a subject matter. Both the math curriculum and the teachers' conception of proper knowledge for their classrooms were driven by the textbook. Most teachers paid little attention to the practicality of math, although it had been a major issue in mathematics teaching for a long time. Instead, they focused on covering what they thought should be taught in a school year through lecture.

Unlike other subject matter, mathematics is hierarchical and the teachers could do little when they got unprepared students. It would be natural under these circumstances for most teachers to focus on covering all the necessary skills for their students to move onto upper-level math. In this situation, the factor that bothered the math teachers most was having students who did not have entry level skills. Getting "not ready" students also gave them discipline problems. It was mostly these students who lost interest in the classes and skipped the classes or became the class clowns.
Since mathematics is required in the high school curriculum, and since many students thought of themselves as "college material" even though they were not, discipline problems in the math classes, especially in the low math classes, were enormous. One French teacher who also had a master's degree in mathematics and taught math at Putnam told me:

I prefer to teach French in high school. French is harder than Spanish. So, I've got good kids. I have not written a referral for a year and half. In math, kids are not motivated and they have to be there.

In summary, the project's plan for promoting math application by teachers visiting business and industry sites earned little teachers' interest. First, the plan ignored the school structure where the teachers worked every day. The involuntary character of the public schools and managerial aspects of classroom teaching made teachers reluctant to leave their classrooms. In addition, because of the context bounded nature of math application and because of a textbook-oriented math curriculum, teachers were not concerned about mathematics applicability. Math application will remain vague and minor in high school mathematics curriculum unless it gains teacher interest by being discussed in relation to school structure and to curriculum.

If teachers had not defined math based only on textbooks, and if they had not been so focused on covering the materials, the project might have made a difference in classrooms.

Some teachers at Putnam reacted differently to the project. Mr. Flack and Ms. Vine had loose interpretations of what to teach. They would do anything to ease the boredom of classroom teaching. According to Mr. Flack, one of the "deadening" aspects of teaching as a job is its repetitiveness: it takes away all teacher intellect. Ms. Ellis differed from these two teachers in that she had the typical opinion of what was proper math for her class. Even though
Ms. Ellis hated being pushed to go shadowing, she couldn't think of grading her student performance without the project-generated computer and she used it for instructional purpose whenever she thought that was proper.

In the following section activities and teacher values in these different classrooms will be scrutinized. Then the two kinds of situations will be compared.

Mr. Flack: His Conception of Proper Math and His Values of Diverse Teaching

Mr. Flack had taught topic math and geometry for years along with one low-level class. His low-level class was pre-algebra in 1992-1993. He had been at Putnam for 11 years and he taught at Lane Community College after school. He held an undergraduate degree in science and a master's degree in mathematics. In the school, his zeal toward his subject matter was known among school personnel.

The most distinguishing aspect of his class was his notion of proper math. He defined math broadly enough for it to be found in every aspect of daily life. It was common to hear him saying, "Why do you want to learn this? Because..." in his classroom. To him math was invaluable knowledge for air plane pilots, road constructors, musicians, and for artists, not to mention its requirement by colleges. Mr. Flack also saw mathematics in connection to other subjects such as writing. According to him, students could learn logical thinking that would lead them from an ambiguous problem situation to step-by-step solutions through writing. Such logical thinking had its importance in math problem solving.

Mr. Flack's broad understanding of proper math affected his classroom activities. He regularly used project-oriented approaches instead of sticking to textbooks. Every visitor would notice the kaleidoscopes, the products of geometry class student project, and various math-related toys on the display
table in the back of the classroom. To him the student projects are a valuable tradeoff. He said that:

We have been doing this project every year. You know, that's all it takes to sacrifice one chapter to do all these other things...It's great pay off.

I let these kids do their own projects. It's for them to learn some hands-on stuff. But, also it makes teaching more interesting to me because I get something from the projects, some really neat ideas and so forth...And the kids like that.

Mr. Flack was the only teacher who created a problem-solving project as a result of the project's shadowing experience. When he visited Hughes Airplane Company he realized that their way of doing math was different from that in the classroom. People in the company emphasized data gathering, analyzing the data, and making sense out of the data when they made cathode ray tubes. Out of that experience he planned the Parachute Project for his pre-algebra class.

The student project was refreshing for him. Mr. Flack could be enlightened by students' "neat" ideas. However, he also admitted that diversifying instruction was not easy, because teaching was "overwork business." Besides, it was hard to come up with class activities that were instructive as well as enjoyable. Still, he believed that the effort to diversify was more important than before because it was hard to gain students' attention by lecture alone. He articulated his argument:

We have to diversify the environment in order to get kids' attention, I mean. They are different from when I was a student. We didn't watch much TV. We didn't go to movies. We had a old country school and we didn't do all these things which kids have access [to] now. And I think that because there are so many things, they have attention deficits. May be it's not diagnosable. It's not severe enough to diagnose. But,
they can't concentrate on something on their own to get to the answer. If they can't get the answer by pushing two or three times, they quit.

Mr. Flack's desire to diversify his teaching also caused him to have different opinions toward project shadowing:

I think that the technology application project has been good in a sense that it gets teachers out of the classroom. And hopefully we'll see the need for diverse instructional methods and see some usefulness in what they are doing because I think sometimes that we, the teachers, loose sight of the applicability of what we're doing.

In Mr. Flack's case, the project supported his opinion about diverse teaching and math application. He was in first place in the number of shadowing hours among the district math teachers. During the 1991-1992 summer vacation, he joined a local company to learn how math was used there. The chair thought that the project idea was challenging to Mr. Flack. She also thought that he could do it because he did not need to prioritize family matters, as was the situation for teachers with families.

It was not surprising that Mr. Flack was first to use computers for instructional purposes. He used the programming lab before the new math lab was established. A noticeable aspect in his integration of computers into instruction was that he did not consider computer integration a big job which demanded major work. Mr. Flack believed that the only way to learn how to use computers was to "mess around."

Mr. Flack personally got the Math Plotting Program and he started to use it in his topic math class in 1991-1992. When he taught trigonometry, he showed students how to use the program on the classroom computer after the lecture. His class went to the programming lab in the next session. The students, by pairs or alone, used the program with handouts. In the lab, students learned how a graph would change based on the variables of a formula that was
hard to do by hand. One black senior student, who usually rested his head on the desk because he was going to get out of school soon, was curious and he was excited by the different shape graphs took based on the variables being graphed.

When I revisited Mr. Flack's classroom in 1992-1993, he was teaching polynomial and used Zig Zag Zot-Slalom program. The program was purchased by Sunburst workshop last summer. It was a game in which the students had to predict the shape of a graph based on a formula with increasing accuracy. Mr. Flack did not make an exception for this observer, so I had to play the game. When a student said, "How come you don't work?" Mr. Flack jokingly replied that the pros don't play with the amateurs.

