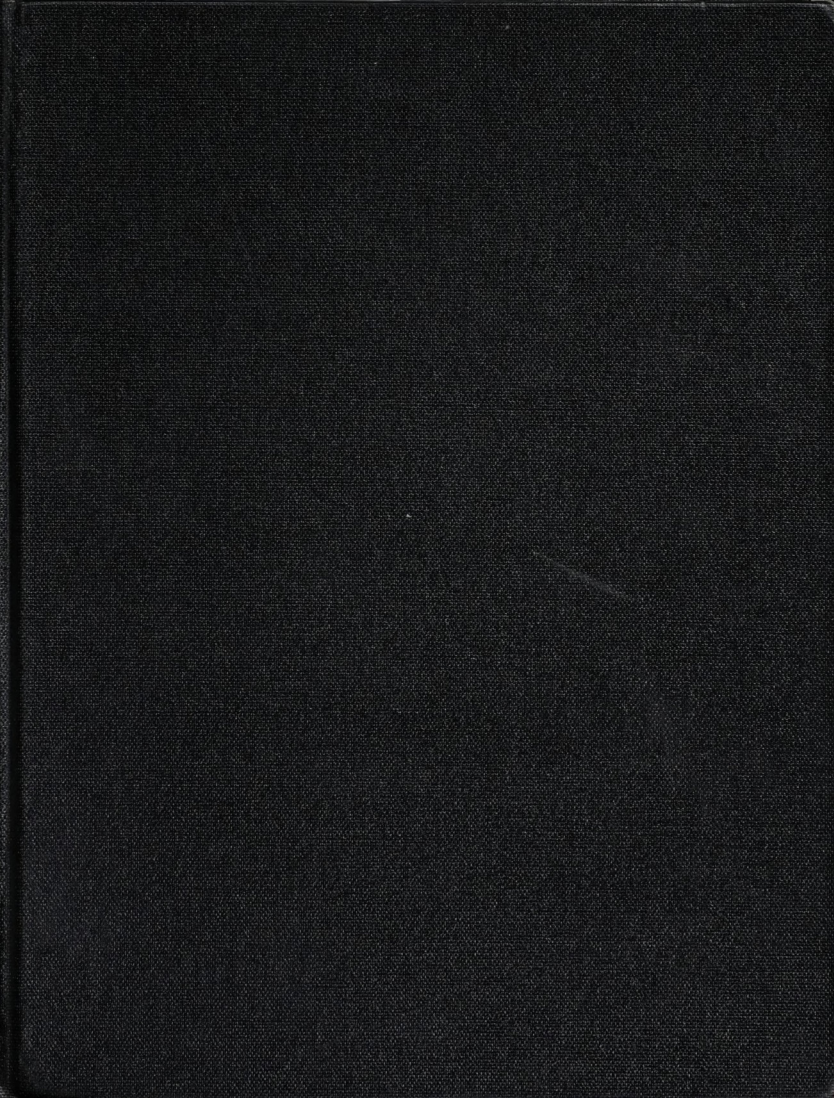






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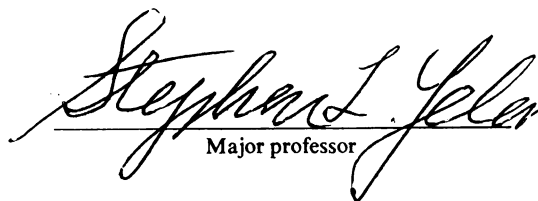
*A Qualitative Study of Faculty's Perceptions of
Computer Use for Teaching and Impacts on
Teaching and Learning*

presented by

Bosede 'Remi Aworuwa

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Educational Systems
Development


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A QUALITATIVE STUDY OF FACULTY'S PERCEPTIONS OF COMPUTER USE
FOR TEACHING AND THE IMPACT ON TEACHING AND LEARNING

By

Bosede Oluremi Aworuwa

Volume I

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ABSTRACT

A QUALITATIVE STUDY OF FACULTY'S PERCEPTIONS OF COMPUTER USE FOR TEACHING AND THE IMPACT ON TEACHING AND LEARNING.

By

Bosede Oluremi Aworuwa

The views that college graduates are going into the work force ill-equipped to use the technological tools of work in society, as well as an inadequate knowledge about how technology functions in higher education classrooms, contributed to recent calls for more research into the use of computers, especially, how faculty and students currently interact with technology in the classroom.

This is a qualitative study of how a group of professors perceive computer use in their teaching and its impact on teaching and learning. Sources of data include in-depth interviews of twelve professors. For an in-depth look at the context in which professors use computers for teaching, three of the professors were selected for further case studies. Additional data collected to build the case studies include in-depth interviews of selected students of the three professors, computer resource personnel and an administrator, classroom observations, and documentation.

Among the findings of this study are that professors use computers for different teaching purposes including enhancing their own efficiency and effectiveness in the classroom, providing computer experience for their students, and extending their office hours. Teaching activities for which professors use computers include classroom instruction, instructional planning, management, communication, information storage

and retrieval, testing, and grading. Impacts of computer use on teaching perceived by professors include the opportunity to expand the range of teaching strategies, efficiency in managing teaching tasks, and more control of teaching. Perceived impacts of computer use on learning include increase in students' class participation, increased in quality and quantity of learning, positive attitudes toward learning, and marketability. Among the impacts on classroom interactions are new mode of communication, increase in cooperative learning, and new roles in the classroom.

Some of the conclusions of this study are that computer use among the professors studied is idiosyncratic, influenced by personal and institutional factors. Positive changes taking place as a result of computer use indicate that computers may offer education the opportunity to redefine educational goals that reflect the needs of the information society. Computers are not likely to replace teachers in the classroom, and full integration of computers into the classroom process is still far from being achieved. The revolution that computers may bring to education may be just that it fits better into the structure existing in the school than prior technologies.



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1994

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DEDICATION

Glory be to God Almighty
and
Our Lord Jesus Christ
For a journey completed and
To Whom I lift up my eyes
For inspiration and guidance
At the dawn of another journey of life.

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CHAPTER ONE

INTRODUCTION TO THE STUDY

Educators and educational researchers consistently cite one factor as central to the full development of technology's use in the schools--the classroom teacher (Office of Technological Assessment, 1988, p. 87). According to H.S. Austin (1988), faculty use of computers is important to the success of any kind of academic computing initiatives in higher education. Yet, there is little known about how professors integrate computers into their work.

This study is a qualitative investigation of faculty perceptions of computer use in teaching and the impact of their computer use on teaching and learning. Two main questions driving this study include: *In what ways are professors using computers in their teaching?* and *What are professors' perceptions of the impact of their computer use on their teaching, on students' learning, and on classroom interactions?*

Origin of the Study

My interest in a study of the use of computers among college professors came about from a combination of many factors. I first came into contact with computers as a tool in my first year of the graduate education program at Michigan State University. As an international student, I had only read about computers in my educational technology textbook when I was completing a masters degree in Educational Technology. I had analyzed data "crunched" from a mainframe computer; but I had never seen one. My impression of computers, therefore, was something you do computations with, and numbers were not my strong points. I could therefore empathize with the students who I later interviewed in this study.

As I began my Ph.D program at MSU, I took two short courses on the use of computers as productivity tools. Thus began my romance with computers. Suddenly, it

became a tool that could empower me. My first proseminar course required me to do a review of journal articles on a topic in my field. As a student of educational technology, and because of my new-found interest in computers, my natural choice was to review computers. Because my major is instructional design, and I was hoping to go back to my home country some day to begin to train others, I chose to review the uses of computers.

I reviewed articles and reports of studies from journals such as *Educational Technology*, *Computer-Based Instruction*, *Technological Horizons in Education*, *Educational Researcher*, *Educational Communication and Technology Journal*, and *Academic Computing*. I focused my review on topics like the use of basic productivity tools, that is, word processors, spreadsheets, databases, and graphics packages. I also reviewed advanced computer usages such as interactive video, multi-media instruction, as well as Hypermedia and Hypertext. These forms were the newest technology at the time.

Most of the studies I reviewed found computer-based or computer assisted instruction (with or without interactive video media) to be superior or equal to traditional instruction in effecting learning. This led experts such as R. Clark to be an advocate for the discontinuity of "effectiveness studies." According to Clark (1989), there is no evidence that the media used contributes to learning gains.

What was surprising to me during this exercise was that there were not as many studies devoted to teaching as there were to learning; and fewer still, were about teaching in higher education. This thought came to mind again four years later when I was taking a course about research on teachers' thought processes. *Research on Teachers' Thinking* is a body of knowledge devoted to understanding how teachers' thought processes influence their practice. In the review of studies on teachers' thought processes conducted by C.M. Clark and P.L. Peterson (1986), 99 percent of the studies reviewed were about elementary and high school teachers. Knowing that I will be

teaching prospective teachers at college level when I return, there was a need for me to study how college professors use technology for teaching, hence this study.

Problems of Education

The second reason I conducted this study was because of a need to fill the information gap in how teachers work with technology. For decades, since the arrival of microcomputers in education, the need to know if and how students learn with technology has overshadowed the need to know if and how teachers teach with technology in educational research. Experts are now redirecting the focus of research from effectiveness of media in learning to effectiveness of teachers teaching with media.

Recently, there has been concern among experts in the U.S. over the relevance of what students learn in schools in relation to the goals of an information society. M.R. Kozak (1992), in his critique of American education, said that the public educational system is not preparing students for jobs at home or for competition in a technology-based global economy.

While globalization and technological changes are taken for granted in today's business and industrial arena, education seems to be much more inwardly-focused. (Kozak, 1992, p. 3)

Schools appear to be immune to the pervasiveness of technology in society. According to A. Luehrmann (1989), educational institutions still resemble those of the industrial revolution classrooms. Schooling is about mental functioning, yet with the computer (which amplifies mental functioning) schools still lag behind other sectors of society in the use of the information technology.

This situation is not limited to public schools alone. Similar trends operate in higher education, which has a vested interest in the social and economic well-being of



society. More college graduates are coming out unprepared to fit into the work structure of an information society. According to R.D. Pea (1985), corporations spent 60 billion dollars in 1984 to reeducate their employees. Moreover, as the U.S. economy begins to change because of information technology, there is a corresponding increase in demand for education. There is an increased change in what must be learned and who must learn. According to H. Kelly of the Office of Technology Assessment (1990),

The system's failure to consider methods that have increased productivity and quality throughout the economy would be cause for concern if only because it is the nation's largest investment; (p. 60)

and because problems in education ripple throughout the economy.

According to N.K. Naron and N. Estes (1986), the problem of lack of adequate use of technology may be because educators themselves have not come to grips with what technology represents in education. Administrators of educational institutions are yet to "define appropriate functions of technology in schools, stipulate the content and process of teaching with or about computers, identify jobs for which to train students, and plan for the future in a fast-changing world of information technology" (p. 90). This is because there is a lack of information upon which educators can base informed decisions about technology use in education.

In order to adequately deal with problems of education and provide a visionary leadership for the future, administrators and educators need information about the current human-technology mix in schools. However, such information is currently not available. J. Paquette (1993, April 7) in EDTECH, an electronic discussion list observed that:

There is an lamentably irresponsible lacuna in our knowledge of how the new technologies are impacting on the overall human well-being of different constituencies in different social groups... As educators concerned with



educational technology, we have, in my view a profound, if not terrifying, obligation to do all in our power to promote broad, searching, and open examination of both the overt and covert impacts of technology on human social development, organization, and well-being (an examination, moreover, which takes full account of the values and beliefs which drive technology in education, in the work place, and in society at large).

Too much research on technology use in education has been conducted with little or no reference to the context in which the technology is being used. Most of the available studies on technology have focused on effectiveness of technology compared to traditional teaching methods, or effectiveness of one medium compared to another. But according to G. Salomon (1990), the effect of a medium cannot be known apart from the context of its use. It is like separating the flute from the orchestra. A more useful research approach is to look at how "aspects of a system, that is, the person and context, coexist and jointly define one another and contribute to the meaning and nature of ... [the] event" (p. 527).

