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INTRODUCTION

CHANGES IN COMPUTER TECHNOLOGY DURING THE PAST several decades have been extraordinary in both their magnitude and rapidity. Ten years ago Lepper pointed out that portable personal computers costing less than $1,000.00 were available that had more computational power than could have been delivered 30 years before that by a $10 million machine the size of an average living room (Lepper, 1985), and the cost per unit of computational power has continued to decline dramatically. An even more striking way of illustrating the pace of change is to compare the computer and automobile industries. As Lepper notes, if the automobile industry had obtained increases in efficiency and reductions in cost comparable to those occurring in the computer industry, a Rolls-Royce would cost less than $2.75. Furthermore, it would get almost 3,000,000 miles per gallon and be capable of towing an aircraft carrier.

These remarkable increases in computational power have been accompanied by rapid proliferation in the uses to which computers can be put. Computers now play an important roll in manufacturing, sales, transportation, entertainment, and finance and are found in consumer products ranging from automobiles to toys for preschool children. Developments in computer networking now allow individuals to communicate with others around the globe with extraordinary speed and ease. Advances in both computer and laser optical storage technologies have led to the development of videodiscs, which enable the user to interact freely with complex multimedia programs in ways virtually undreamed of only a few decades ago.

The likely social and economic consequences of this technological revolution are a subject of considerable controversy (Burnham, 1983; DeSola Poole, 1977; Dunlop & Kling, 1991; Hiltz & Turoff, 1978; Kling, 1991; Toffler, 1980; Zuboff, 1988). Some scholars pre-

sent an almost utopian vision of the potential embodied in these developments (Feigenbaum & McCorduck, 1983; Papert, 1980; Straub & Wetherbe, 1989). Others have a profoundly different view, emphasizing actual or likely negative consequences (Braverman, 1974; Buesmans & Wieckert, 1989; Mowshowitz, 1986; Reinecke, 1984; Weizenbaum, 1976). However, most proponents of these diametrically opposed schools of thought generally agree on one thing – that change has been and will continue to be major in both size and scope.

Much attention has been paid to the impact of computer technology on work, perhaps because changes in this realm have been so far-reaching. Training for a wide variety of civilian and military jobs, ranging from Federal Express delivery personnel to tank gunners, has been profoundly influenced by the advent of computer-controlled videodisc systems (Garfinkel, 1989). Developments in robotics have substantially altered the nature and number of blue-collar workers needed in many industries. Advances in other sorts of computer technology have changed many white-collar and professional jobs in important ways (Bikson, Gutek, & Mankin, 1981; Buesmans & Wieckert, 1989; Derfler, 1989; Folk, 1977; Hiltz, 1982, 1988; Kuhn, 1989; Lipinski, Lipinski, & Randolph, 1972; Mowshowitz, 1986; Shaiken, 1986; Strassman, 1985; Straub & Wetherbe, 1989; Wood, 1989). Opinions differ sharply about whether these changes are to be welcomed, but the existence of change is rarely denied.

The impact of computer technology has not, of course, been limited to the workplace. For example, popular press reports suggest that computers can facilitate romance as individuals utilizing electronic networks become acquainted with each other and then engage in electronic courtships. On the other hand, the term, *computer widow*, has been coined to describe the situation of wives whose husbands seem to prefer interacting with their home computers to interacting with their spouses. Computer-based "virtual reality" experiences attract thousands of vacationers in cities such as Las Vegas. The extent to which computer technology has changed leisure time activities is highlighted by the growing incidence of "video-wrist," an ailment found among adolescents who spend

long hours, and large sums of money, playing video games. The medical community is also faced with learning how best to treat numerous other stress-related injuries stemming from the increasing use of computers in the workplace (Horowitz, 1992). In sum, the broad scope and significance of the changes that computer technology appears to foster suggest that Herbert Simon and others who contend that the computer is not just the invention of the century but a "one-in-several-centuries" innovation (Simon cited in Lesgold & Reif, 1983) are correct.

One important domain of life that appears likely to be influenced by advances in computer technology is that of education. Here again there is controversy about the probable effects. Some scholars make rather startling claims about the computer's revolutionary potential. For example, Derrick Walker (1984, p. 30) contends that "the potential of computers for improving education is greater than that of any prior invention, including books and writing." In 1984 Seymour Papert (quoted in Cuban, 1986, p. 72), the developer of LOGO and a well-known proponent of the benefits of educational computing, claimed, "There won't be any schools in the future. . . . The computer will blow up the school."