It was fun for Mr. Flack to do different activities in his class. His integration of computers followed Gagne and Briggs' (1979) work of the proper way to use a new medium in instruction, although Mr. Flack had never heard about it. Gagne and Briggs (1979) suggest getting learners' attention by introducing a new medium that they were going to use, informing the learners of what is expected from their work, and elaborating learning experience after its use. Handouts were used as a guide for students when they worked with computers. Mr. Flack considered the project beneficial to his teaching. This attitude made him different from the rest of the faculty.

Mr. Flack's broad understanding of the proper math and his effort to diversify did not exempt him from the effects of school structure. He also suffered from the "I don't care" attitude of students. The assistant principal and the chair said that since he was eager to share his excitement about his subject, he was more vulnerable to students' indifferent attitude than were other teachers. He sometimes took his problem students to the principal's office. In 1992-1993, he had a more difficult time than before in his pre-algebra class because it was
the sixth hour. A low-level class in the afternoons meant a hard time for the teachers.

To Mr. Flack, the worst problem was that many students today avoid responsibility for their own learning. Raised in a poor farmer family, he could not accept students blaming the system, parents, friends, and teachers. He thought that such avoidance of responsibility came from low self-esteem; it blocked students from doing anything on their own. This avoidance of responsibility was also found when technology was used in class. According to him, technology was a tool and it could not "think" for students. But it was common for students to assume that the calculators or the computers would give them an answer by punching the numbers found in a question statement.

In summary, Mr. Flack's different notions of proper math in the classroom and his belief in diverse instructional techniques helped him use the technology application project in his classes. It was natural for his class to use computers whenever instructional computer use provided benefits otherwise hard to get.

However, Mr. Flack was also influenced by the same school structure and curriculum as the rest of the math faculty. He suffered from students' indifferent attitudes, especially that of students in low-level classes. In addition, the solitary nature of classroom teaching caused Mr. Flack's efforts to remain on a personal level. His difference did not affect other teachers' classrooms. Though the chair and other math teachers praised Mr. Flack's enthusiasm, their approval did not mean that they were willing to change their own classroom instruction.
Ms. Vine: Her Exploratory Character and Instructional Computers in High Level and the Low Level Classes

Ms. Vine was one of three teachers who used computers for instructional purposes. Her high-level class was pre-calculus and low-level class was applied math. She was the teacher who helped the chair write the proposal for the new math lab. According to her, it was the teachers who always ended up doing extra work without reward. Ms. Vine valued the usefulness of computers in her instruction although she was not a supporter of the technology application project.

She liked students who voiced their opinions. According to her, while the low-level class students were not afraid of expressing themselves, those in the high-level class were not accustomed to doing so. Her strong character appealed to some students, and it caused some other students to avoid her class. One of the applied math students was transferred to another teacher's class because he was not comfortable with her style.

Ms. Vine's strong and dynamic character helped her benefit from the project. One noticeable aspect of her character which was manifest in her teaching was that she was not afraid of saying "I don't know." At first I thought that she was refusing to elaborate her views by saying that. As time passed by, it was realized that she did not mind admitting that she did not know everything going on in the class. This openness was represented in her use of instructional computers. Lack of time to preview software and scarcity of software did not prevent her benefitting from existing resources. She used the lab time to learn with her students about the software. When students asked questions, she did not hesitate to say that she did not know.

Ms. Vine tried to do guided discovery learning using the new math lab in 1992-1993. Before learning a new chapter, students used related software with
handouts in order to discover the principles and rules of the lesson. When I asked her whether the strategy made any difference, she said, "I don't know, but the kids have fun."

Guided discovery learning with computers worked better in the higher-level class than the lower-level one. Student attitude toward schooling seemed to make a difference. In her pre-calculus classes, most students were busy finding how graphs change according to the variables in trigonometry formulas using the Drive program. When one of her black boys found the nature of the graph based on the formula, she grabbed his shirt collar and screamed "ri—ght" with her husky voice. Like Mr. Flack, Ms. Vine also seemed to find her reward in her students' excellent work. She told me that this class was the bright spot of her day.

When doing the same discovery learning using the Algebluster program in her algebra I class, there were more students who did not understand what they were doing. That day's topic was factoring algebraic expressions. A black girl did nothing but copy the answers from her partner. Her partner was the "thinkist" as well as the "typist." A pair of black boys did not read the explanations on the computer screen. It seemed that they were not interested in discovering, but in filling in the handouts by any means. One white boy sat alone in front of the computer; he did not have a clue what he was supposed to do. After I showed him how to factor the algebraic expressions in a couple of questions, he got the idea and worked by himself.

The students needed help so much in the low-level class that Ms.Vine could not fool around with the program for herself. When I asked her why she did not use the computers for her applied math students, she said that she would not even let the students get out of the classroom. There was too much risk for her in using computers with her low-level class students. Her reaction was
typical among the math faculty. It was common that managerial difficulty kept low-level students from exploring instructional computer use.

Though not related to computer use, the class project called "Math Lab" showed the importance of individual teacher values in implementing the idea. Ms. Vine developed Math Lab. It was a hands-on class activity for measuring units. Students were supposed to figure out the unit price of a 6-pack of cola and a 2-liter bottle of cola. They were also to decide which one was the better buy. Three math teachers including Ms. Vine were teaching applied math at Putnam, and they all agreed to do Math Lab. The actual class activities, however, were very different. In Ms. Vine's class activity, she had to raise her voice several times, and the activity was messy. One group accidentally poured water on a desk and students talked to each other about class related/non-related matters. Yet, the class did talk about the difference in measuring units, measuring errors, and which one was the better buy in this noisy atmosphere. A black boy sitting next to me calculated the unit price all right, though he constantly insisted that he knew the place where a 6-pack cola was cheaper than the 2-liter bottle one. The important result was that most students had fun and they succeeded in the lesson.

The same Math Lab idea turned out totally different in Mr. Johnson's class. Although the class did the same hands-on activity, a paper task was emphasized because the teacher was not fond of hands-on activity. The Math Lab was conducted quietly and neatly. The teacher warned students not to spill the water. It seemed, however, that students paid too much attention to trivial matters, such as counting the cups of water poured into a bottle and doing exact measuring. When one white boy asked why they were doing this, the teacher said, "I don't know. Read the directions."
The Math Lab case reflects the importance of teacher values in carrying out an instructional idea. Ms. Vine shared the Math Lab idea with other teachers and her effort made a difference in classrooms. On the other hand, Mr. Johnson did not give much thought to the Math Lab. His lack of interest made the lab into a busy work for students. Teacher values make a difference in implementing the idea in one class section, and they will certainly influence accomplishment of the technology application project goals in classrooms.

Ms. Ellis: Instructional Computers and the Collective Nature of Low Level Math Class

Along with Mr. Flack and Ms. Vine, Ms. Ellis frequently benefitted from the new math lab. She sometimes used the project-generated computers for instructional purposes. Ms. Ellis moved to Putnam High School from Putnam Junior High in 1990-1991 and she intentionally remained in the low-level math classes. Most of her classes were pre-algebra. Ms. Ellis differed from other discrepant cases because her teaching style was typical. She taught from the textbook and she paid much attention to the managerial aspect of the instruction. She spent a considerable amount of time on paper work. In a departmental meeting Ms. Ellis asked Ms. Vine how she handled paper work so she could go home as soon as school finished.