An important aspect of the context of learning is the teacher. To date, little information exists about how teachers integrate technology in their teaching. Sorely lacking is the information about the kinds of changes that teachers are making in their classrooms, and what technology means to them personally and professionally. "Nearly every innovation requires teachers to change on several dimensions: the use of new materials, alterations in their teaching behavior, and changes in their beliefs and attitudes" (J. van den Akker, P. Keustern, and T. Plomp, 1992, p. 68). There is little known about the functioning of these dimensions within classroom contexts where computers are used. According to J. Olson (1992):

We still have not reached a point where we can fully appreciate what it means for life in the classroom to adopt any or all of the machine-person ideas currently on offer to schools. We know little of the intellectual content of these visions, and we know even less about what taking them seriously in schools would mean. (p. 79)

An obvious source of information on technology that has frequently been overlooked in research is the teacher. Until the last two decades, when *Research on Teachers' Thinking* made it known that teachers' thought processes influence the outcome of teaching, teachers have always been seen as persons whose behavior effect students' achievement. Most research in the *Process-Product* tradition focused on linking teachers' overt behaviors--like lecturing, asking questions, and giving directions--to students' achievement gains (J. Brophy and T. Good, 1986). But "many processes of teaching and learning cannot be understood and explained when the views and the knowledge of the individuals involved are not considered." (M. Ben-Peretz, R. Bromme, and R. Halkes, 1986, p. 2). *Research on Teachers' Thinking* increased the understanding about how teachers' beliefs, knowledge, and decision-making influence outcomes of classroom events.

Notably absent from *Research on Teachers' Thinking*, however, were the views of the college professors. Over 30 studies reviewed by C.M. Clark and P.L. Peterson (1986) focused exclusively on elementary and high school teachers. Ninety percent of the studies conducted under the *Research on Teaching* tradition, popularized by L.S. Shulman (1987), are on elementary and high school teachers. S.A. Bray's (1986) study was one of the few studies that focused on teachers in higher education. Bray's study is about what university instructors in a professional school think about during teaching.

The recent shift in focus of research in academic computing from student's learning to faculty's use is welcomed by educators as a change in the right direction. H.S. Austin's (1988) study of Oakland Community College faculty is among the earliest faculty studies. Through a survey, Austin examined the faculty's interest in, and opinions concerning, the computer as a professional tool and as an instructional method. Among his findings is that computer interest of faculty varied by discipline. High levels of computer literacy were experienced by only a small minority of

professors (5 percent). Austin was able to identify two categories of computer uses among faculty--computer use for instruction and the computer as a professional tool.

R.E. Betza's (1986) study documented instructional uses of computers at the University of Washington. Through a telephone survey of faculty who used computers in their courses, Betza developed a framework of computing that grouped computer use for instructional purposes into tools, tutor, and tutee functions. Betza also identified educational objectives that computers were used to serve. These included learning, performance, and job preparation.

As notable and useful as these earlier studies are, they have not provided a framework for understanding how computers function in the classroom. The process of combining skill, knowledge, interest, and belief with educational goals within the individual faculty's classroom has not been studied. As society's expectations for higher education begins to change with information technology, a closer look at the process of education that utilizes technology as a tool becomes imperative. How do users, especially professors perceive its impact on their work and their students' learning. What roles are computers allowed to play in the classroom by professors? Providing answers to these questions is preliminary to developing visionary models of computing in schools.

Purpose of Study

The purpose of this study therefore is to investigate and describe faculty's perceptions of their computer use for teaching and the impact on teaching and learning in their classrooms. This study is necessary because knowledge thus generated may serve several purposes. It may provide a basis for faculty who are beginning and non-users of computers to make informed decisions about computer use in their teaching. "Faculty members need to see how creative and effective teachers change the curriculum, their assignment, the arrangement of the classroom, and the ways students



interact when faculty introduce technology into their courses" (R.B. Kozma and J. Johnston, 1991).

This study may enhance understanding about how educators can plan for future use of computers in schools. Knowledge about the current use of computers may serve as a pointer in defining future educational goals and roles of computers in education.

The Focus of the Study

This study focused on computer usage for teaching by individual professors in their classrooms. The study was based on the perceptions of faculty concerning the way they use computers in their teaching. It also explored faculty's perceptions of the impact of such usage on their own teaching, their students' learning, and on classroom interactions.

Scope of the Study

This is a descriptive study of how faculty at MSU are currently using computers in their teaching, and their perceptions of the impact of such usage on teaching and learning. The main focus was on professors' computer use for teaching. Teaching here is defined as all activities relating to teaching, including, instructional planning or preparation, classroom instruction, testing, grading, and instructional management. Faculty computer uses for research and personal productivity were not included.

By using a qualitative approach, the topic of faculty computing was allowed to develop from participants' perspectives. The details of the professors' experiences presented in this study were for the purpose of providing exemplars of computer usage to which new or non-users could relate.

The study did not attempt to provide information about how computing skills develop over time. The purpose of the study was to find out what people do, depicting



the process of faculty computing at a particular point in time, so that others can be informed as to what the possibilities may be. As an exploratory study, therefore, the results may provide a basis for a longitudinal study of how faculty develop computer skills over time. I found results similar to those reported in studies of academic computing, teaching, and innovation adoption and implementation, thereby contributing to the knowledge base in those areas.

THE LITERATURE: CONTEXT OF RESEARCH QUESTIONS AND INSTRUMENTS

A review of the literature was undertaken to provide a background for this study. It was also a means of identifying appropriate research questions to guide the study. The literature review was grouped into the following major categories: a) information society, b) the role of higher education in an information society, c) visionary models of computing in higher education, d) faculty role in setting visionary computing agenda, e) teachers and teaching, f) computers in education, g) research on faculty, and i) theoretical framework. Each section ends with a summary. A final summary of the literature review is presented at the end of the chapter, followed by the plan of the dissertation.

Information Society

According to sociologists, we are living in the "information age." (K. Gapen, 1990, p. 50). New information technologies have permeated all walks of life (Naron and Estes, 1986). The arrival of personal computers more than a decade ago makes it easier for individuals to own computers. The increase in capacity and low cost helps to accelerate the process of the computer revolution in the society. Both big and small businesses are using computers for record keeping, business accounts, salaries, and word processing. Increasingly, more homes are acquiring microcomputers for games,

for keeping family accounts, and for educational purposes. Pressure from parents and employers combine to thrust educators and hardware manufacturers into the race to equip the school with computers. In schools and colleges, computers have become part of the basic equipment and are being used for both administrative and instructional purposes (P.K. Egbo, 1987).

Global Economy

There are currently "technology superhighways" linking people at distant locations, thus increasing access to information, people, and products.

The expanding growth of world output crossing national boundaries, because of dramatic advances in transportation and information services, has advanced the concept of a one-world economy. Somewhere in the world, markets are open. Products are commonly produced in one country utilizing materials from a second country and exported for sale to still others... No American firm can afford to assume that it is impervious to foreign competition. (Kozak, 1992, p. 2)

Survival in this global economy depends on the ability to successfully access and use information. The Coalition for Networked Information (CNI) (1993) believes that:

International competitiveness depends less and less on traditional factors such as access to natural resources and cheap labor. Instead, the new growth industries are knowledge based. They depend on the continuous generation of new technological innovations and the rapid transformation of these innovations into commercial products the world wants to buy. That requires a talented and adaptive work force capable of using the latest technologies and reaching ever-higher levels of productivity.

Kelly (1990) describes the changes taking place in the U.S. economy, in particular, as:

...a shift to smaller, more responsive production facilities; increased attention to volatile, specialized markets; movement toward less centralized management; an

increase in the value added to primary energy and material resources; and an increased use of complex services such as marketing, product design and contraction. These changes increase the demand for education both by creating a need for more workers in job categories that have always required well-educated people and redefining traditional occupations in ways that have increased the need for education (p. 60).

New skills demanded by jobs in an information-intensive economy include, quick comprehension of written materials and an ability to speak and write clearly. New technologies increase the demand for interpersonal skills as well as technical skills.

There are also changes in who must learn. The economic changes mean education has to serve a much more complex constituencies than it has in the past. People with a complex mixture of backgrounds and learning skills are coming back to school, to either have their skills upgraded or learn a new set of skills (Kelly, 1990, p. 60).

Moreover, the pace of technology change is so rapid that students would need lifelong learning skills in order to cope with information obsolescence in the work place (N. Teger, 1991).

... To keep a competitive advantage in a world economy, [therefore] it is widely accepted that tomorrow's workers must have the skills to use computers and be able to exploit their power in new situations...(Kozma and Johnston, 1991, p. 22).

Summary

Information technology has brought about the concepts of an information society and a global economy. Survival of nations in this global economy will depend on effective competition. A nation's competitive edge hinges on a well-educated workforce that can adapt to change quickly. Students in U.S. higher education institutions, as in other nations in the global village, must learn to work with the tools of the trade, develop the ability to use information, communicate effectively, and develop life-long learning skills. What roles do higher education play in an information society?



The Role of Higher Education Institutions in an Information Society

According to M. Trow (1988):

Higher education is, today, I believe, the key institution in American society, the source of its most important ideas, values, skills, and energies... American higher education will be an even more important institution in this society in the decades to come: as supplier of more advanced skills as well as a source of greater social equality, continuing social commentary and criticism, and the transmission of ever-broadening cultural heritage. (p. 22)

The growing use of information technology creates new opportunities and challenges for society and education. The acquisition of basic computer competencies is of increasing importance to all students for success in an information society. Students need a full range of skills, knowledge, understanding, values, and relationships in order to function in a technological world and to cope with the inevitable changes that will occur. The opportunity to use computers and to develop skills in using software and in controlling the computer should, therefore, be provided, and this opportunity should cut across curricula and not be limited to any one academic area (G. McMeen, 1986, p. 104).

What are the prospects of higher education fulfilling this role, given its peculiar and deep-rooted characteristics? American higher education cannot afford not to respond to society's needs. By its very nature, it resembles the society because it is the product of, and a response to, forces and motives in the society.

The characteristics of American colleges and universities that help to shape how they respond to change include the market and market-related forces.

We can see the emergence of strong market forces in the early history of American Higher Education, we can see them today in the very structure and workings of our institutions... Among the market forces are the need for various kinds of professionals, and the number and diversity of institutions means that they compete among themselves for students, resources, faculty, and prestige. (Trow, 1988, p. 16)



There is also a symbiotic relationship between society and higher education. Higher education receives its support from federal, state, and local governments; private sources such as churches, businesses, firms, foundations, and individuals; and from students in the form of tuition. "In 1985-1986, expenditures of all kinds on American colleges and universities were estimated to be over \$102 billion...This represents roughly 2.5% of the Gross National Product." (Trow, 1988, p. 19) Such groups demand greater accountability from colleges and universities for the use of these funds.

The changing student population has been a trend in higher education since the early 1970s. An increasing number of older students are returning to school, and an increasing number of students are enrolled part time. There is also a large increase in enrollment of women and minorities (Trow, p. 14). Information technology has brought changes in occupational structure, such as the growth of knowledge and information industries. This has increased the number of jobs for college-educated people. Today, higher education, apart from serving people with a more complex mixture of backgrounds and learning skills, must also serve a much more complex market.

Computer technology provides higher education with a tool of work and learning. Its impact will only be felt with proper planning and implementation.

Summary

Society depends on higher education to survive in an information economy through research and development, and through the production of an educated workforce. Conversely, higher education depends on society for its existence and funding. How can information technology help higher education to fulfill its role in society?

Visionary Models of Computing in Higher Education

According to R. F. Weissman (1988):

If technology is implemented thoughtfully, the 1990s will witness a significant change in the way faculty and students use computers in learning and research. To be sure, this change will be brought about by the introduction and adoption of more advanced technology. Of greater importance, this change will occur because the values and models of computing--our vision of what computing can and should do and how users should be able to work--will change quite substantially. (p. 10)

Implementation of computers hinges on a well-thought-out vision of what computers should be able to do in education. McMeen (1988) believes this vision depends on the ability of higher education to rethink the current use of technology and to anticipate innovative changes that will reflect upon the nature of the educational process. The vision should include, not only the provision of resources, but also how computers can be used effectively in the education of large groups of students and students with special needs. The vision should also include anticipated social impacts of technology on schools and society (p. 105).

Setting Goals

According to M. Noblitt (1993), technology and its use must be built around issues, goals, and job requirements. School policy must focus on creating ownership of computing by the kinds of training and technical support provided, educational goals being served, and the reward structure. There must be widespread agreement upon the value of using computers in schools, and how they may be specifically utilized (McMeen, 1986).

Because the world will continue to change rapidly, education cannot stop with high school or even college. Today's students will continue to learn throughout their entire lifetimes. To support life-long learning, education is undertaking a complete transformation, with a strong emphasis on 'learning to learn'. Computer related technology will play an important role in this learning

process. As instructional methods change, the educational environment must also change... (F. Hill, 1988, p. 2)

Resources

In developing a visionary model of computing, provision of resources to achieve the stated goals should be the top priority among educators. Resources for computing include training of users, technical support, administrative support, and provision of hardware and software. University structure and policy should also be considered in this process.