Others take a much more restrained view. For example, Cohen (1988) points to the often glacial pace of change at the core of our educational system and concludes that if computer technology does become widely used in ordinary school settings, it will be for standard and relatively undemanding activities such as drill and practice. He calls for stepping back from the rush to acquire computers for schools to ask both value questions about how one should learn and teach, as well as hard-headed financial questions about cost-effectiveness. Cuban (1986) reminds us that at one time people held what, in retrospect, seem to be almost ludicrously exaggerated expectations about the potential impact of other technological innovations such as radio, film strips, and television on the educational system and cautions against the heedless adoption of computers by schools merely because they are widely used elsewhere. Other scholars have even argued that computer use can exacerbate problems in our educational system. For example, since schools serving affluent children tend to have more computer

equipment than those serving less affluent children, the long-standing achievement gap between the rich and the poor is likely to grow even wider if computers do contribute importantly to children's education.

In spite of such divergence of opinion within the scholarly community, there is a widely shared expectation in the general public that the use of computers will somehow enhance education. Thus, it is common for PTAs and other parent groups to engage in fund-raising drives to procure computers for their children's schools. Apple Computer's "Apple for the Students" program, which gives computers to schools in exchange for students bringing in receipts for purchases from local merchants, has received widespread community support. Further, there is concern that children who do not become familiar with computers during their years in school will be left behind in an increasingly technological society. Such concerns are reinforced by government reports, such as the report of the Secretary's Commission on Achieving Necessary Skills (U.S. Department of Labor, 1991), which indicates that the ability to use technology is one of the five broad competencies required for effective participation in today's workplace.

These two factors have contributed importantly to an extraordinary increase in the number of computers in schools in the past 15 years. For example, between 1981 and 1987 the proportion of U.S. schools with one or more computers intended for instruction more than quintupled from 18% to 95% (Office of Technology Assessment, 1988). Furthermore, the average number of computers available in schools that have computers also rose dramatically, increasing nearly tenfold in the 4 years between 1981 and 1985 according to some estimates (Staff, 1985). Although the rate of change has recently slowed somewhat, the number of computers in schools is still increasing at over 10% a year (Quality Education Data, 1992). Current expenditures for computer hardware and software for pre-college education total almost $1 billion a year (Anderson, 1993). Furthermore, as Levin and Meister (1984) point out, such figures significantly understate real costs since substantial training and maintenance expenses are also incurred when computers are used.

In spite of the rapid proliferation of microcomputers and related

technology in schools, and the very significant amount of money spent on them, many schools and school systems appear to have given relatively little thought to how to utilize these machines once they have them. Further, when such thought has occurred it has often been focused narrowly on issues such as what software to purchase or how to keep the machines from being physically damaged or stolen. These issues are undoubtedly very important. Obviously, if the software is poorly designed or the computers are lost or broken little of educational value will result from their purchase. However, I would argue that equally fundamental to realizing the potential of computer technology to improve education is an awareness of schools and classrooms as social organizations that both influence the way in which any new technology will be adopted and are influenced by that technology in sometimes unanticipated ways.

A long history of research on change in educational settings suggests the importance of an awareness of the ways in which the structural and organizational aspects of educational systems influence the adoption and adaptation of innovations (Crandall & Loucks, 1983; Fullan, 1982; Gross, Giaquinta, & Bernstein, 1971; Huberman & Miles, 1984; Oettinger, 1969; Sarason, 1971; Schofield, 1982; Smith & Keith, 1971; Sussman, 1977; Van den Berg, Van Velzen, Miles, Ekholm, & Hameyer, 1986). There is little reason to think that things will be different with computers, as Cohen (1988) and Cuban (1986) have suggested. In fact, although little research has focused on this sort of issue, that which does exist highlights the influence of social and organizational factors on computer usage in schools. Thus, in thinking about likely consequences, one needs to recognize that computer systems are "complex social objects constrained by their context, infrastructure and history" (Kling & Scacchi, 1982, quoted in Kling, 1991, p. 358). A particular combination of hardware and software may be utilized in very different ways in different contexts with very different results. For example, Becker (1984) found that the amount and type of computer utilization in elementary school classrooms is related to the relative importance of different actors (teachers, principals, or other administrators) in the acquisition of those machines. Another