Ms. Ellis expected little from the project. She thought that it was "absolutely" a waste of time to go shadowing. In the spring of 1991-1992, the math department had to spend project funds of $5000, which was set aside to preview software. Because the math faculty could not set time aside to preview software, they wanted to spend the fund on a workshop offered by Sunburst. Ms. Ellis told me, "It certainly is a waste of money, isn't it?" She resented the state education reform movement as well as the technology application project.
Ms. Ellis said, "We need student reform, not school reform." She sarcastically mentioned that making math fun in her class would require this scenario:

By making rap songs and letting kids dance on the desks with a banner which says "MTV." By doing that let the kids memorize all the rules and principles. Other than that, it's tough for my Pre-Algebra kids.

Because she was the teacher who quietly mingled with the majority, it surprised other math faculty when Ms. Ellis started using the computers for instructional purposes. It might be her diligent character that made her not want to waste any available resources. She was the teacher who had taken four sick days in her 27 years of teaching. Besides, it was her routine to remain in her classroom till 5 o'clock to finish daily paper work. Such a personality might have caused her to follow the requests of the project as much as she could under given circumstances.

On the other hand, her case created a question as to what was proper use of the instructional computers in already stratified math classes. She used Algebluster, Mathematics Tool Kit for her algebra I class and some basic levels of Geometric Supposer for the geometry class. The main use of computers was to practice what the students had learned in classes. It was common that in the lab some students were excited, while some were lost, and some were bored.

When Ms. Ellis' algebra I class practiced algebraic simplification with Algebluster, a white girl kept complaining that the program was boring. In contrast, a white girl couple, sitting one seat apart from the bored girl, had no idea what to do. The instructional computers did not allow for more individualization of classroom learning, especially in the low-level classes. The teacher in low-level classes was usually too busy to help all the students needing assistance. When I asked what was the benefit of using computers in her classes she replied, "Well, at least the kids can do something besides listening to me."
Ms. Ellis' case demonstrated that instructional computing activities alone did not bring a significant difference in her mathematics classes. Instructional computing in her algebra class was not different from any of her other classes in the respect that it did not overcome the collective nature of classroom learning. Rather, the use of instructional computers in Ms. Ellis' classroom showed that computers could also be absorbed into the existing school organization. Computers could be treated the same as other instructional resources. They could be used as accessories to textbooks. Instructional computers alone could not make any difference unless there were accompanying changes on the math curriculum and on the school structure.

In this section we have examined the discrepant case teachers at Putnam. Their difference presents three issues: (1) sufficient conditions of integration of the instructional computing; (2) the reward of such teachers' work; and (3) the effect of their effort on the math curriculum. Certainly the availability of the hardware in the new Math Lab affected the discrepant case teachers' effort to integrate computers into instruction. It seemed, though, the school's broad interpretation of academics, and the math department's acceptance of different teaching styles, were as important as hardware accessibility. The flexible understanding of what should be taught in the classroom allowed some teachers not to define math based only on textbooks. The teachers' interpretation of math curriculum was important in instructional computing and math application because it became a primary factor in deciding the instructional strategy. For example, it was rare for AP-calculus teachers to use any instructional method other than going over the textbook and intensive review of the practice exams. The teachers' narrow definition of proper math prevented them from considering various ways of learning math.
The discrepant case teachers' different views toward math knowledge made them look at the technology application project in relation to their classrooms instead of considering it as extra-work with little benefit. The noticeable aspect of the discrepant case teachers' use of instructional computers was that use happened as an individual effort. Unlike many other teachers, they did not see computer integration as a task that demanded messy and unnecessary work.

Such individual effort was well contrasted with the chair's effort to integrate instructional computers at the department level. Recently, the chair wrote a proposal asking for a school year off to prepare computer-integrated lesson plans for the whole curriculum along with the software cataloging. On the other hand, the discrepant teachers did not worry about lesson plans and their limited knowledge about the available software. Instead, they decided to use the accessible resources when they saw the possible benefit for their students.

Though such personal effort mainly remained at the individual classroom level, it was invaluable because it brought actual changes to the class. The Math Lab was an example that showed the importance of teacher values in carrying out planned activities. The reward of teacher efforts to integrate instructional computers and math application also remained on a personal level. When Ms. Vine saw one of her students "discover" the regulations governing trigonometry, and when Mr. Flack found that his lazy boy in the second hour suddenly showed distinctive mathematical sense in solving applied math problems, their faces shone and nobody could stop them talking about such "magic" moments. In this respect, their reward was intrinsic.

However, such personal effort did not alter the school structure. The solitary nature of classroom teaching made it difficult for discrepant case
teachers to affect other classrooms. Moreover, the discrepant case teachers themselves were reluctant to practice instructional computing in lower-level classes because of managerial difficulties. The collective nature of classroom learning prevailed even when instructional computers were used in the lower-level classes. Instructional computers alone could not narrow the gap between the low and high mathematics classes.

**Summary**

In this chapter, we examined how teachers at Putnam made meaning out of the technology application project. The project aimed to alleviate the filtering role of the high school mathematics curriculum by gender and race. It emphasized the practicality of mathematics to motivate girls and minorities to pursue higher mathematics. The gap between the original plan of the project and the implemented one presented the ideological difference between the teachers and the district math coordinator.

The mathematics teachers at Putnam thought that the project had little relevance in their classrooms because the project goals were not on their personal priority lists. None of the teachers saw the minority and gender issues as problems in their classes. Instead, their problems were related to classroom and school structure.

The involuntary nature of compulsory high school education generated indifferent student attitudes, and teachers did not know what to do with such indifferent attitudes. High school math classes were more sensitive to students' apathy than were other classes because students are obligated to take these classes for graduation and for college entrance.

In addition, the hierarchical nature of mathematics was more vulnerable to the collective nature of the classrooms. The teachers could do little for
students who did not have entry-level skills. Also, the managerial aspects of classroom instruction made teachers uncomfortable in visiting business and industry sites. Most teachers strongly believed that their job was to be with students in the classroom. They thought that such a visitation request undermined the instantaneous nature of the classroom.

Another aspect that weakened the persuasiveness of the project for teachers was the vague notion of math application and instructional computing. Most teachers were so accustomed to a textbook-oriented curriculum that they themselves had an abstract notion of the practicality of mathematics.

Instructional computing was not an exception. Although teachers thought that computer integration was necessary because of today's job force, they questioned the use of one classroom computer with 25 students. Their computer knowledge remained on the technical level and no inservice was available about how to use one computer in a class. There might be no step-by-step knowledge of math application and computer integration. Such knowledge took a different form based on student characteristics and teaching styles. In this sense, math application and instructional computing demanded individual teacher effort.

However, most math teachers at Putnam were so exhausted by the managerial aspects of classroom life they were concerned little by issues such as math application and integration of the instructional computing. This lack of teacher interest rendered math application and instructional computing vague and easily ignored.