Many faculty members are ill-prepared to utilize technology. OTA (1988) findings from studies of computer use in schools indicated that investment in technology cannot be fully effective unless teachers receive training and support. The inability of teachers to use computers extensively in teaching has been attributed to a number of factors. These include lack of knowledge or computer competencies, inadequate hardware and software, lack of computing support, and organizational structure of the school system (Kozma and Johnston, 1991).

Lack of Knowledge or Computer Skill

Of the three levels of competency that E.S. Vasu and M.L. Vasu (1987) identified as necessary for faculty to have in order to successfully integrate computers into the curriculum, computer literacy is the lowest and the most basic. Based on their study of computer integration into the social science curriculum in higher education, Vasu and Vasu developed a three-level framework for discussing the knowledge and skills that faculty need to use computers effectively in teaching. Level I of this framework includes basic knowledge of computers--the hardware and software--and ability to use basic application programs like word processors and courseware. Level II consists of Level I competencies and the faculty's ability to select, match, and evaluate software/courseware in terms of instructional objectives and students' needs. Level III

consists of Level II competencies and the faculty's ability to design and develop courseware incorporating effective instructional principles. Most faculty are still at Level I competency (D.L. Lillie, W.H. Hannum, and G.B. Stuck, 1989).

van den Akker, et al. (1992) believe that lack of technical skills in using computers creates uncertainties on the part of the teacher. A consequence of this may be that educational computing will be restricted to the limited level of expertise of the teacher.

The nature of training received by teachers has been criticized on the grounds that such a training provide only basic knowledge of the structure of computer systems. Most of the past teacher training programs have centered around computer literacy. Lillie, Hannum, and Stuck (1989) describe such programs as:

... noteworthy introductory computer courses. For the most part, these courses focus on how computers work, how to select appropriate software and hardware (usually from the viewpoint of technology), and how to use well-known applications packages. They also deal to some extent with the issues raised in using computers in the schools. Occasionally, courses include an introductory programming language. (p. 2)

Lacking in such training programs are competencies that encourage creative use of computers for teaching, especially how to integrate computer use into the curriculum. "Teachers need to know why, when, and how computers can be used to support effective instruction." (Lillie, Hannum, and Stuck, 1989, p. 3).

Moreover, the content of teachers' training needs to reflect societal goals and expectations. Teachers, because of their daily contact with students, must themselves be prepared to appreciate the globalization of society and to accept the concept of constant technological change (Kozak, 1992, p. 5).

Hardware and Software

M.J. Hannafin, D.W. Dalton, and S.R. Hooper (1987), writing on the myths that keep computers out of education, said that users believe that there is still not enough hardware in schools to encourage large-scale usage. In most elementary schools, for instance, the mode may be one computer per classroom. In such situations, teachers tend to regard computer use as an "extra" they have to take care of in addition to other classroom challenges like planning lessons, preparing materials, grading papers, and attending meetings. They do not view the computer as a tool that can be used to enhance the instructional process (D.I. Novak and G. Knowles, 1991).

The problem of inadequate hardware and software is compounded by very user-unfriendly software. Hannafin, et al., (1987) advocate easy to use authoring systems with "pull-down" menus and integrated support that would enable educators to gain routine, automatic comfort with computer use--just like driving. Documentation is also an important element in professors' use of computers. B.J. Winkel (1983) said that user-friendly computer documentation is that which is readable, well-organized, and easy to follow for new and old users.

Administrative Support

Administrative support for teachers is essential in planning a visionary role for computers in education. "Certainly, technology may enable the teacher to teach with new tools in exciting new ways that make the learning process more immediate and individual, but teachers may either not be ready for these changes or educated to their inherent advantages." (McMeen, 1988, p. 103). Moreover, teachers are anxious about learning computing skill and learning how to structure content and classroom environments to accommodate technology. Therefore, they must have support for experimentation and innovation, as well as time to learn and practice. C. Wagner and

A. Picciano (1993) believe that the computing policy of most universities that says to faculty "here is the equipment, you are on your own" does not work. Faculty needs training, technical support, and funding.

Recognizing the human elements in learning to use computers is a form of administrative support that most teachers need. The change in instructional role associated with computing may create unanticipated problems for teachers. Computers challenge teachers' existing instructional routines by requiring them to shift role from the image of the all-knowing teacher to that of a guide and a learning partner (Olson, 1992; Kozma and Johnston, 1991). Many teachers find this shift uncomfortable, and many do not know how to make the transition. Moreover, teachers experience many practical problems when they start to use computers. Computer use demands from teachers many time-consuming management and organizational activities (van den Akker, et al., 1992). Implementation of microcomputer technology in the classroom requires additional time for preparation. Teachers must be allowed time to learn and time to plan to integrate computers according to their educational needs (McMeen, 1988).

Team Approach

According to McMeen (1988), curricular innovations are always a team effort. Colleagues who have insights into computing may be a good resource to other professors. P. Albro (1987) found that peer involvement projects at Castleton College enabled the college to increase faculty computer literacy to about 60 percent in two years. Faculty's perceptions of how computers may be used in appropriate and unique fashions for their fields can be shared with their colleagues who are beginners (McMeen, 1988, p. 104).

A team approach in which knowledgeable faculty form user groups and technical support groups has been seen as another way administrators can provide support.

Organizational Factors

D.E. Drew (1989) believes that:

... those of us who want to increase the use of computers by universities must consider the unique, sometimes bizarre, structure and functioning of academic institutions (p. 59).

Educators must begin to realize that the introduction of computers in education is a complex innovation which encompasses more than just bringing the hardware, the software packages, and some trained teachers together into schools. The process may require new teaching strategies, other types of classroom and school organization, other roles and tasks of the teachers, new relationships between teachers and students, and even new courses or new emphases in the content of existing courses (T. Plomp and J. Moonen, 1992, p. 3).

T. Plomp and W. Pelgrum (1992), in a study conducted to examine the potential of restructuring education through the computer, found that there is no real structural change yet in classroom and school management. They contend that a large-scale structural change is needed for a major impact of computing to be felt. However, most school systems are unwilling to make such changes. Colleges and universities, in particular, seem to have complex problems in planning and implementing technology-based teacher training systems. Institutional constraints on developing entirely new courses and sequences are formidable (Naron and Estes, 1986).

Other organizational factors that can have an influence on how higher education copes with change include the university reward structure and budget. Presently, the



university reward system does not encourage computer use. According to S. Lindenau (1984), the university structure places a lot of weight on research and publishing, and little emphasis on teaching. Faculty are rewarded with promotion and pay raises based upon research and publications. Therefore, the use of technology for teaching would receive attention from faculty only if they saw it as something useful to them.

...In a profession where peer esteem and internal satisfaction are expected to supplement humble salaries for one's compensation, it should come as no surprise that faculty would use writing or consulting to improve their financial condition... In such an environment, new technology applications in college instruction will be undertaken primarily for the secondary benefits that they will produce: They must promise saving of or release from teaching time ... (M. Waggonner, 1984, p. 9).

The university budget can also place a limit on planning and implementation of computing. According to D.G. Carson (1986), a limited budget can drive technology change. The ability to acquire is integral to choices made about computing. Inflation and budget cuts mean that less money is available for innovation (Waggonner, 1984). The effect of this may go both ways. It may encourage the university administration to curtail waste by eliminating unnecessary programs. On the other hand, limited funds and the perception of lack of administrative support may force faculty to continue to perform along traditional lines to safeguard their jobs. This tends to override inclinations toward the more uncertain consequences of innovation (p. 9).

Policy

J. Johnston (1986) said that:

...On most campuses, the growth of computer use has not been a result of a campus-wide policy, but policies emerge when activities become sufficiently widespread to require policy.

Many of the schools studied by Plomp and Pelgrum (1992) have no formal policies for instructional computer use. Naron and Estes (1986) reported similar findings in their study of public schools and higher education. But, as Naron and Estes observed, policies regarding funding and other practices have changed. More funds are being allocated to technology, and most of the schools and colleges have computer literacy as their goal of computing.

The skill needed to interact effectively with the newer information technology, however, has gone beyond computer literacy. J. Sculley (1989), addressing the CAUSE 1988 conference on information technology, stated that there is a need for a new definition of productivity that will reflect the information age. Emphasis should be focused on empowering the individuals within institutions to perform to their utmost. "The real productivity gains in the information economy are going to come by getting the individuals to change the way they do things, change the way they work." (p. 12)

Developing an Effective Information Base

Colleges and universities need to encourage research in order to develop effective information systems on which to base future computing decisions. According to Johnston (1986):

Policy decisions should be based on thorough and accurate information... As with any new system introduced into an organization, it is important to identify potential problems with the implementation. What kinds of technical problems arise as students and faculty use computers? What are the limitations in the software being employed? Are there technical problems with sharing electronic text? Will the technical problems get in the way of accomplishing the desired academic tasks? How will non-using faculty react to the introduction? (p. 17).

Implementation of technology is an expensive venture for any institution. Adequate planning and proper implementation will insure less waste of resources. Information

about current computer use may guide decision-makers about future purchases, curtailing waste, devising implementation strategies, and formulating new goals.

Summary

Developing a visionary computing strategy in higher education requires setting goals that reflect the needs of the information society. It requires provision of resources for users. Budget and institutional structures may impose limits on how far the vision can go. Planning will help to curtail the waste of resources and insure proper implementation.

The Role of Faculty in Setting Computing Agenda

Instruction is one of the primary missions of higher education, and faculty are responsible for instruction. Therefore:

... any discussion of the application of technology to higher education ought to begin with a discussion of the kinds of work that faculty and students seek to accomplish (Weissman, 1988, p.10).

Teachers are the key to any technology implementation initiatives in education. Teachers can make or mar an innovation. The best conceived innovation may fail if teachers do not see its utility. Teachers may change the nature of an innovation to suit their purpose. The way teachers have modified Programmed Instruction to take on more of the characteristics of the regular classroom instruction is an example (W.L. Kritek, 1976).

Moreover, as McMeen (1988) suggests, computing issues in an institution should incorporate teachers' views because, teachers often represent the best clinical expertise available in terms of their knowledge about the practice of teaching (p. 105). The fate of computers-in-education will depend on how teachers and students utilize

their computers for instruction and learning purposes (D.F. Walker, 1983, p. 103). Knowing about the perceptions of professors' about teaching with technology may expand knowledge about the nature of an innovation because, as Olson (1992) states:

...Innovations often involve new ways of assigning meaning to practice. Teachers are aware of these meanings and their significance. They are engaged in a process of re-assigning meanings as they try new practices. To understand the actions of the teachers, we must think that teachers are doing more than act directly as instruments of students achievement. They act indirectly as well by expressing things about the subject they teach and the materials they use. They convey messages about what is important-about how they feel, about what they are doing, and about the class (p. 83).

There are still a large number of faculty not using computers for any professional purposes. Knowing how their more experienced colleagues creatively use computers in their own classroom, may help such faculty (Kozma and Johnston, 1991; Austin, 1988; Albro, 1987).

Summary

Faculty are responsible for instruction, one of the key missions of higher education. To adequately implement computing and use it to define new goals in higher education, faculty's views about the technology needs to be taken into consideration. Faculty represent the best clinical expertise on how computers can be used to promote the goals of education that are compatible with aspirations of the information society.

Teachers and Teaching

What is the context into which faculty try to integrate computers? There is currently no organized knowledge base on how faculty teach. A review of the literature on teachers and teaching in elementary schools and high schools reveal how teaching is done at those levels, which may have implications for higher education.

The context in which teaching and learning take place is very complex, unpredictable, unique, and value laden. Each group of students, each classroom event, each instructional strategy, and each topic present a unique combination of factors at a particular point in time. Each teaching occasion therefore presents teachers with certain challenges and problems. Through thoughtful consideration of practice, teachers design practical solutions to such challenges. Teaching, therefore, is an adaptation process which requires flexibility on the part of the teacher and requires the teacher to constantly make decisions to adjust to new situations.

Teachers' decisions are substantially influenced by teachers' thought processes. Teaching is both a rational and deliberative process (C.M. Clark and R.J. Yinger, 1987), even though there are elements of unpredictability about it. It is a rational process because it is well thought out and deliberately planned. Teaching is deliberative because it involves teachers' reflections and decision-making. Teachers' reflections about their practice is an active process whereby teachers carefully consider their own behavior and values as they respond to certain teaching situations (Clark and Yinger, 1987, p. 99).