part of the same study demonstrated a linkage between the type of individuals heavily involved in the acquisition process and teachers' reports of the impact of these computers on both cognitive and noncognitive student outcomes. Similarly, a paper based on a series of case studies of microcomputer usage concludes that "the effects of microcomputers on education will depend, to a large extent, on the social and educational contexts within which they are embedded" (Sheingold, Kane, & Endreweit, 1983, p. 431).

Although the ways in which computers are utilized are undoubtedly influenced by the ongoing context into which they are introduced, it is also reasonable to expect that their use will in turn influence that context, again often in unanticipated ways. For example, Hativa, Swisa, and Lesgold (1992) studied two contrasting computer-assisted instruction (CAI) systems used in schools and concluded that both influenced classroom competition in ways unanticipated by their designers. Similarly, several studies have suggested that using computers in the classroom leads to changes in the teachers' role, such as a decrease in teacher-centered activities or a shift from an emphasis on lecture and recitation to more individualized coaching (Gearhart, Herman, Baker, Novak, & Whittier, 1994; Kerr, 1991; Linn, 1992; Office of Technology Assessment, 1988). In light of all the attention given to the possible improvement of student learning as a consequence of computer use, it is both fascinating and somewhat ironic that some studies find that teachers are quick to observe changes in student enthusiasm, peer social processes, and student–teacher relations after the introduction of computers into their classrooms even when they do not see much change in student learning (Becker, 1983; Sheingold et al., 1983).

There are many indications that changes in classroom structure and social processes often follow the introduction of computers (Brod, 1972; Collins, 1991; Hawkins, Sheingold, Gearhart, & Berger, 1982; Kerr, 1991; Levin & Kareev, 1980), as discussed earlier. However, their widespread use in schools is so recent and research relating to their social impact in educational settings is so sparse that few generalizations seem warranted. One thing does seem clear – though computer use in and of itself is hardly a concep-

tually satisfying variable likely to have consistent and predictable results. Factors such as the purposes for which the computers are used (drill and practice, simulations, tutoring, communication, etc.), the specific hardware and software chosen to achieve these ends, the ratio of students to computers, and the physical location of the computers (classrooms vs. school libraries or computer labs) all seem likely to influence social and academic outcomes profoundly. To take an obvious example, it is unrealistic to expect measurable academic consequences of computer usage when students do not work on the machines for more than 10 or 15 minutes a week, as is frequently the case. On the other hand, intensive use might be expected to shape both the amount and the nature of what students learn.

Just as the kind and amount of computer use have obvious implications for the likelihood of various academic outcomes, so too they have implications for social outcomes. For example, drill and practice programs that do little more than serve as electronic workbooks may pose relatively little challenge to standard operating procedures or traditional teacher–student relationships. However, artificially intelligent computer-based tutors or wide-area computer networks may pose a much more profound challenge to existing classroom practices and roles. For example, artificially intelligent tutors could well influence authority relations in the classroom by reducing students' dependence on the teacher for achievement of their learning goals. Similarly, wide-area computer networks have the potential to reduce students' dependence on their teachers by giving them relatively easy access to a wide variety of individuals with expertise greater than their teachers' in specific content areas. In addition, such networks make possible close and ongoing collaboration between students from widely separated geographic areas that just was not feasible before.

THE RESEARCH QUESTIONS

The perspective developed in the preceding section, which is very consistent with a viewpoint Kling (1990, 1991) and his colleagues

have dubbed "the web model," influenced the research reported in this book in two fundamental ways. First, it led to the dual focus on how computer usage changes classroom social processes and on how the social context shapes computer usage. Second, it led to a methodological decision that will be discussed shortly.

The dual focus of the research reported in the following chapters can best be captured by indicating the two general questions that underlie the work. The first is, "What is the effect of the instructional use of computer technology on students and on classroom social processes?" Since classroom social processes are of great potential significance, both for their effect on academic achievement and for their impact on students' conceptions of learning and attitudes toward school, it is important to take the possibility of such impact seriously and to explore the extent to which it is a reality. Chapters 2 and 3 detail some of the ways in which computer use does indeed appear to affect students and teachers, as well as the classrooms in which they function.