Two discrepant case teachers showed how individual teacher notions of proper math influenced class activities. When the teachers conceived math knowledge beyond the textbook, they tended to bring applicability of what they teach that made these teachers use various instructional approaches. These
teachers thought of the project in relation to their classroom instruction, and that made the difference.

However, such discrepant case teacher efforts remained at a personal level because of the solitary nature of classroom teaching. The discrepant case teachers were also under the dominant school structure where involuntary and collective values prevail. Their different conception of proper math and their effort to diversify classroom activities did not make them immune to general classroom problems such as apathy and student avoidance of the responsibility for their own learning. Because the project designers did not take into account existing organizational structure, the project's goals could not affect mathematics classrooms at Putnam.

**Ramifications**

The technology application project was designed to motivate minority students and the girls to move into higher mathematics by way of instructional computing and math application. The project, however, defined these students' low motivation only in terms of instructional issue. By doing so, it ignored the social aspects of lower-level mathematics classes. In addition, the project failed to see math application and instructional computing in relation to school culture. By ignoring the organizational characteristics of the school where math application and instructional computing were to be practiced, the project decontextualized such issues. These decontextualized issues rarely received much teacher attention. As the result, the accomplishment of planned change in the math curriculum was trivial.

On the other hand, the project had unplanned effects. First, in the school-wide respect, the project contributed to the unequal distribution of computer resources among the departments. The project boosted the existing pattern of math and business-oriented distribution of instructional computers.
Most math teachers in the school received classroom computers, while many other department teachers had little access to computers.

Second, the project benefited higher-level math classes such as pre-calculus and topic-math. At Putnam, all the low classes were distributed equally among the math faculties. So, the unequal distribution of the computers within the department was not apparent as at the other school. However, the project-generated computers were rarely used by lower-level classes. The teachers believed that sophisticated technology like computers was better off in higher-level classes than in lower-level ones because of the content. What was more important was that the teachers were focused on managing students in the low-level classes and did not consider using methods such as instructional computers.

New instructional techniques can breed unforeseen incidents. It was commonly thought among the math faculty that some students' destructive behavior in the low-level classes could damage the hardware. The teachers' notion about the subject matter in the low-level classes and their conception of the student body in those classes had kept them from trying diverse teaching.

Third, the project made the gender and race issue in mathematics more invisible than before by reinforcing the status quo of the existing math curriculum. The project's goal was set not because the district math coordinator and the local teachers thought it was worthwhile. Instead, it was established because the National Science Foundation's criteria for the grant required the promotion of race and gender issues. Both the math coordinator and the local teachers desired the funds available through the grant since technology such as the computers is hard to get.

In addition, the project's conception of the race and gender issues only in relation to instruction ignored the complicated nature of such problems in math
classrooms and in school organizations. The race issue in the math classes was intertwined with social aspects of the classroom. The teachers blamed the low social economic status of the family and lack of parent support of their children's education. Such aspects of the race issues caused teachers to disregard of student placement based on race even though there were more black students in the low-level classes than in the higher-level ones. Math teachers did not consider race concerns as teacher problems.

A placement pattern based on gender was not found in students taking math in the school. However, teachers believed that the boys were better in the higher math classes regardless of class rank because the boys' minds were able to deal with higher math such as calculus. It is another question whether teacher attitudes affected student learning or not. These teachers' discriminatory attitudes were difficult to rationalize. Their belief in boys having inquisitive minds, and their belief that boys are better at three-dimensional thinking than girls, were a priori.

The project did not influence the race issue or the gender issue. Instead, these issues were ignored and suppressed in the high school math curriculum because the school maintained the status-quo regardless of the project's written goals. In this regard, the project ignored the gender and race issue in the high school math curriculum, thus nullifying the intent and outcomes of the National Science Foundations' distribution of grant money.
CHAPTER V
CONCLUSIONS

In this chapter the main findings of this study will first be summarized. The study's limitations will be indicated and its implications will be discussed.

During the last decade schools have purchased a great number of computers in response to the demand that they educate children for a high-tech society. Although there has been a significant increase in the number of machines in schools, computers, especially in traditional academic core courses in secondary schools, are seldom incorporated into instruction (Becker, 1991c).

This study has described and analyzed how computers were actually used and not used for high school mathematics instruction in two schools through a technology application project. It has identified school organizational features that inhibit and shape instructional computer activities. Also, it has shown ways in which the implemented project exacerbated the conflict of interests among teachers and the central office administrator and how such conflict was resolved or left as it was. Such conflict affected the use of instructional computers in schools.

This study reveals that instructional computers were adapted to the existing math curriculum, minimally altering teaching style and teacher beliefs. By adjusting to the school's culture rather than changing it, the project reinforced the status quo. To support these interpretations, the findings of the study will be arranged based in order of the original questions.
Findings

Impact of current math curriculum, instructional computing, and organizational routines on the project

The technology application project reflects current educational reform movements that emphasize computer use for higher-order thinking skills and for connecting math to the work world, especially for unmotivated mathematics students. Local businesses and industries took the leading role as mentors. In addition, instructional computer use through the project was based on a bureaucratic curriculum model reflected by a clear division of labor and hierarchy which can be represented on an organizational chart.

Project goals were set and decisions were made at the top level of the bureaucracy. In the technology application project, the district math coordinator set the goals and implementation plans to fit into the criteria of the National Science Foundation's Private Sector Partnership Funding program. In bureaucratic models, curriculum change is understood to be an input-output process. The project was expected to generate the intended outcomes once necessary resources—hardware, software, and teacher training—were provided.

The implemented project revealed, however, that instructional computer use in both high school math classes was massively molded by organizational routines and by each school's specific needs. Implemented instructional computer use suggests that curriculum is more than an input-output relationship. Rather, this study pointed out that computer integration into curriculum was a contextualized process; it was affected by the history and community of the two schools.
Difference of instructional computing based on community and history of schools

The surrounding community of a school affects what to teach, how to teach, and whom to teach. Located in a prestigious part of the town, Bill Hank High School traditionally has done an excellent job in teaching college-track mathematics through its pervasive teacher lecture method to its middle and upper middle class students. Instructional computer use through the technology application project affected little of the math curriculum in Bill Hank. The project targeted the college track math curriculum by promoting four consecutive years of mathematics courses to all the students. However, math teachers thought they were already doing a good job. They were proud of their teaching and they saw little need to change.

Many Bill Hank math teachers thought that available software was too "slow" for their accelerated track students. Math teachers at Bill Hank did not see that their traditional lecture method worked because of the rigorous filtering of the students. The school's affluent community approves the teaching methods, although parents sometimes make a fuss about who will be their children's teacher and what level of classes their children will be in. Parents demand top performances from their children, and that expectation translates into educating them in the way their parents were educated. Because of these factors, computers were rarely used for the intended outcomes.