Teachers' deliberative process spans three phases of teaching. The process begins with the planning that teachers do prior to classroom instruction. It continues through classroom instruction and post-classroom events (J. Herman, 1988; Clark and Yinger, 1987; Clark and Peterson, 1986). Teachers make deliberate decisions during each of the three phases of teaching, decisions that are goal driven. The quality of these decisions influences classroom outcome and students' achievement.

Teacher's Decisionmaking During Planning

Clark and Peterson (1986) define teachers' planning as "a basic psychological process in which a person visualizes the future, inventories means and ends, and constructs a framework to guide his or her future action." (p. 260) When teachers plan,

they are "thinking in the future." Many researchers attach a lot of importance to teachers' planning because they believe effectiveness in the classroom is determined by the quality of the planning that the teacher does prior to classroom instruction.

At the planning phase, teachers set the class goals, state the curriculum objectives, formulate strategies, specify content, select method of assessment, and develop class materials. This can be done as yearly, term, weekly, or daily planning. A teacher's planning is greatly influenced by her beliefs and is drawn from many knowledge bases. These include knowledge of subject matter, discipline requirements, students' learning, students' prior knowledge, school timetable, and resources available (Herman, 1988; R.J. Yinger, 1979).

Teacher's Decisionmaking at the Instruction Stage

The majority of teachers' classroom decisions concern the instructional process (Clark and Peterson, 1986). Teachers make decisions whether to continue to follow instructional procedures or strategies that they set out during planning. They can change their strategies or procedures in response to situations that arise once instruction has begun. Situations that may arise include concern for the students--whether or not they understand, whether their expectations of students' performance is being realized, or whether students are paying attention. A teacher's decisions to change classroom activities may be based on the interaction process, such as students asking questions, rather than only on teacher's observation of the situation.

Post-active Planning

The post-active planning takes place after the conclusion of the lesson. The distinction between this phase and the preactive planning phase is very blurred. According to Clark and Peterson (1986), teacher planning includes their thought processes prior to and after classroom interaction. Both guide teachers' thinking and

projections for future classroom interaction. While most of the processes and function of preactive planning were clearly demarcated in research, postactive activities, like the role of evaluation of learning, seems to be absent from the research reviewed by Clark and Peterson (1986).

Teachers' Beliefs or Theories

Teachers' theories or beliefs are "the rich store of knowledge that teachers have that affect their planning and interactive thoughts and decisions. Conversely, teachers' thought processes also affect teachers' theories and beliefs (Clark and Peterson, 1986, p. 258). Teachers' beliefs about teaching are tied to their teaching goals and significantly influence the effectiveness of any curricular event (H. Munby, 1983). According to Munby, teachers have beliefs or theories about: 1) students' learning and developmental goals, that is, curriculum goals, extracurricular, academic, personal goals, and subject-matter principles; 2) teacher autonomy and authority in the classroom, that is, the degree of control over curriculum; and 3) students' needs and limitations.

Teachers' beliefs/theories and practice are influenced by the constraints and opportunities in the context in which they practice. The constraints and opportunities may be perceived as residing at the various levels, namely the classroom, school level or the institutional level, or in the society outside of the school system. The constraints may be the physical setting of the classroom, the school, or it may be the curriculum.

On the other hand, teachers' teaching may be enhanced by opportunities, for example, a supportive dean and/or the availability of grants for instructional development projects. Also the extent of teachers' participation in the decisionmaking process has been shown to be an important factor in their effectiveness (Clark and Peterson, 1986, p. 258).

Teachers' Knowledge

Shulman (1987) identified seven categories of knowledge in his "Model of Pedagogical Reasoning." According to this model, teachers possess a variety of knowledge that influence their practice. They include: 1) content knowledge, i.e., teachers' content background in the subject they teach; 2) general pedagogical knowledge, i.e., "broad principles and strategies of classroom management and organization that appear to transcend subject matter"; 3) curriculum knowledge, i.e., knowledge of curriculum materials that can be used to teach a particular topic; 4) pedagogical content knowledge, i.e., mixture of content and pedagogy and professional understanding; 5) knowledge of learners, which informs teachers about how students learn, their developmental levels, motivations, preconceptions and misconceptions; 6) knowledge of the educational context, the classroom groupings, character of the school district, and the community; and 7) knowledge of educational ends, purposes, and values, and the philosophy behind them (p. 8).

Apart from the types of knowledge identified above, expert teachers also possess a practical knowledge of their craft. This craft encompasses the wealth of teaching information that very skilled practitioners have about their own practice. It includes deep, sensitive, location-specific knowledge of teaching, and it also includes fragmentary, superstitious, and often inaccurate opinions (G. Leinhardt, 1990, p. 19). Craft knowledge is contextualized knowledge. The contexts are sometimes clear, but more often, they are murky. There are pieces of the craft knowledge which are probably true in some situations, and there are combinations of circumstances that render them inaccurate.

Summary

The context of teaching is a complex interaction of people, beliefs, goals, routines, and opportunities and constraints. Teachers teach and make decisions, decisions that are influenced by their beliefs or theories about teaching, about students, and about themselves and their knowledge. In addition to their beliefs, teachers often utilize a large knowledge base consisting of knowledge of the subject matter, knowledge of how to teach, students' characteristics, and the school and society.

What do computers offer teachers in terms of performing the task of teaching, the role of teachers, and fulfilling educational goals.

Technology in Education

Historical Perspective

For decades, educators have grappled with how to improve the quality of teaching and learning. There has been much talk on how to individualize instruction so that more able students do not have to move "lockstep" with the rest of the class, or less able students left behind. To compound this situation is the issue of how to solve educational problems such as increased enrollment, poor learning skills, classroom management, instructional strategies, and structural changes. As a result, many innovations have been introduced into the classroom.

Attempts to cope with changes such as serving the need of a diverse student body, increasing cost of education, and accelerating technology gave rise to the alternative movement (R. Gross, 1976). Characteristics of the movement were open learning, non-traditional study systems, external degrees, and extended or expanded campus. Programmed instruction was hailed as an alternative to the teacher, which allowed the learner to learn at his own pace and time. Educational television was seen as a means of bringing reality to the classroom, so that learners' visual perception could



be enhanced. Yet many of the problems that these innovations were meant to solve are still very prevalent in schools today.

Computers in Education

Computers are the latest on the educational scene. In the recent past, many schools and colleges in the U.S. have begun to invest heavily in computing. The 1980s, in particular, can be characterized as a decade of "microcomputer revolution" in higher education. "Virtually all institutions have expended large sums of money to establish microcomputer laboratories for students' use, in addition to providing individual units for faculty" (D.G. Smith, R.R. Smith, and R.H. Trent, 1988, p. 41). On the international scene:

Many national governments continue to stimulate the use of computers as tools in education and/or the teaching of introductory courses in computer literacy or computer science, while large amounts of money are being spent on training teachers, providing schools with hardware, and stimulating educational software development. (Plomp and Moonen, 1992, p. 3)

Why are educators optimistic that computers will succeed where other educational innovations have failed?

Two major reasons were associated with failure of earlier innovations. One of them was due to the fact that, in an attempt to implement the innovation, educators did not grasp or take into consideration the complexity of instructional situations. Over the years, there is increasing knowledge about the nature of schooling, classroom dynamics, and learning. The second reason is the characteristics of the innovations themselves. In the case of programmed instruction, for example, a number of texts on elementary mathematics were written by psychologists or educators who did not have



adequate training in mathematics (P. Suppes, 1992, p. 12). If precautions are not taken, computers may suffer the same fate as its predecessors.

The "revolution" supposedly prompted by computers in classrooms may pass in a few years, going the way of such earlier "revolutions" as back-to-basics, career education, mainstreaming, education of the disadvantaged, open education, programmed learning, new math, and discovery learning. Or, like chalkboards, overhead projectors, maps, textbooks, workbooks, and activity sheets, computers may become just another trapping of everyday classroom... The fate of computers-in-education will depend on the instructional uses to which teachers and students can put their computers. (Walker, 1983, p. 103)

Despite cautious optimism, criticisms, and the enthusiasm of advocates and critics alike, computers stand a better chance of succeeding where other educational innovations have failed. Among the characteristics of the computer that make it a more viable tool to teachers is its information processing capabilities, flexibility and capability for adaptation, and capability for high level of interaction.

Information processing capability.

The computer is capable of processing information in different symbol systems in a way that is not possible with standard television or laboratory demonstrations. While television, for example, is able to employ two modalities, namely visual and auditory, the computer is capable of representation in multi-symbol systems.

Computers can juxtapose, or transform, information in one symbols system to that in another ... A learner can type in printed text, and a computer can with a voice synthesizer transform it into speech. The computer can take equations, numerical values, or analog signals and transform them into graphs. (R.B. Kozma, 1991, p. 195)

Flexibility and adaptability.

The flexible information processing capability of computers makes them potentially useful in a wide variety of educational applications. They can facilitate teaching and learning at all levels and can be used effectively in all subjects (G.



Kleinman, 1984, p. 120). Computers enable greater access to learning and information. They provide teachers with the opportunity of teaching a larger number of students in ways that allow individual progress toward learning goals.

Interactivity.

Computers allow learners to work with a variety of information including text, numbers, pictures, and sounds. Its flexibility makes it a powerful tool to put control of learning in students' hands.

Computers in Higher Education

Carson (1986) describes many different computer uses in academia. According to Carson, computing means different things in each academic area. While there are administrative applications, there are also uses specific to subject areas. For example, in engineering, computing means using high level programming languages such as FORTRAN to write problem-solving programs for specific situations. Whereas in the humanities and social sciences, there is a tendency to rely totally on off-the-shelf programs. In schools of education, academic computing is seen as computer-assisted instruction, tutorials, and simulations, while computer science departments equate computer literacy to knowledge of programming in a language such as Pascal. To those in library science, computing means telecommunications and access to on-line bibliographic databases. To scientists however, computers can be used to control scientific apparatus for automated recording of data (Carson, 1986).

Computers can be the object of training (computer literacy), the medium of training (computer-directed training), and the manager of training (computer-managed training). Computer-enhanced technologies can provide electronic learning environments. Computers could also be electronic dictionaries, drills, and practice for language learning. They can be used for problem-solving in "what if" situations, etc. (Lindenau, 1984).

In 1988, Weissman predicted what a faculty's integrated workstation would look like in the decade of the 1990s. According to Weissman, a scholar's workstation would contain, 1) a compound document word processing tool; 2) database tools; 3) data acquisition tools, modeling, analysis, and data visualization tools; 4) hypertext concept-linked research databases; 5) intelligently linked information files; 6) integrated bibliography management; 7) seamless weaving of graphics, images, text, and sound; 8) multimedia documents/databases; 9) on-line access to library card catalog and external databases; and 10) desktop multi-user journal and book editing/publishing. Various combination of these tools may differ according to the discipline of the users.

Computer-Based or Computer-Assisted Instruction

Computer-assisted or computer-based instruction is gradually becoming an important instructional use of computers. The terms, computer-assisted instruction or computer-assisted learning, computer-based instruction or computer-based education, have been used so interchangeably in education and research that the distinction between them has blurred over time, hence it is used to mean the same in this study. The terms refer to a process of instruction which allows the student to explore various actions and experience the consequence of those actions in a simulated environment (A.J. Romiszowski and B. Grabowski, 1989). Computer-assisted instruction, in most cases, combines simulation, problem-solving, and modelling.

There are various attributes of computer assisted instruction (CAI) that enhance learning. M. Cox (1992) conducted an extensive review of computer-assisted instruction programs that are used to teach science, along with studies that were done on computer simulations of scientific concepts. Cox found that computer simulations have been mostly useful where: 1) an experiment is too dangerous, costly, or expensive or takes too much time to perform in the school laboratory; 2) computers can evaluate

with speed and accuracy complicated mathematical expressions through analytical or numerical methods, allowing students to explore the scientific relationships and theories with their own parameter values relevant to their own experiences; 3) interactive, dynamic, graphical displays produced by computers can assist students who have difficulty visualizing multi-dimensional relationships, a familiar problem to many science teachers; and 4) three-dimensional drawings can be produced on the screen to provide a clear image of an electric or magnetic field.

Visual displays can play a significant role in providing a picture which demonstrates the relative importance of the parameters governing particular relationships. Computers enable students to test hypotheses, investigate behaviors of models of physical systems, interpret experimental data, and contrast simulations with experiments.

Cox (1992) reported two studies that investigated the kinds of learning which take place when students are using science simulations. One investigation was carried out by S. Kemmis, R. Atkin, and E. Wright (1977). As a result of the study, the researchers built a model of general categories of computer-assisted learning (CAL) based on the kinds of interaction the programs permit. The four kinds they defined include 1) instructional, 2) revelatory, 3) conjectural, and 4) emancipatory.