The second question that underlies this research is, "How does the social context in which computers are used for instruction shape their use?" When beginning the study, I expected that classroom processes were likely to be changed by computer usage in ways that were anticipated neither by those who developed the technology nor by the decisionmakers who were responsible for the computers' presence in the classroom. Initially, this second question was seen as secondary. It quickly emerged as a very important focus of the research as work during the first months of this project again and again suggested the crucial and pervasive effects of context on computer use. Chapters 4, 5, and 6 deal with this issue.

With regard to methodology, the belief in the likely importance of context led to the decision to undertake an intensive qualitative study of computer usage at one high school so that it would be possible to delineate the context studied in rich detail. It seemed as if this strategy would be fruitful in suggesting linkages that might not be readily apparent otherwise, given that very little is known about what these context effects might be. However, awareness of the highly varied nature of computer applications and of the likeli-

hood that different applications might both have different effects and be affected in different ways by context factors led to a decision to explore a wide variety of applications within this school. Thus, following Sheingold, Hawkins, and Char's (1984, p. 51) exhortation to "ask questions about particular uses of . . . technology in order to begin to understand its relation to the social life of classrooms," the study reported here examined virtually every case in the school in which computers were available for use. This led to the exploration of situations as varied as geometry classes in which college-bound students used artificially intelligent computer-based tutors to learn how to construct proofs and business classes in which vocational students learned basic word processing skills.

Having given the reader a sense of the questions that the research was designed to illuminate, as well as of the general approach taken, I will briefly lay out the structure of the rest of this chapter. First, I describe Whitmore High School,[1] the site at which this study was conducted, and discuss why it was selected. Then, I briefly outline the historical and policy context of computer usage there. Next, I turn to a description of the methods used in gathering and analyzing the data upon which this book is based.

RESEARCH SITE

Data gathering took place during a 2-year period, from September of 1985 to June of 1987 in Whitmore High School, a large urban high school that serves approximately 1,300 students from extremely varied socioeconomic backgrounds in the Waterford school district. Although the data were gathered some time ago, my continuing research on computer use in several schools in Waterford (Schofield, Futoran, & Eurich-Fulcer, 1994a; Schofield, Futoran, & Eurich-Fulcer, 1994b) clearly suggests that the issues raised in this book are still very pertinent. Whitmore's student body was about 55% African American and 40% white. Most of the remaining students were

[1] Pseudonyms are used for all individuals, institutions, and places in order to protect the confidentiality of those participating in this research.

Asian Americans. Whitmore's student body roughly mirrored the racial and ethnic composition of the students enrolled in the school district in which the school was located, although it had a slightly higher proportion of African Americans than the district as a whole.

As is the case in a great many urban high schools, the kind of student body found at Whitmore changed materially during the 1970s and 1980s. In the early 1970s, whites constituted over two-thirds of the student body. Many of these students came from well-educated and reasonably affluent families living in a neighborhood that was widely considered one of the most desirable residential areas within the city. Another substantial group of students came from Italian and Irish ethnic working-class communities. Fifteen years later a markedly increased proportion of the students were African Americans from economically disadvantaged neighborhoods with relatively high drug abuse and crime rates. The turnover rate in the predominantly African American community immediately adjacent to the school exceeded that of any other community within the city, posing to the school the challenge of working effectively with numerous transient students. Whitmore continued to enroll many students, both African American and white, from working-class and middle-class backgrounds. However, the proportion of students from such backgrounds dropped sharply, whereas the proportion of students whose families routinely had to deal with marked economic hardship increased markedly.

The school's faculty was about 80% white and 20% African American. African American teachers were distributed relatively evenly throughout the school's 10 departments, with the notable exception of the foreign language and science departments, which were entirely white. Roughly half of the school's 88 teachers were women. However, the gender composition of the different departments varied dramatically in ways that one might expect given traditional gender roles. So, for example, about 70% of the mathematics teachers were men compared with about 30% of the English teachers. Also consistent with traditional staffing patterns was the fact that the school's principal was a white male.

The very large majority of the school's faculty were middle-