The community of Putnam High School consists of working class families with a relatively high percentage of Afro-Americans. Using a traditional school concept, Putnam pushed their faculty members and students to improve the school's public image. Instructional computer use in Putnam math classes was mostly influenced by its faculty culture. Math teachers also defined the curriculum through textbook content, but this definition was not as narrow
as it was at Bill Hank. This interpretation and the chairwoman's encouragement of instructional computing allowed more teachers to use computers in instruction.

However, a substantial portion of instructional computers were used for drill and practice activities. Teachers' interpretation of their students as lacking basic skills influenced actual computer use. Planned computer integration for problem-solving and math connections to recruit minorities and girls to higher-level math did not occur at Putnam, either. This finding confirms that community values and beliefs and teacher interpretation of curriculum and student needs mold the kinds of instructional computing students receive in schools.

**Teacher interest in "owning" classroom computers and their actual use**

Regardless of the actual use of classroom computers, math teachers at both schools wanted their own computers. Teachers' desires to have classroom computers differed according to the faculty culture. Math teachers at Bill Hank were individualistic and competitive; they competed through textbook coverage, level of classes taught, and classroom computer acquisition. A polarized student body that makes a "day and night" difference between lower-level math classes and higher-level ones, and the chair's lack of power to control "old timers" who were known as good teachers, created unspoken understandings that resource distribution in the department was not fair. Classroom computers became a status symbol that proved a teacher had the power of control over scarce resources; this fact encouraged teachers to pursue computers.

Fairly united math teachers and the chairwoman's leadership made the process of classroom computer distribution smooth at Putnam. The image of classroom computers as a symbol of teacher prestige in the department was not
distinctive, although the computer distribution pattern correlated with the teachers' seniority. Classroom computers at both schools were usually used for teacher convenience. Grade-keeping and word-processing programs were used regularly.

When a classroom computer was not incorporated into instruction as "legitimate" school work, there was a chance to observe the use of classroom computers on a voluntary basis. Student self-motivated use of classroom computers differed between Bill Hank and Putnam. Most classroom computers at Putnam were covered and were not turned on. Student access to these machines during break time and study hours was discouraged. The math teachers' conception of their students as destructive and out-of-control resulted in many teachers not allowing voluntary student use of classroom computers.

On the other hand, several Bill Hank teachers who taught higher-level math classes turned the machines on and let the students play with them during break hours or after finishing class assignments. When students used the computers voluntarily, boys were the typical users. Most girls did not come near the machines. This finding confirms Sutton's assertion that poor, minority, and female students have less access to computers at school (1991). Teachers' attitudes that better-behaved students deserve more computer time also existed in both high schools' math classes.

Teacher resistance

Teacher resistance to using computers for instruction was not sporadic or individual-preference based. Rather, it was a collective phenomenon that demands recognition. Teachers resisted intended computer use not because it had little instructional value, but because it differed from their established behaviors. Therefore, their refusal to use computers was quiet and persistent.
In addition, teachers themselves had to figure out how to incorporate computers into their instruction; there was little support from the school administration and the district math coordinator.

Math teachers' priorities at both high schools were massively influenced by embedded organizational routines. Although there is a difference in intensity, both schools' teachers defined their job as teaching the content of textbooks. The chairwoman at Putnam's understanding that the curriculum was textbook-driven, and many teachers at Bill Hank's interpretation of textbooks as "basic math" that must be covered within a school year, points out teacher priority. In this matter, math teachers paid little attention to the intended computer use because recruiting minorities and girls was not their primary concern. Rather, both schools' math teachers were concerned about what kind of students they were going to teach and what planning hour they were going to get.

"Why is math curriculum textbook-driven?" was an uncomfortable and dumb question to many teachers because they took it for granted. Teachers themselves learned math in the same way when they were in high schools, so their students must learn math in that way in order to get a high school diploma or to go to colleges. The concept of the practicality of math was ambiguous and uncertain to many math teachers when their priority was textbook coverage, and it will remain so if teacher priorities do not change.

Intended computer use for math application and problem solving demands teacher time to develop their own curriculum and lesson plans. Lack of time was the most frequent teacher reason for not incorporating computer use into instruction. Dealing with one hundred or more students in a day, teachers always lack time for anything but doing routine work. The teacher-proof curricula of the 1960s and 1970s are criticized for de-skilling teachers, but it is
also true that such pre-packaged materials meet a teacher's need to save time for developing their own lesson plans and classroom materials (Apple, 1982; Jungck, 1985).

Lack of time was more noticeable in the project's computer integration because teachers had to leave their classrooms several times to observe math use in the workplace. Most math teachers at both schools were more resentful than appreciative of the opportunity to observe the practical use of computers in the work world. Since the teachers did not see the benefit of the visitation in relation to their instruction, visitations became official and extra work to be avoided if possible. The visitations had the potential to provide "refreshing" opportunities that could show district math teachers application of math in "real life". However, the project's lack of consideration of necessary teacher time and effort to transfer such experience into instruction nullified possible benefits from such visitation. Rather, it reinforced teacher belief that central administrators do not understand classroom teachers' work and, therefore, rarely work on teachers' behalf.

Time as a necessary resource for intended computer integration should be understood in relation to teacher priority. It is not likely that teachers will incorporate computers into their classroom instruction merely because extra time is given unless they are interested in using computers as an instructional resource. Teacher interpretation of curriculum and their student needs was a critical factor for instructional computer use. When teachers believed instructional computer use was not proper for their students because their students were not disciplined or smart enough--or too smart--for a new instructional method, or when they interpreted the math curriculum as textbook content, computers were rarely incorporated into instruction. This was especially true for innovative purposes.
The importance of teacher understanding of computer use in relation to their instruction was revealed through the discrepant case teachers. For different reasons, AP-calculus class teachers and lower-level class teachers did not pay attention to instructional computer use. While teachers interpreted AP-calculus content in terms of the advanced placement test and focused their teaching toward preparation for that test, lower-level math classes avoided computer use because they thought students in those classes were too destructive and undisciplined. Other discrepant math teachers at both schools incorporated computers into average and moderately higher courses such as algebra, geometry, topic math, and pre-calculus. When these teachers saw the relevance of computers to their courses and students, they willingly stretched their personal time for computer integration.

Another factor that caused teacher resistance was lack of local administrative support. The Putnam principal's denials of the math department chairwoman's request for resource teachers and release of classroom time for development of lesson plans and curriculum for computer integration were examples. Teachers knew that a resource teacher in the computer lab and extra time for instructional computing planning was the first resource to go when the budget was tight.

Administrators at both schools did not see the kinds of situations that teachers would have to cope with in their attempt to implement new classroom practice. Rather, they assumed that it was a classroom teacher's job to figure out computer use. Therefore, administrators thought insuring teacher autonomy would help classroom teachers integrate computers tailored to their own classroom needs. Alleviating organizational control such as classroom time allocation or extra released time for teacher preparation was not considered.

Autonomy of high school math classes was stronger in regard to
administrative intervention because of subject specialty. Administrators considered math teachers "semi-experts" in teaching mathematics: teachers know what works best in their classroom. Both school administrators thought that having classroom computers was good but they did not have specific notions as to what ways computers could be used beneficially in classroom instruction.