According to Cox, the instructional kind of interaction CAL software is intended to replace the teacher by presenting students with a description of the topic, posing questions, checking the validity of the answers, and providing feedback to reinforce learning. The revelatory kind of interaction encourages student to discover the rules of the environment created by the software. Students can investigate relationships between variables and explore a simulated physical process. Conjectural simulations allow students to learn through experimentation and exploration of topics, but they are not constrained by predetermined hypotheses or dictated by a fixed model. The emancipatory kind of interaction is based on the concept that the computer can release

the learner from unnecessary tedious labor, such as repetitive calculations, leaving him or her free to investigate aspects of the topic which are relevant to promote understanding.

A second categorization described by Cox is that of L.M. Laurillard (1978). Laurillard's categorization describes the learning interaction that takes place when students are using CAL simulations. They are mostly general science process skills. The categories include: checking knowledge and understanding; experimenting; visualizing; reasoning; and interpreting (p. 25).

However, much still needs to be done to realize the hopes of computer assisted instruction in education. There is a need for better design of CAI and more research. "Appropriate development of CAI programs will enable us to take a highly significant step beyond introduction of books to offer unparalleled variety and depth of curriculum to students of all ages." (Suppes, 1992, p. 11).

New Technologies

The new technologies that make possible the kind of scholar workstation described by Weissman and the increasing use of computer-assisted instruction include multimedia platforms such as authoring systems, interactive video, DV-I, M-Motion, CD-ROM, and Hypermedia; and networks such as electronic mail and ISDN.

Authoring Systems

What has contributed to the increasing popularity of computer-assisted instruction as an educational application is the emergence of authoring systems. Authoring systems are easy-to-use software that allow instructors to develop learning materials to their own specifications. Most authoring systems combine icon, menu-driven, hyper features, and authoring language capabilities to complement the deficiency of each of the component technologies.

Icons increase interactivity by linking one part of the program to the other and linking the program to special effects like video and graphics at a prescribed point in the lesson. "Authoring languages allow an instructor to customize lessons more completely and convey information more precisely" (E. Greenfield, 1990, p. 7). The hyper features allow students to move about in a lesson in a non-linear fashion according to his or her needs and interests. Authoring systems can be programmed to access information stored on CD-ROM or videodisc. The information can be text, sound, as well as pictures.

Some authoring systems also use the concept of the library. Authoring libraries contain content material that may be used and reused when creating a particular course or lesson. It allows sharing of materials that other instructors may incorporate into their lessons, thereby reducing instructional development time.

Authoring systems have implications for the educational process. They are not just tools for teachers to develop course materials, they can also become a learning tool for students. According to Greenfield, the potential of authoring systems would be under-utilized if they remain just a teacher's tool. Evidence has shown that students can learn a topic better by being asked to develop a course or lesson on the topic using an authoring system.

Interactive Video

According to R.A. Braden (1988), interactive video instruction evolved from a combination of two electronic technologies (computers and television) and two design technologies (instructional design and visual design) (p. 154). The information processing capability of the computer is merged with the storage and random access information retrieval capabilities of the videodisc in interactive video technology. The videodisc can hold 30 minutes of motion video and 54,000 frames of still images, along with two tracks of audio.

With an authoring system or a programming language, instructional materials can be programmed into the computers that reference the information stored on the videodisc. Students can interact with the materials based on their interest and at their own pace. Random access and branching capabilities allow students to control the path of their own interaction with the materials. Some interactive video programs are developed to keep a record of students' interaction, and they can be programmed to provide students with feedback on problem-solving exercises.

Compact Disc-Read Only Memory (CD-ROM)

In the light of the information explosion, CD-ROM offers education the opportunity for information management. Its potential lies in its storage capacity and searchability. According to J. Green (1991), one 5.25" CD can hold up to 270,000 pages of text. Because of its searchability, references to any topic can be located in less than 30 seconds with the right software. Using Boolean logic, a search can be narrowed down using appropriate keywords.

In addition to its capability, CD-ROM is also an inexpensive medium for bringing a wide variety of information to educators and students. Volumes of academic references can be contained in one CD-ROM, which in turn costs less than its book equivalent. Also, CD-ROM provides an opportunity for bringing more recent information to users, thus bypassing the lag between manuscript and book.

A use of CD-ROM that has had a profound impact in education is the ERIC. ERIC is an educational database named after its vendor--the Educational Resources Information Center. "ERIC is a nationwide information network of 16 major universities and educational organizations that acquires, selects, abstracts, and indexes significant and timely education-related reports, interpretive summaries, articles, and books--all with annotated bibliographies." (J. Green, 1991, p. 54). ERIC CD-ROMs allow students and scholars to search through a wealth of materials on any educational

topic in seconds. The ERIC CD-ROMs are updated every three months, thereby assuring users of current information on any educational issue.

Digital Video-Interactive (DV-I)

DV-I is a multimedia platform that can provide an alternative to videodisc technology. It has a capture board for capturing and playing back full-motion video, still pictures, and digital audio. It is based on a compression and decompression algorithms. Because of this capability, it can capture, store, and playback over one hour of motion video from a standard CD-ROM. It can display information on a VGA monitor or monitor with higher resolution. Moreover, it has the capability of storing motion video on any digital storage device such as a hard drive or CD-ROM.

M-Motion Video Adapter

M-Motion performs functions similar to DV-I. M-Motion is specifically designed to deliver full-motion video and audio to the user. It records, plays back, and stores digitized audio and video information. Full-motion video images can be received from videodiscs, video cameras, close-circuit television, or VCRs. The card can also capture and store still images.

Hypermedia

Hypermedia is based on a combination of metaphors ranging from interactive information access, node linkage, interactor annotation and navigational systems. According to R. Paske (1990), hypermedia is an audio-visual and textual communication system that allows users to interactively navigate through a multimedia information base using their intuition, memory, and interest as a guide (p. 54). It combines film and video, computer graphics, sound, music and text in a unified information-delivery system centered upon the personal computer.

The hyper structure of the system links knowledge in one domain to other domains. "A true hypermedia allows the connection of any piece of information, often called a node, with any piece in a logical and coherent way." (Paske, 1990, p. 54). A user searching for information on world population for instance, may ask the database for a map of the distribution of the world population. Knowing about the most populated region in the world may trigger information about China. The user may want to link that with birth control patterns in China as a form of population control. Because of the linkage possibilities, a hypermedia system must provide maps or navigational aids so that users are not "lost in its information-space." (Paske, 1990).

In addition to the multimedia technologies described above, another technology that has made an in-road into education is the electronic network. Earlier versions of networks were text-based. With the development of the integrated services network (ISDN), video images and graphics can also be transmitted through the networks. Applications such as electronic mail and teleconferencing are based on the concept of networks using telephone technology.

Electronic Mail

According to M.B. Solomon (1990), electronic mail (e-mail) consists of information, usually text, that is electronically transmitted over the phone lines from a single sender to one or more recipients. The receiver of an e-mail message can easily reply. E-mail messages are digital computer files that can be manipulated, edited, saved, and retrieved like any other word processor file.

A common academic use of e-mail involves joint authorship of papers by writers who reside in different locations. Authors can exchange documents, modify and manipulate the text using word processors, and then re-transmit the altered transcripts. Without e-mail, joint authorship of an article or book entails long delays between exchanges. With it, the authors can trade updated drafts daily.



Another growing and significant use of e-mail is bulletin board services (BBS) through which people exchange ideas on a wide variety of topics. Such BBS allow people with common interests to communicate and debate without the time delays of traditional mail or the costs of travel. E-mail as an instructional medium is becoming prominent in the school systems.

Integrated Services Digital Network (ISDN)

Integrated services digital network is being developed by AT&T. It is a network of fiber-optic cable and high-speed digital circuitry, capable of supplying digital video imagery and audio signals to anyone on-line. Sound, images, and text can be transmitted through telephone lines from an originating source to receiving sources almost instantaneously. A two-way audio link can allow users in different places to communicate in real-time.

ISDN's usefulness in education may push the boundaries of instruction and learning. Teachers and their students do not have to be at the same location before meaningful interaction can take place. All kinds of information sources can be accessed in less than a second to enrich learning.

Summary

A multimedia approach to instruction and learning may become the technique of the future because of the emerging technologies which make possible the production, storage, and increased access to several media such as video, text, graphics, audio. Fiber-optic and microwave networks linking schools and universities may help spread the advantages of improved processing capabilities and greater built-in intelligence of the computer. However, S. Chorp (1990) warned that:

We must be careful not to become enamored with the technology. Effectiveness of technology still remains the most important reasons for its utilization. The challenge facing education is not only to provide adequate tools and resources to knowledgeable users, but to understand when to acquire them and for what purpose (p. 4).

Research on Teachers' Use of Computers

Of the available studies on teachers' use of technology, most were conducted on elementary and high school teachers. Of the few studies about college and university professors, most were reports of surveys about the types of computers facilities available to them for teaching. Recently, there was a call that more descriptive studies should be conducted which focus on how technology actually functions in the classroom (D. Neuman, 1989). According to Neuman, many times computer-based instruction projects are placed in the classroom with little or no regard for the context. Most of the studies reviewed in this report were conducted in the K-12 settings. However, issues surrounding teachers' computing in that setting were also relevant to college teachers.

Plomp and Pelgrum (1992) reported part of a study by the International Association for the Evaluation of Educational Achievement (IEA) to examine impacts of "computers in education" (COMPED). The study compared computer use in more than 20 countries, namely European countries, Japan, and U.S. The purpose was to investigate whether computers offer possibilities of restructuring schools or classrooms. The focus of the study was on national and school policies and practices, the type of use of computers by teachers and students, the problems experienced in using computers, and the reasons for schools and teachers not using computers.

Questionnaires were administered to principals, computer coordinators, teachers of introductory computer education, and teachers of mathematics, science, and mother tongue in junior high schools in the countries selected for the study.

The results of the study indicated that the number of computers in schools is increasing. However, access problems limit extensive use throughout the school curriculum. General purpose software such as word processors, spreadsheets, and database programs is broadly available in schools. However, educational software is not widely available. The most intensive computer users are found among mathematics teachers. Only a limited number of teachers of other subjects use computers. In each country, the type of computer use ranges from playing games to computer-assisted instruction, including demonstrations in front of class, introductory courses about computers as tools, and remedial and enrichment CAI. Among the objectives for using computers in schools are the preparation of students for the future, keeping the curriculum up-to-date, and making school more interesting.

Plomp and Pelgrum concluded that structural changes in schools are possible, but certain conditions must be fulfilled. Schools need time to build up enough expertise, knowledge, and experience among teachers before any impact might be expected. Even though there may be no real structural changes, many teachers have started to change their classroom management using computers. By applying different forms of grouping and student-student interaction during lessons with computers, teachers change their roles.

Time to innovate was an issue in another study carried out by K. Sheingold and M. Hardley (1990). The researchers conducted a nationwide survey of teachers who teach 4th through 12th grades. These teachers were asked about the influence that available technology has on their practices and the perceived value of these practices. The study was also to investigate the circumstances that may promote or hinder effective technology use.

A 16-page questionnaire was sent to the 1200 teachers selected to participate in the study. The questionnaire included questions about: 1) teacher's current practices using educational technology; 2) ratings of barriers to integration in the past and

present; 3) ratings of incentives for integration; 4) perceived changes in their teaching resulting from computer use; 5) descriptive information about their own training, experience with computers, and point of view about computers and demographics about themselves and their school.

Sheingold and Hardley found that teachers devoted a lot of time and effort to using computers in the classroom, and spent their own time to learn about technology. Concern for their students was the key incentive for the teachers using computers, and the personal gratification of learning a new skill. Extensive technology support was very crucial in the teachers' use of computers, and time to master computer-based teaching strategies was also an issue. It takes five to six years of teaching with computers before teachers can achieve a current comfort level with computers. The teachers in Sheingold and Hardley's study used computers as a multi-purpose tool. They had a variety of educational software, such as, programs for drill-and-practice, problem solving, and productivity software such as word processors and databases. The teachers believed that computer use has changed their teaching. Their expectations of their students have increased, and they can present more complex materials. Computers presented them with a great opportunity to individualize instruction and the learning environment for students. Inadequate hardware and time to plan and implement computer-based lessons were some of the perceived barriers.

The researchers concluded that among the factors that contributed to teachers' achievement with computers were teachers' own motivation and commitment, administrative support and support from colleagues, and access to sufficient technology. Certain conditions have to be met before this success can be realized on a wider scale. They include adequate technology and unrestricted access, support and time for teachers to learn to use technology, and the school culture that encourage teachers.

D. Dalton (1987) believes the greatest hurdle to jump before computer-based education (CBE) can have any meaningful impact on classroom instruction is the attitude and perceptions of teachers. In a survey of 63 K-12 teachers in a rural school district, Dalton investigated how teachers are currently using computers to support classroom activities, how teachers wish to use computers in future, and what factors teachers believe prevent them from effectively using computers.

The teachers in the study were asked to rate five computer instructional applications in terms of overall priority for implementation. The applications include remediation, enrichment or extension activities, problem-solving simulations, word processing, spreadsheets, and basic skills instruction.

Dalton found that teachers perceive computers more as an instructional tool or a supplement to their own instructional programs. Word processing was the most commonly used computer-related activity in the classrooms. Teachers rated basic computer literacy and keyboard familiarity as their top priorities in the implementation of computer-based education.

A departure from the studies reviewed above was that of K. Sheingold, J. Kane, M. Endreweit, and K. Billings (1981). Their study, in addition to using a qualitative and descriptive approaches, also adopted a sociological perspective to investigate the impact of computing in school systems. According to the researchers:

...Sociological research on the impact of computers in organizations suggests a rich set of implications to explore, the central one being that the implementation and impact occur within social and political contexts. Individuals and groups who use technology, plan for its use, and evaluate it powerfully shape its effects. (p. 1)

With this perspective, Sheingold et al. investigated the impact of technology use at various levels of the educational system of three school districts. They investigated

social factors in implementation, organizational impact of computers, and critical social values, such as equity.

In-depth interviews were used to collect data from administrators, media specialists, teachers, students, resource personnel, and community persons. Observations of students using computers in a variety of contexts were also conducted. Data collected were analyzed at the individual teachers' level, classroom level, and institutional level, using descriptive and case study analysis.

Sheingold et al. found that school systems used microcomputers in ways that are consistent with their own goals, needs, and ways of operating. Goals such as improving students' scores on basic skills were the concern of one school district. In another school district, even though computing resources were centralized, decisions about actual use of computers were made at the school level. The researcher also found differential access to computers, emergence of new roles in response to computer use, lack of integration of computers into the curriculum, and inadequate preparation of teachers. Any implementation of computers included a complex interaction of technological development, market forces, professional and popular ideologies, and powerful interests and values (p. 5).

The sociological perspective and the method used in Sheingold and Hardley' were of particular interest to the current study.

College Faculty Research

Very few studies have addressed how college faculty use computers in the classroom. Most of the available studies were surveys of what kinds of computers are available in universities, the role computers play in instruction, and the kinds of problems faculty face using computers. In a few cases, semi-structured interviews were used to solicit faculty's opinions about computer use. The context of computer use, teachers' beliefs and attitudes toward computers and how they might impact classroom

events and outcomes were not explored. The studies reviewed here are among the few that were conducted specifically on colleges and universities and/or college professors.

Naron and Estes' (1986) study was conducted at both the public school and higher education levels. The part of the study reviewed was that relating to higher education. The research was a case study analysis of the impact of technology use in nine colleges and universities. Through administration of a questionnaire, telephone, and/or site interviews, the researchers investigated the role of technology in the instructional program, policy structure, management support services, and teacher training and teacher functions.

Naron and Estes found that computers were the most used of all available information technologies. Computer courses were offered by various departments in mathematics, education, business, and computer science. In colleges of education, students were exposed to hardware and software with a specialty in a technology-focused area through interdepartmental arrangement. There were mainframes as well as microcomputers in most of the cases.

Most institutions reported that their formal policies had not been altered by computing, even though more funds had been allocated to technology. But acquisition of computer literacy skills was a requirement for students. Management support services are provided by all the nine institutions investigated. Instructional support services provided included maintaining databases relating to student records, course information, and other instructional management information.

The researchers also found that teacher training has not been substantially altered by technology use. Pre-service teacher training in the departments of education was geared toward providing technology literacy; and, unless a student-teacher is specializing in instructional technology, his or her exposure to technology is limited. Faculty evaluation and their compensation have been impacted only minimally by technology in the institutions in the study.

The researchers concluded that generally, elementary and secondary schools are leading colleges and universities in new information technology.

Perhaps one of the strongest reasons that teacher training is approached in a more haphazard way in the nine colleges/universities than in the 16 public school settings is that faculty members in higher education hold sacred a high degree of autonomy. Many do not voluntarily choose to upgrade their skills in a new area, whereas teachers in elementary and secondary education often are mandated, or at least given strong motivation from bonus pay or credit, to do so. (Naron and Estes, 1986, p. 95)

Closer to this study was a study by Betza (1986) that documented instructional use of computers at the University of Washington. Even though it was another survey study, the kinds of questions asked were very relevant to this study. Through a telephone survey of faculty who use computers, Betza investigated the ways faculty use computers for instruction. Research questions included educational objectives for which faculty use computers, sources of support and the kinds of resources that faculty use, problems of use, and evidence that computer use has benefitted students. Faculty were also asked to envision what resources they would need for future computing.

Betza found that the uses of computers for teaching among faculty can be grouped under five categories of educational objectives. These include: 1) tool, 2) tutor, 3) tutee, 4) simulations, and 5) computer literacy. The use of computers as a tool or for simulations were the most common applications reported.

As a tool, faculty required students to use computers to perform certain tasks. Four of the most prominent tasks include: a) programming as a means of solving or analyzing a problem; b) statistical analysis; c) word processing; d) electronic communication. The computer as a tutor was used by a few departments through computer-assisted instruction, to study basic math and writing skills. Students learned concepts and skills, and they could do so at their own pace and time. Approximately 50 percent of the CAI at the university was used in education and English classes to

familiarize students with K-12 software. The computer as tutee was more prominent in mathematics, engineering, business, and science courses. Students "taught" the computer by programming. Students either learned how to program for its own sake, especially students from the computer science department, or programmed an application in a specific discipline.

A variety of simulations were used on campus. Some simulations were used by students to learn about a subject, just as in tutor use. Some were programmed by students to develop and test models as in tutee use. And there were those used as tools by students of business and science to make forecasts of markets or migrations. Most computer use in the computer literacy category was for the purpose of familiarizing students with computer functions and tools. Only a few courses were designed specifically as computer literacy courses.

Top on the list of evidence that faculty present about the benefit of computer use to their students is job. This was followed by student motivation and learning. According to the professors, students needed computer skills to get good jobs. Evidence of students who had started their own computer-based business was also cited. Improved attitude to learning and high motivation due to computer use were also cited. Students rated computer homework highly. Learning and improvement in performance were also mentioned by faculty. According to the faculty, students were more capable and more competitive, citing evidence of students who had won awards, published articles, or presented papers on projects originating from computer-related courses.

Sources of funding and resource support varied among faculty. Sources mentioned include grants from companies, government sources, and the university itself. Some said they had no support. Hardware and limited access were among the barriers to computer use mentioned by the faculty.

What Betza's study and others lacked which this study addressed was the description of the process by which faculty achieve educational objectives using computers. Moreover, computers were seen in most of these studies as student tools. What it means to faculty to have the computer as a tool for teaching was not addressed. This study addresses faculty perceptions of computer use and the impacts on teaching, learning, and the classroom processes.

THEORETICAL FRAMEWORK

This study was grounded in two theoretical frameworks, namely change theories and symbolic interaction. Computer use in education is about change. The change theories provide a basis for understanding how people cope with change. Symbolic interactionism provides a framework for the design of the study.

Understanding Change

Computer use in the classroom represents change to faculty and to the institution. Available change theories were consulted in order to understand how selected faculty within Michigan State University responded to computers as a change process.

According to L.B. Fossum (1989), change in an organization essentially means a modification of the way things get done in the system. Change can occur in two ways. Sometimes the individual chooses change, and sometimes the choice to change is made by others. Frequently a person's attitude about a change is determined by the degree of control they have about the change. People who choose change on their own are likely to perceive themselves more in control of the change. There have been various theoretical models dealing with how individuals and organizations cope with a change in progress.

Change Models

Fossum (1989) summarizes available models for understanding change. These include Systems Theory, Force Field Analysis, The Configurational Learning Model, and The Grief Cycle Model. Systems Theory and Forcefield Analysis deal with how organizations look at and respond to change. Forcefield analysis provides a framework for recognizing supporting and opposing forces for change that exist within a system. System Theory identifies limits and boundaries within a system which keeps things relatively stable.

The Configurational Learning Model and The Grief Cycle Model deal with how individuals cope with change within an organization. The Configurational Learning Model provides a basis for understanding how individual's previous experience is used to interpret change. The process involves the individual rearranging his or her "configuration" once the change has been accepted. The Grief Cycle Model provides a means for understanding the various stages individuals pass through when dealing with change. There is the initial stage of denial, followed by anger, and then acceptance. Using some of these models, Fossum (1989) developed a change matrix that explains the different dimensions of change.

The Change Matrix

According to Fossum, change can be viewed in two dimensions. The first dimension describes the levels at which change can occur in a system. The second dimension describes the stages which each of these levels pass through in dealing with change. Intervention of a change manager is needed at each level to help individuals and the organization through the stages of change.

Levels of Change

Change can occur at the personal, group, organizational, and environmental levels.

Personal change

Personal change occurs when the change affects the individual directly. The change may involve addition or loss of something--relationships or a position by the individual. These types of change are of major personal consequence. A change manager needs to address the personal impact of change upon the persons and help them cope with such a change.

Group change.

Change can affect people on a group basis. Because a group is facing similar circumstances, many of their concerns are similar. A manager of change will have to assist them as a group.

Organizational change.

People may face change that directly affects the whole organization. Organizational change can come about as a result of structural changes like merging of departments or merging the organization with another organization. This means that individual employees are now facing new procedures, new policies, new culture, and new people. The change agent will need to work cooperatively with a lot of different people to effect change and, at the same time, help individuals to cope with the change.

Environmental change.

Environmental change can be caused by a major political action such as a budget cut. This has implications for the organization, groups, and individuals. A manager of change must be prepared to assess and anticipate the impact of environmental change on the organization.

Stages of Change

At each level of change, individuals, groups, and organizations go through four major stages of change. These include denial, resistance, adaptation, and involvement stages.

Denial.

Denial is the first stage of change. Individuals or groups may deny that any change is taking place. Even if there is a change, it might not affect them personally. Failure to recognize the group's part in the whole is denial. At the denial stage, a change manager begins to build awareness of the change through:

- communication
- creating ownership of the change

Resistance.

Resistance usually follows denial. Resistance can take various forms ranging from a negative attitude or outright opposition to change. Resistance can occur at any level and it is the most difficult stage of change. The change manager may find himself or herself managing conflict resolution. Issues that may surface at the resistance stage include:

- control, power, and helplessness
- loss or grief
- risk--a feeling that the change brings danger
- conflict or anger.

Adaptation.

The third stage of change is adaptation. In this stage the change begins to become accepted or even welcomed. People learn to implement the change for themselves and others. A change manager's task at this stage becomes goal setting and problem solving.

At the adaptation stage, people begin to exhibit:

- independence
- personal responsibility and
- acceptance of differences.

Involvement.

Involvement is the final stage of change. At this stage, people actively participate in the change, make contributions and suggestions, initiate work on their own and come to see the change as it is. At this stage, the change becomes stable until the next change cycle begins. The change agent's task is to encourage team building. Individuals or groups get involved because the change manager or sponsors:

- provide them with complete and accurate information
- involve them in the planning and execution of the change
- reward them for their participation and assistance.

Of interest to this study is change at the individual professor level, how professors are coping with computer use as a process of change in teaching.

Symbolic Interactionism

The second theoretical framework is symbolic interactionism on which the design of this study was based. The theory is important to this study because of its sociological perspective. In conducting this review, I drew heavily on the works of P. Woods (1992), E. Jacob (1987), and N.K. Denzin (1978).

The major tenets of symbolic interactionism are that: a) human beings attribute meaning or symbols to objects; b) meanings attributed to objects influence how they act toward those objects or things; c) meanings are socially constructed in a human society, and meaning attribution is a continuous rather than a static process (Woods, 1992; Jacob, 1987). This view can be broken down into its component assumptions.

Assumptions about Human Nature and Society

Humans act toward things on the basis of the meaning those things have for them, rather than as a response to instinct or previous conditioning. These meanings are symbolic phenomena, which arise only through social interaction with others. Humans

are seen, therefore, as living in a symbolic environment as well as a physical environment, and they act in response to symbols as well as to physical stimuli. Human beings use symbols such as signs, language, and gestures to convey meaning, and such meaning is usually constructed in social interaction. However, socially derived meanings are modified through an interpretive process occurring within the individual.