Space and placement of computers were other factors that influenced teacher resistance. Classroom computers in both schools math classes were seldom used for instructional purposes. Unlike other classrooms where project-oriented instruction was used so that some students could use the classroom computer, teacher-centered instruction was dominant in math classes at both schools.

Conformity in math classroom activities did not allow for the computer corner to be used for instructional purposes. Creating a computer lab so that each student could use a machine was not an easy task because most teachers wanted classroom computers and because neither school had extra space. There were teachers who did not have their own classrooms, and they questioned the value of having another computer lab when they had to float from classroom to classroom for an entire school year.

At Putnam the programming teacher and word-processing teacher resided in the labs. Their presence in these labs added one more reason for teacher avoidance of instructional computer use. The programming lab at Bill Hank had a similar problem. The lab's physical configuration, which shares the same entrance door and windows between the lab and the programming teacher room, made Ms. Mayer extra cautious when she brought her geometry class to the lab.

The technology application project in both high schools showed that technical knowledge of computers was not sufficient for computer integration. The project assumed that once teachers were comfortable with hardware
configurations, they would use computers in instruction. Teacher familiarity with hardware did not lead them to use computers for instructional purposes. The programming teachers at both schools were computer experts and they did not practice instructional computing in classes other than the programming class. Hardware familiarity did not guarantee software familiarity. Many teachers questioned how to use a classroom computer for instruction with twenty-five or more students. They were seeking instructional techniques and different teaching styles that were proper for instructional computing. Lack of knowledge about new instructional techniques and teacher unwillingness to change their teaching styles had not been addressed in the project teacher-training efforts.

**Discrepant case teachers: their motivations and differences**

Discrepant teacher effort was individual rather than institutionalized. A few teachers who tried instructional computer integration in their classes used their autonomy in doing so. They pointed out their personality as the driving force. These teachers tried to avoid "boredom" in teaching's repetitive nature. They continuously looked for new methods and techniques and instructional computer use was one of them. The project was another chance for them to diversify their instruction.

Their zeal in pursuing instructional computer use helped them overcome some of the organizational constraints. The discrepant teachers willingly stretched their personal time to review the computer programs and they did not assume that the programming lab was just for programming classes. Instead, they saw an opportunity in the lab where the computers sat idle most times. Although these teachers were not sure of the instructional benefits of computer use, they all agreed that computers eased the boredom of teachers and students and for this reason alone were worth trying. Since their effort was individual
rather than institutional, these teachers rewards also remained on a personal level: they found their reward in the rare moments of student "bright" responses and from personal satisfaction that they had opened the door of computer use for some of their students. Other math teachers also gave them credit for their efforts. This recognition brought them the benefit of easier access to computers. Their hard work justified their priority on computer access.

Autonomy allowed in each classroom gave these discrepant teachers flexibility to overcome organizational constraints such as scarce time, hardware, and software. The discrepant teachers gained access to computers by talking to other teachers and they got the computer programs through their department chairpersons, librarians, or from their friends. The flexibility allowed to individual teachers was in strong contrast to the chairwoman's effort for computer integration into the mathematics curriculum at Putnam. She needed helpers and extra classroom release time to develop lesson plans for all the math classes. Developing computer integrated curriculum demands serious software preview, cataloging, and paperwork. Unlike individual teacher effort, the chair had to pay attention to "forms" to deliver "content" to other teachers. Her request for computer-integrated curriculum development was too demanding at a time when the budget was tight.

Organizational control in both high school mathematics classes was too pervasive to allow intended instructional computer use to anyone. Rather, the discrepant teachers' computer use was based on their own interpretation of their student needs and curriculum. They also thought that low-level students did not deserve instructional computer time because of their destructive behaviors, and drill and practice programs were used in average-level math classes. Tool-based programs were used in upper-level classes. In this regard, the assumptions that mathematics is hierarchical, that drill and practice programs are proper mostly
for low-achieving students because they can master basic skills, and that minorities and low socio-economic status students lack these skills, were prevalent teacher beliefs at both high schools, even among the discrepant teachers.

**Quality of student work with computers**

Organizational routines impinged on the quality of instructional computer use. The collective nature and pressure to cover a certain amount of work in a given time also existed in student work with computers. Teachers often used cooperative learning techniques and discovery learning methods when they planned instructional computer use. These instructional techniques, however, cannot guarantee that students also understand these teaching methods and are ready to cooperate with their teachers. In many cases peer-learning was not motivating to students and the group nature of classroom learning prevailed. Below-average students had a hard time understanding what went on in the lab and many of them were more concerned about filling out activity sheets than understanding lessons through programs and the help of their partners. Above-average students finished required work early and got involved in doing class-related or other work. Discovery learning rarely motivated students.

Activity sheets were prepared when the teachers planned computer use in their instruction. They served the purposes of guiding and evaluating student classroom work. Teaching practice that demands frequent student evaluation drives teachers to gather the evidence that students did legitimate work and activity sheets serve that purpose. Activity sheets used during lab time also served as guides for student work. Since the teachers cannot lead the class as they do in lecture, activity sheets provided students a path for using a computer program to learn a particular concept. On the other hand, most students did not
expand their learning beyond the activity sheets. Such sheets set the boundary for lab work, and students seldom tried to cross the boundary even when they had the capacity. The collective nature of the classroom, and time constraints, along with the pressure to cover a certain amount of work, made student work with computers a replica of existing classroom practices.

Roles of local business and industries in the technology application project

The participation of businesses and industries in the project was mainly intended to help the district math coordinator acquire the Private Sector Partnership grant. Most local businesses and industries indirectly contributed to the project by opening their doors so teachers could observe workplace mathematics. The local IBM Company was to donate substantial numbers of its IBM 286 computers for the project, but this promise was canceled because the local company was closed at the time of project implementation.

Teachers visited companies for a variety of reasons: they chose the sites because they heard the place was fun to visit, because their friends were there, or because they were interested in what the companies do. However, teacher visitation to local businesses and industries took considerable teacher class time, and teacher lack of time inhibited the application of what teachers had observed during their visits. In particular, teachers in lower-level classes had to use a considerable amount of time in catching up after their absences. Lack of time, along with the absence of teacher knowledge and commitment to convert the visitation experience into classroom practice, contributed to the lack of benefit teachers received from visits to local businesses and industries. The business and industry involvement helped little in changing the math curriculum from textbook orientation to problem solving and math application.
Limitations

The limitations of this exploratory study on the process of instructional computer use can be addressed through three aspects: (1) time spent in the sites; (2) perspective focus; and (3) elements of the technology application project observed.

Curriculum reform is a long-term and continuously changing process. By spending limited time in field work in two schools of the district, only a static picture of the process was captured by this study.

Second, this study focused on teacher perspectives on the technology application project implementation. Public schools are similar in their organizational routines and in their use of a relatively standardized curriculum. However, the culture of a given school is specific to that school because of its people. Teachers and students are vital curriculum elements who help decide what goes on in schools. By ignoring the student interpretation of instructional computer use through the technology application project, the study shows only a part of the project application.

Third, this study focused on implementation of the project's computer use. Calculator use was not addressed, although it was the other technology included in the project. There were ample chances to observe the use of calculators in math classes because the observation schedule did not consider whether teachers used computers or not. According to my observation, calculator integration into math classes followed common teacher beliefs that a sophisticated technology is more beneficial to higher-level math courses. Lower-level math class students used scientific calculators, while algebra II and topic math classes frequently used graphic calculators. Issues in incorporating calculators into high school math classes would be another domain to explore.
Implications

Findings about the computer use in high school classes through the technology application project revealed that it altered classroom practice very little. Moreover, it exacerbates the status quo in distributing computer resources and in their actual use. Reasons for such striking effects were found through high schools' organizational features and different ideologies. Instructional computers in the project addressed little of the organizational control of math curriculum. Rather, the technology application project was one instance of the trend to expand instructional computer use in the direction of a bureaucratic model of curriculum development (Kliebard, 1977).

In this trend, the implementation of instructional computing was understood as a technical task that invests necessary input—hardware, software, and teacher training for planned outcomes. In the last two decades of the 20th century, state government and local districts are investing more in hardware, software, and teacher training (Reinhold, 1986). This study shows how the project's over-emphasis on teacher training, with little understanding of actual constraints that teachers confront in their workplace, produces few positive effects. Teachers are extremely reluctant to change teaching styles that work under the current school structure. They try to avoid unexpected managerial problems that often follow new instructional techniques. Because the difficulties teachers confront were not addressed in teacher training opportunities, teachers had no support in figuring out how to incorporate this new instructional tool into their classrooms. In this circumstance, instructional computer use was often found to be a replica of an existing classroom practice that fit the innovation into existing school structures and culture. By excluding consideration of structural control mechanisms and ideological conflict in the
process of curriculum change, the bureaucratic curriculum model reflects popular functionalist theories in educational innovation.

The implemented technology application project revealed how the project was actually molded by factors not considered in the project planning stage. First, the implemented technology application project showed non-bureaucratic characteristics of school organization through mismatches of its intentions and actual actions. Where there was no consistent control, involved members interpreted opportunities provided by the project according to their own interests.

National Science Foundation (NSF) funding, through its Private Sector Partnership program, emphasizes the following factors: (1) involvement of the private sector from project development to implementation; (2) teacher training; and (3) encouragement of traditionally under-represented math and science populations. The criteria reflect current education reform movements that envy the business and industry sector's productivity and efficiency, target excellence as well as equity, and stress school reform through teachers. These criteria remained at the policy level.

Because of geographical remoteness from local schools and because of differing priorities, federal supervision of the project emphasized documentation of the project activities and exact spending of allocated funds. This supervision method was not focused on the intended instructional computer use. To the contrary, central control through documentation brought more difficulty in implementation of the planned project. The rigid allocation of funds that emphasized teacher training drove the district math coordinator to push local teachers into joining more inservice sessions regardless of the sessions' relevance to the project goals.
The official documentation of the project revealed only part of the project's implementation. It included problem solving questions that were gathered by teachers from local business and industry visitations, increased minority students in higher mathematics courses, and actual spending of funds as planned. The written documentation, however, does not report that the problem solving questions were rarely used by teachers, and teacher training offered was not focused on instructional computing for minorities and girls. Central control of the project reinforced teachers opinions that the project was another 'official' effort with little relevance to their classrooms.

The role of the district math coordinator in project implementation was more like a "middle man" whose job is to negotiate the differences between his superordinates (central personnel) and his subordinates (local teachers). Dr. Perry's main concern was to manage the project funds as planned. As a district math coordinator, Dr. Perry searched for the opportunity to meet the local teachers' continuous demand for classroom computers. His intervention during the project implementation was concerned with maintaining the project rather than accomplishing project goals. Not having any mandatory regulation for "hard to please" district math teachers to act on behalf of the funding requests, Dr. Perry had to create his own control mechanism, and classroom computers served this purpose. The project-generated computers were awarded according to teacher shadowing and inservice hours. This policy set aside the intended goal--instructional computer use to motivate minorities and girls--for the sake of manipulating local teachers into meeting the requests of the Private Sector Partnership program of the National Science Foundation.

Low-level class teachers at Bill Hank, who taught many minority students, did not participate in the project to gain classroom computers. When there were no more computers to distribute, there was no alternative that could
encourage district math teachers to cooperate in the project's implementation. Lack of teacher involvement caused the project's termination in the second year of the grant years originally proposed. Any project that does not pursue its intended outcome has to expect early termination. But, the reason for the technology application project's abrupt demise was not that it did little toward intended outcomes, but that the project under-spent the allocated funds. The reason for early termination of the project created suspicion about the sponsor's seriousness in accomplishing the project's goals.

Math teachers at Bill Hank and Putnam were interested in gaining classroom computers through the project. Their unanimous response to the projects' benefit says it all. Math teachers did not pay attention to the intended computer use because of lack of actual assistance that could ease the school routines, and because of their different ideology in instruction. When there was pressure to do well on standardized tests and to cover textbooks, math application and problem solving had secondary importance. Math teachers also believed that what it takes to do well in mathematics is ability and hard work, and they did not see the role of computers in encouraging these characteristics. Other factors such as race, gender, and socio-economic status concerns were viewed as by-products that did little to influence instruction. Rather they were outside school problems which teachers could do little to change.

The implemented technology application project revealed that interests of involved members were "loosely coupled." The absence of regulatory power to bind these remotely related members into one accord made the planned change hard to accomplish. Instead, these different interests allowed various interpretations of the project that often deviated from its intention. By ignoring the teacher ideology that impinges on the very intent of the project--use of
technology for minorities and girls—the project provided little benefit to these students.

Second, the technology application project reinforced the distrustful relationship between the superordinate (the district math coordinator) and subordinates (school teachers) through the way the project was planned to include the district math teachers in the process. The technology application project reflected the current trend of school reform movements by emphasizing the role of teacher as a mediator to bring changes into math curriculum. The role of teachers in the project was defined by the district coordinator to fit the criteria of Private Sector Partnership Funding of the National Science Foundation. The district teachers did not define their roles in the project application.

The manner of defining teacher roles in the project revealed the assumption that teacher behavior would be changed through rigorous training. Again, the project's input-output view of mathematics curriculum change was revealed through this assumption which, by ignoring the organizational control mechanisms, did not reflect the actual difficulties teachers confront in changing their teaching styles and instructional techniques. Instead, teachers were defined as passive recipients who need to be trained. When training does not work, blame goes to individual teachers. By deflecting attention from structural variables onto individual teachers, popular functionalist theories maintain the structural status quo at work in the implemented project.