Society and individuals are viewed as inseparable units. To understand one, there is a need to understand the other. Both influence one another, neither being completely determined nor the determiner. Human society is made up of collection of actions of people. It is this social process in group life that creates and upholds the rules, not the rules that create and uphold group life.

Assumption about Human Self

Individuals' experiences are mediated by their own interpretations of experience. These interpretations, created by individuals through interaction with others, are used by individuals to achieve specific goals.

The 'I' and the 'Me' are the two phases of the self. The I is the impulsive tendency in individuals. The Me represents the incorporated "other" within the individual, that is the organized set of attitudes and definitions prevailing within the group. The self is seen as a flowing process of interaction between the I and the Me. The I constitutes the initiation of the act prior to its coming under the control of the definitions and expectations of the others (the Me). This view is useful in understanding the set of beliefs individuals have that can influence their actions.

Socialization

Symbolic interactionism also embraces the concept of socialization. A person acquires the language to label and define objects in terms of shared meaning. Individuals see themselves not only from the point of view of significant others but also

in terms of the generalized norms, values, and beliefs as part of a sub-group or a society. In this regard, social organization provides a framework inside which people construct their actions. Such a framework might set conditions for people's actions, but it does not determine their actions.

Socialization is not a one-way process "by which the individual learns a set of meanings and values shared by members of society and which the individual is required to learn if he or she is to participate in society." Socialization, in a symbolic interactionist sense, is an

...abstract model, offering general guidance. Appropriate conduct is worked out by an interpretive and interactive process.... Socialization is not an unmediated internalization of norms and values, but a developed capacity to take the role of others effectively. Through this process, the individual learns an enormous number of meanings and values, and thus actions through communication of symbols with others. (Woods, 1992, pp. 345-346)

The socialization aspect of symbolic interactionism can be used to explain how students learn to use computers as a professional tool from the professors.

Methodology

Symbolic interactionists provide certain guidelines for conducting research within the tradition. The guidelines help define the focus and goal of the research, as well as data collection and analysis techniques.

Goal

The goal of any study conducted in the tradition of symbolic interaction is to render society more understandable through exploration and explanation, rather than testing relationships between variables.

Focus

Symbolic interactionists are concerned with getting at the participants' point of view and the processes by which the point of view develop. They are interested in knowing how individuals take another's perspectives and learn meanings and symbols in concrete instances of interaction. A study in this tradition is usually focused on members of a group or groups occupying similar positions in the social structure, and who develop common mental frameworks and patterns of behavior for dealing with the situations they encounter. Units of study could be: a) "selves" b) "meanings and values that a group of individuals hold toward some specific object or set of activities" c) social situations; and d) social relationships.

Techniques

Life histories, autobiographies, case studies, letters, open interviews, and participant observation are some of the methods used. Life histories allow a view inside the experience of the actor. Participant observation is the most favored technique because it allows the investigator to have a first-hand experience of the lives of the people he or she is trying to portray (Jacob, 1987).

Data Collection and Analysis

Data analysis and data collection are done sequentially with the preliminary analysis informing subsequent data collection. A long stay in the field is expected in order to get close to the meanings within the context of study.

Focus of analysis.

The researcher seeks to identify and discover significant classes of things, persons, and events and the properties which characterize them. Units of analysis could be behaviors, languages, definitions, attitudes, and feelings of the participants. Attempts should be made to match private features of the social acts with its publicly

observable counterparts. According to Denzin (1978), humans act in ways which reflect their unfolding and emergent definitions of themselves and the social situations they confront (p. 79). They link the symbol (meaning) to interaction (class events).

Analysis techniques.

An unstructured recording technique (interviews or observation) demands description, classification, and interpretation. It is necessary to reproduce, as fully as possible, the actual experiences, thoughts, and actions of those studied (Denzin, 1978).

According to Denzin, indicators of the presence of a behavior are frequency and observability. The frequency condition implies that the more times a behavior occurs the better the indicator of its presence. The behavior could also occur in multiple instances. The observability condition refers to the extent in which the behavior is based on publicly observable acts or activities. The greater the public nature of the act, the greater its assumed validity.

I used the assumptions and techniques prescribed under symbolic interaction theory in this study to determine the meanings ascribed by professors to computer use for instructional purposes.

Case Study as a Research Method

"A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used." (R.K. Yin, 1984, p. 23). A case study is useful when one is trying to understand and explain relationships. A case study involves exploration and description of the real-life context in which a phenomenon has occurred, and which has no clear, single set of outcomes.

A case study may be exploratory if relatively little previous research exists on the topic. It may be illustrative "portraits" of social entities or patterns thought to be

typical, representative, or average. Both exploratory and illustrative case purposes may be combined in a single study. A case study can also be a policy research, in which case, the study presents a description of examples of "good practice." (C. Hakim, 1987)

A case study is typically based on two or more methods of data collection. "The use of multiple sources of evidence allow presentation of more rounded and complete accounts of social issues and processes in the case study." (Hakim, 1987, p. 63) Such data sources may include in-depth interviews, large-scale structured surveys, analysis of administrative records and documents, and participant or non-participant observation.

In this study, I borrowed elements of a case study as described by Hakim (1987) and Yin (1984). I used the individual case approach to present three case studies. The personal accounts of the professors selected for the case studies were combined with evidence from observations and documents. A descriptive report of the cases presented are examples of faculty computing at Michigan State University.

Summary of the Literature Review

In an information society, higher education can no longer be reactive in dealing with educational innovations. It has to be proactive in planning for the future because of its unique position in society as a center for research and development, and as provider of education for the society's professional workforce. Planning for the future involves setting goals and implementation strategies. The goals set in higher education should take into consideration the needs of the information society. Implementation strategies include faculty members who are well prepared to use technology as a tool and who can communicate to policymakers about technology uses in the classroom.

Relevant generalizations that emerged from the literature review include:

- Teachers use a variety of computer-based technologies like, electronic mail communication, videodiscs, electronic bulletin board, simulation, text processors, and graphics for their teaching (Sheingold and Hardley, 1990; Austin, 1988; Betza, 1986).
- Teachers use computer-based technologies for teaching activities like instructional planning, instructional delivery, testing, grading, management of instruction and students' records (Sheingold and Hardley, 1990; Austin, 1988).
- Institutions would use computers for goals that are important to them. The curricula goals that teachers use computers to serve include, teaching difficult concepts, remediation and enrichment of instruction, and application of concepts through problem-solving exercises (Naron and Estes, 1988; Dalton, 1987; Betza, 1986; Sheingold, et al., 1981).
- Teachers believe that their teaching has changed as a result of computer use. They could teach more complex concepts and provide a variety of examples using the computer (Kozma and Johnston, 1991; Sheingold and Hardley, 1990).
- Teachers express needs for computer resources such as more and better hardware and software, technical and financial support, and training (Kozma and Johnston, 1991; Sheingold and Hardley, 1990; Naron and Estes, 1986).

On the personal aspects of computing, findings from the review indicate that:

- Teachers' attitudes and perceptions are important factors in their use of computers. Teachers perceive computers as a supplement to their instructional goal (Dalton, 1987).
- Teachers who are self-motivated and have administrative support are likely to integrate computers into the curriculum (Sheingold and Hardley, 1990).
- Time to innovate is still a concern of many teachers (Plomp and Pelgrum, 1992; Sheingold and Hardley, 1990; McMeen, 1988).

Exploratory Study

Taking the next step implied by the literature, I conducted an exploratory study of Michigan State University (MSU) faculty's use of computers for teaching. The purpose was to discover what factors were important in college faculty using computers for their teaching at Michigan State University.

The exploratory study consisted of in-depth interviews of three professors who used computers for different teaching purposes. The transcripts of the audio-taped interviews were inductively coded and analyzed for categories of factors. Details of the exploratory study are presented in Appendix A.

Some of the findings supported those in the literature. However, other findings emerged from the exploratory study which differed from the findings of the studies reviewed above. They include 1) that professors have teaching goals which they used computers to meet and they have learning goals that they set for their students; 2) that professors have philosophies behind their computer use for teaching; and 3) that the procedure of teaching with computers differ from one professor to the other. These findings with those supported by the literature were used to design the research questions and instruments for the current study. The Research Questions are presented in Chapter Two and the research instruments are in Appendix C).

Definition of Terms

In this study, important concepts are defined as follow:

Computers: Both the hardware and software that make possible a particular usage. It also refers to the microcomputer, which can be used to run stand-alone software packages or can be hooked up to a mainframe through the modem for network communication purposes.

Teaching Activities: Teaching functions for which professors use computers. Such activities must be of longer duration rather than a one-time event. These include activities like instructional planning, instructional delivery, grading, testing, and instructional management.

Computer's use in **instructional planning** include creation of a course syllabus, lecture notes, overhead transparencies, assignments, test items, and class activities.

Computer's use for **instruction** include use as a professor's tool to support classroom presentations, or use computer-generated materials in class presentation.

Computer's use for **testing** include administering tests to students electronically. Computer use for testing may also include using word processors to make test items or set up and manage a test bank.

Computer use for **grading** include scoring tests, record, and process grades. It may also include using computers to make grade sheets, provide feedback on assignments, and communicate grades.

Computer's use in **instructional management** include making class schedules, grouping students for projects or class presentations, preparing directives, maintaining students record, and keeping records.

Computer use for **communication** include exchange of E-mail messages between students and faculty about class materials. Computer for communication may also include setting up a class bulletin board.

Computer use for **information storage and retrieval** may include storing educational materials on devices like an interactive videodisc and providing users access through a computer program.

Computer use as **computer-assisted instruction** include programs developed by professors and used in classroom presentation or as a review program for students.

The Dissertation Plan

Chapter One of this dissertation presents the context of the study which includes the overview, origin of the study, statement of the problem, the purpose, and the scope of the study. These are followed by a review of the literature. The chapter also contains a review of two theoretical frameworks addressing the process of coping with change and the design of the study. The chapter closes with a summary of the literature and the definition of concepts used in the study.

Chapter Two contains a description of the design of the study. It contains the method for selecting participants, the development of the research instruments, sources of data, and procedures for data collection and analysis. The chapter closes with a description of quality control methods adopted for the study.

In Chapter Three, the analysis of the data addressing research question one--the ways in which faculty use computers for teaching--is presented. It contains the profiles of the twelve professors and the summaries of their responses to the interview questions. There were responses about goals of computing, teaching activities, teaching procedures, resources used for computing, and sources of computing support.

Chapter Four presents data analysis addressing research question two--the perceptions of impact of computers on teaching. It contains faculty responses to the interview questions about the perceived impact of computer use on their teaching, students' learning, and classroom interactions.

Chapter Five presents the case studies. It contains a description of three selected cases and the report of additional data collected to build the cases. The case studies include the case of Professor Hake who uses the computer as an instructional delivery tool, the case of Professor Dillon who uses computers in a peripheral role, and the case of Professor Adamson whose main use of computers for teaching is computer-assisted instruction.

Chapter Six presents the summary of findings, discussions, and conclusions of the study. It also contains recommendations for further studies and policy implications.



CHAPTER TWO DESIGN OF THE STUDY

Introduction

This study investigated how a group of professors described their use of computers in their teaching, and their views on the effect of computer use on teaching and learning. The goal was to increase understanding about the role of technology in education and how computers can be used to facilitate desirable educational outcomes. To achieve this goal, I sought out a group of professors known for their computer use in teaching at Michigan State University. I asked the professors to describe the ways in which they use computers for teaching and to interpret the impact of computer use on their teaching and on students' learning. I was particularly interested in purposes and activities of teaching for which they use computers, the setting, situations, and the processes of computer use.

The qualitative design of the study was based on the symbolic interactionist approach to inquiry. According to C. Hakim (1987), qualitative research is appropriate when "one is looking at the way people respond to external social realities at the micro-level" (p. 28). My focus was on the effect of computer use on individuals, especially professors, rather than on the institution as a whole. However, I was open to faculty's interpretations of institutional factors that have influenced their computing decisions.

Faculty interpretations of their computing environment were important because the major assumption of this study was that of professors as "actively constructing meaning" rather than merely responding to an external environment (P. Woods, 1992; W.A. Firestone, 1987; C.M. Clark and P.L. Peterson, 1986). My aim was to present a view of the world from the perspective of those studied and to identify the set of beliefs and values that guide participants' actions in the classroom and shape their attitudes toward a new tool.