It is said that in a non-bureaucratic organization authority exists only when subordinates grant their superordinates a legitimate claim on their obedience, when they "decide" to participate in the organizational system at hand (Metz, 1990). If teachers are skeptical of many of the reform movement claims, and if they do not share interests with their superordinates, they lose
"faith" in their administration as an agency that will assist them to prepare for change. It is not rare that teachers "roll their eyes" when they hear that advanced technology will solve their classroom problems: a claim such as this one becomes a cliche that comes and goes. Uncompromised interests among the members in public education results in distrustful relationships. Teacher resistance against a change planned by their superordinates is reinforced and will be there for another burgeoning reform movement.

Third, the technology application project supported the technical potential of computers on behalf of un-motivated minorities and girls. By planning to raise these students' motivation only through instructional computing, the project assumed that the problem of low motivation is an instructional problem. On the other hand, teachers believe that student lack of motivation is social, that it goes beyond instructional boundaries. According to teachers, minority students in both schools did not enroll in a college-track math curriculum because they did not see the relevance of those courses in their future. Teachers believe that student life situations outside school massively affect students' attitudes and motivations for higher-level math classes. However, by considering low motivation of minority students and girls only as an instructional issue, the top executors of the project could not give teachers an opportunity to reach these students.

The project assumed that school life can be separated from its social context, yet social context has an irresistible power to influence each classroom, including mathematics classes. By ignoring the outside-school life of students who are not traditionally in the math population, the project failed to provide an opportunity for teachers to think about why minorities and girls lack motivation to enter higher-level mathematics courses. Ogbu argues in Metz' critique of current educational reform that minority students who see older relatives, even
those with diplomas, chronically unemployed will not make an effort in school as a means to earn a place in the workforce (Metz, 1990). The math teachers at both high schools, however, did not consider such social environment of minority students although they thought motivating these students was beyond instructional issues. Without this understanding, computers can hardly be used to counteract these students' social experience.

The technology application project was directed toward changes that the high school mathematics curriculum badly needed. The district public schools suffer from resegregation. The resegregation problem is especially distinctive in mathematics classes because of the rigorous filtering that is justified by the subject's stratified nature. There was no Afro-American student in calculus classes in the district's high schools for 1987-1990 school years, and minorities were under-represented in other higher-level math classes. Presenting mathematics in such a way that these under-represented students can relate classroom learning both within and outside school life is worthy of attention, and computers have a potential for this purpose.

However, enhancing opportunities for minorities and girls remained in policy statements, and no actual encouragement of these students occurred. Contrary to its intended goals, the technology application project was based on the very assumptions it was designed to eliminate. By ignoring the organizational features of schools, by assuming passive teacher roles that will be changed by intensive training, and by defining student low motivation only on instructional variables, the intended outcome could not be accomplished through the project implementation.

It is said that policies are rarely implemented as planned and frequently they bring "unwanted effects" (Jungck, 1985; Metz, 1990). Computer use in the project demonstrated that administrators and teachers subverted goals. Project-
generated computers were placed in higher-math classes, and students in average and upper-level classes were given more opportunity to use project-generated computers. Moreover, by ignoring teacher ideology, which reinforced the existing filtering role of the math curriculum by race and gender, the project implementation nullified the intentions of the National Science Foundation. This subverted project implementation might create additional equity issues in instructional computer use by pointing at the intended beneficiary population for their failure to assimilate into the mainstream culture despite "several opportunities" offered by state, government, and private grants such as the technology application project.

The implementation of computer activities in two high school math programs is an example of current computer integration effort that is defined as a technical task to invest hardware, software, and teacher training for desirable outcomes. Established conceptions of textbook-oriented knowledge, of teacher belief about students, and of organizational controls are taken for granted in current government and state level effort in educational computing. As a result, computer activities are rarely incorporated into instruction and they reinforce the status quo when used in classroom learning.

In summary, the technology application project brought computers to schools in order to change the high school math curriculum so that it no longer eliminated students from participation in higher-level math courses by gender, race, or SES prejudice. Instead, the project's purpose was to enhance and enrich math curriculum so that student motivation would be increased and so that students would see and appreciate the relevance of mathematics in work and daily life. In this way, more students could be presumed to take middle- and high-level high school mathematics courses. This study has suggested that instructional computer implementation should not be conceived as an
instrumental process for identifying inputs and outputs, goals and means, but as a process interacting with political and social factors by examining how schools shape actual instructional computer use. In order for empowering and innovative computer experience to take place, resources have to be made available, and both the rules and dominant ideologies that regulate the work in schools and conceptions of curriculum have to be examined critically.
APPENDIX A

RECORD OF CASE STUDY DATA COLLECTION SCHEDULE

Bill Hank

1991 -1992

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APPENDIX B

INTERVIEW GUIDELINES

School culture
- How long have you been here?
- How did you come to the school?
- Changes in school
- Changes in the department
- In what kind of school/department are you working?
- Parent involvement (PTA influence, relationship between the parents and teachers...)
- Ongoing support from the administrators and from the community?
- Appropriate schooling for students (college prep., job skills, parenting...)

Faculty culture
- How math department is regarded from other school staff?
- Who takes math? (SES, gender, race...)
- Who uses the math lab? (control over resources, priorities...)
- How do you decide who teaches what classes?
- Aspects that you emphasize in classes (covering concepts, doing well in tests, make math practical...)
- Different atmosphere in honor and fundamental classes - who can mostly benefit by instructional computer use?
- Who is considered to be a good teacher among the colleagues?

Technology application project
- How do your school do?
- goals of the project

Shadowing
- How did you choose the sites?
- Did you go alone or with other teachers?
- Is shadowing worthwhile experience?
- learning experience
- applicable to the class
- substitute teachers
Use of computers
main use
will be beneficial to your kids?
will make difference eventually? (picture ten years after...)
why computers in the first place?
distribution of the first five computers
ownership?
proper place for the project-generated computers
necessary in your teaching
feel pressured to use computers
the place of the instructional computer use in your priority list

Purchase of software
Who purchase software?
decision making process (how to purchase software)
software which is used frequently

Training
in-service you have had in the past
in-service from the project

Peer coaches
their roles
What did they do for the implementation of the project?
How they were selected?
channel between teachers and the district math coordinator
teachers who were not participating the project
merit from the project?
suggestions for a future similar project (instructional technology)
any aspect that I left out?
DATE
Mr. Friend
Bill Hank Senior
1011 Limestone Dr.

Dear Mr. Friend:

This is Eunsoon Kwak, a Ph.D. candidate in the program of Instructional Design and Technology at the Ohio State University. These days I am auditing classes at the University of Limestone in educational research. Although I am in the field of technology use in education, I myself have a limited first-hand experience of it in US schools.

Recently, I learned that the technology application grant is available in your department. I am interested in your point of view about the project. I am neither an employee of the central office nor of the university. I am planning to do this with the hope that I might write a dissertation which is focused on your views about using calculators/computers in instruction. I hope that I can learn more from you.

Thank you for your time.

Sincerely,

Eunsoon Kwak
## APPENDIX D
### TECHNOLOGY APPLICATION INSERVICE PROGRAMS

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REFERENCES


Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Whittrock (Ed.) *Handbook of research on teaching* (3rd edition) (pp.119-161), New York: Macmillan.