In order to understand people's actions and the meanings attached to such actions, there is a need to ask them in their own terms rather than assume the meaning from their overt behavior (S. Jones, 1985, p. 46). I chose in-depth interview to get at participants' reality. In addition to the interviews, I included classroom observation and document analysis as part of the data about the professors chosen for case studies.

Experts in qualitative inquiry suggest that the quality of a study increases as more relevant evidence is brought to bear on the situation under study. To portray a "rounded" picture of faculty's computing, therefore, I included evidence from interviews of students, administrators, and computer resource personnel. I also included my perspective as a researcher in a qualitative research tradition. My judgment about what data to collect, what to attend to in the field, and what to report, played a significant role in this study.

I discuss the implications of professors' computing for higher education in Chapter Six of this study. Any form of computer usage by the professors studied represents a unique combination of personal and institutional elements, including, but not limited to, professors' belief systems, perceived opportunities, and resources. Personal and institutional factors must be well balanced for change to occur in education through technology use. Individual faculty, university administrators, and faculty trainers have roles to play in this balancing act.

The Plan of this Chapter

The remaining sections of this chapter contain the research questions, the setting of the study, description of how participants were selected, data sources and data collection strategies, data analysis procedures, and the limitations of the study. The chapter concludes with a description of the strategies adopted for ensuring quality in the study.

Research Questions

The research questions were based on the purpose of the research. The purpose was to find out how faculty perceive computer use in their teaching, in order to inform other professors, administrators, trainers, and software designers. I consulted two major sources in building the research questions, namely the literature and an exploratory study that I conducted. Details of the exploratory study are reported in Appendix A.

The research questions that guided this study were:

Broad Questions

1. *In what ways do professors use computers in their teaching?*
2. *What are professors' perceptions of the impact of computer use on their teaching, students' learning, and classroom interactions?*

Specific Questions

The main research questions were subdivided into questions A-C to further define the scope of the research.

1. *In what ways do professors use computers in their teaching?*
 - A. *For what teaching purposes do professors use computers?*
 - B. *For what teaching activities do professors use computers?*
 - C. *What are the processes of computer use for teaching among professors?*
2. *What are professors' perceptions of the impact of computer use on their:*
 - A. *teaching?*
 - B. *students' learning?*
 - C. *classroom interactions?*

The Setting

The choice of Michigan State University (MSU) as the setting of this study was based on my perception of the university as a center of excellence in teaching and research. In the early 1960s, MSU established one of the first and most extensive educational development programs (EDP) among large institutions of higher education in the United States (M. Moallemian, 1984). With an enrollment of about 40,000 students and its land grant status, MSU's responsibility to the society through teaching, research, and public service cannot be overemphasized. Part of being responsive to society's demands has been the evolution of computing initiatives on the MSU campus. Of interest were those initiatives specifically geared toward promoting teaching through technology.

MSU has a large teaching faculty of about 3,000 among whom are users and non-users of computers. An estimate by some faculty and academic computing staff reveal that the proportion of faculty using computers for teaching may be about 10 percent. This estimate seems to be in line with the findings of studies about faculty computing. For example, Austin's (1988) study reveals that about 5 percent of the faculty at Oakland Community College use computers in any form for their professional and personal work. My focus in this study was on how some of the estimated 10 percent of faculty computer users at MSU use the technology in their teaching.

The "Social World" of Professors

The context in which professors use computers include the university environment, especially the university computing support systems, the faculty themselves, their disciplines, students, and colleagues. Knowing that faculty computer usage cannot be divorced from the context of their work, it became necessary to look at the computing environment that is provided for faculty at MSU. What specifically are

the computing resources available to professors, and how do faculty perceive the adequacy of the resources?

The information I used in describing and analyzing this environment came from three major sources: informal conversations, university documents, and a seminar on faculty computing that I attended. The detailed report of computing resources at Michigan State University is presented in Appendix F.

The Study Participants

The main participants in this study were professors who use computers for teaching. Other participants were recruited for the purposes of corroborating evidence from professors in order to strengthen the conclusions that I drew from studying faculty's perspectives.

Selection and Description of Faculty Participants

Twelve professors participated in the in-depth interviews. Out of these, three were selected for detailed case studies. I used purposeful sampling to select professors to reflect the "maximum variation" among them. According to I.E. Seidman (1991), purposeful sampling allows the researcher to select a range of participants that will be fair to the larger population. Selection should reflect similarities and differences among them. I used Seidman's suggestions in the selection of the participants for this study.

I set out to find a group of MSU professors who were known by their colleagues for their efforts in using computers for teaching. The professors selected vary by discipline, the type of computer usage for teaching, and the years of teaching with computers. The decision to choose professors according to discipline was influenced by what I learned from the exploratory study. Professors interviewed for the exploratory study seemed to emphasize particular computer applications based on their subject areas. Because of the small number of participants involved in the exploratory



study (3 participants), I could not verify whether or not the choice of application was influenced by the professors' discipline or by other factors. In the main study, I decided to choose faculty from various disciplines to verify the discipline hypothesis. The second purpose was to present a variety of computer usage so that other professors in similar disciplines may learn from the experiences of their colleagues.

I also chose professors according to the number of years they have been teaching. The studies in *Research on Teachers Thinking* reviewed by C.M. Clark and P.L. Peterson (1986) supported the view that experienced teachers possess a highly-developed set of classroom routines that enabled them to teach effectively and efficiently. I wanted to see if experience in teaching made a difference in the way professors currently use computers for teaching.

I explored two major sources in selecting the faculty participants. Those sources included the Computer Laboratory at Michigan State University and academic departments or colleges within the university. An additional source was professors. I began by asking the staff of the Hypermedia Unit at the Computer Laboratory (MSU) to identify professors who use their services extensively (Informal Interview, 12/3/91). The Hypermedia Unit helps professors with developing technology-based instructional materials. Most of the information provided by this unit was also supported by evidence from documentation on computing published by the Computer Laboratory (Acronyms, 1993, 1992, 1991).

Of the many professors identified through the Hypermedia Unit, a group of fifteen stood out. They were the first set of professors to receive the Integrated Technology Curriculum Development (ITCD) grants from the Office of the Vice Provost for Academic Computing and Technology. The ITCD grants consisted of money, equipment, and programming time to encourage faculty to develop teaching units that are technology-based. The ITCD grant is discussed further under "Computing Resources at MSU" in Appendix F.

I contacted the professors who were identified through the Hypermedia Unit by telephone and electronic mail and asked if they would like to participate in the study. Of the twelve professors who responded, I chose seven based on their disciplines or departments and the number of years they have been using computers for teaching.

For comparison purposes, five other faculty who were not ITCD grant recipients were also asked to participate in the study. Even though I did not set out to study the influence of the ITCD grant on faculty computer use, the fact that this resource was available to faculty might have some impact on their use of computers for teaching. To select those five professors (non-ITCDG recipients), I used the directory of MSU Faculty to locate departments and colleges that were not represented in the ITCD group. The chairperson of departments or dean of those colleges were contacted by telephone and asked for names of professors who were using computers for teaching. I also asked other professors to nominate colleagues whom they regarded as computer users for teaching purposes.

A list of 25 professors was generated from those sources. Using similar criteria as those used in selecting ITCD grant recipients, that is, discipline, experience, and the type of computer use for teaching, I chose ten professors representing seven departments. Out of these, five professors representing five departments volunteered to participate while the remaining five declined. The professors who participated in the study are listed in Table 2.1.

There was an element of self-selection of the professors because the nature of the study demanded that subjects volunteer to participate (Seidman, 1991). The participants and the context of their computer usage represented examples of the situation under study. I believe the participants selected were a fair representation of the larger population of MSU faculty who use computers for teaching. However, generalization to the population was not assumed or intended.

Table 2.1
Faculty Participants and their Departments

	Professor*	Department
ITCD grant recipients	Smith	Entomology
	Kandel	Humanities
	Cain	Geology
	Adamson	Veterinary
		Medicine
	Landon	Human Medicine
	Englebar	Telecommunication
Non-recipient of ITCD grant	Mattsen	Computer Science
	Hake	Technology in Education
	Johnson	Mathematics
	Forester	Crop and Soil Science
	Dillon	Teacher Education
	Boss	Arts

* Pseudonyms are used instead of professors' real names.

Selecting Professors for the Case Studies

Three professors were selected from the twelve who participated in the in-depth interviews to participate in detailed case studies. They were selected based on their responses in the interviews. The criteria used in the selection included:

- 1) Computer use in classroom instruction or usage which directly involved students, as opposed to using the computer for just planning, grading, testing, or instructional management;
- 2) Computer use that included details about context, such as the kind of computing resources available to professors and students, either in their departments, colleges, or university-wide; and

- 3) Characteristics of the professor, such as experience in computer use or computer usage that was different from other professors.

The first was the case of Professor `Hake', a professor of technology and teaching in the college of education who used computers as an instructional delivery tool. He was teaching prospective teachers how to use technology in their own classroom. Professor Hake has been teaching about computers in the classroom for over 20 years. I was interested in how his experience in teaching with computers influenced his decision making in the classroom. I was also interested in exploring whether a professor whose subject matter was computers made decisions similar to or different from those who teach other subjects.

The second case was about Professor `Dillon', a professor of teacher education in the college of education, who used computers to provide a variety of learning opportunities for her students. I was interested in exploring and documenting her experiences as a beginning college professor and a beginning computer user and how these characteristics influenced the outcome of computer use in her classroom. The Playschool project was a unique learning experience that Dillon provided for her students. I wanted to find out what the Playschool contributed to students learning to use computers as a teaching tool in their own classrooms.

The third case was about Professor `Adamson', a professor in the college of veterinary medicine, who developed computer-assisted instructional packages and used them as part of his instructional strategy in the classroom. I was interested in exploring the rich computing resources that he described in the interview and their effects on his computing choices. I also wanted to find out the impact of his discipline, students, and colleagues on the way he currently use computers in his classroom.



Selection and Description of Student Participants

Because this study was also looking at the impact of faculty's computer use on their students' learning, it became necessary to include students' perspectives. Experts in qualitative research argue for the use of multiple sources of evidence to increase the validity of conclusions drawn at the end of a study (R. Yin, 1984). A good source of supporting evidence of the perceived effect of computing on learning was students. However, it was not practical to interview students of all twelve professors. Therefore, only the students of the three professors selected for the case studies were included in this research.

My intention was to select and interview three students from the class of each professor in the case studies. This was not possible, however, due to peculiar characteristics of each case study. Instead, I used opportunistic sampling, that is, selecting students based on the opportunity to do so. I selected students from among those who volunteered. I selected more than one student for each professor to strengthen evidence from student sources and for comparison purposes. I used the maximum variation principle to include students with or without prior computer knowledge, and students who were in the same and different groups for class projects.

My contact with the students originated from the professors themselves. As a result, I took extra precaution to protect students' identities because of the nature of the information solicited. Protecting participants' interests was a condition for obtaining approval of the university committee on research involving human subject (UCRIHS) to conduct the study (see UCRIHS's approval letter in Appendix B).

Selecting Students for the Case of Professor 'Hake'

After the first interview, I asked Professor Hake for permission to visit and observe his classroom and to interview his students. My first visit to the class was an opportunity to meet students as well as to conduct an observation of classroom events.



After class, Professor Hake introduced me and allowed me to talk to the students about my research.

I briefly described my project, and how I wanted students to contribute. I then asked for volunteers to participate in the study. To assure them that their identities would not be known by their professor, I informed them that I wanted as many interested students as possible to sign up on the sheet provided. Out of those who signed up, three would be selected. In this way identities of the three students who finally participate in the study would be protected.

Ten students signed up for the study. The list contained students' names, telephone number, and the group to which they belonged in their class project. This was important for the purpose of comparison among the groups in the class project. The three students selected to participate in the study were "Rosa," "Connie," and "April." Connie and Rosa were in the same group for their class project. I later found out that their group could not work together because of personality differences. "April" was in one of the groups that was able to work well together.

Selecting Students for the Case of Professor `Dillon'

After a preliminary analysis of the data of her interview, I decided to include Professor `Dillon' in the case studies. I contacted her and asked for permission to interview her students as well as observe computer use in her class and at the "Playschool." Professor Dillon had mentioned in the interview that she was collaborating with colleagues in other institutions on the "Playschool" research project. She, however, saw the `Playschool' as an opportunity for her students to learn some professional skills. So the Playschool was a project option in her class. See Chapter Five for a further description of the Playschool.

As was the case in Professor Hake's class, I sat through two of Professor Dillon's regular classes, one per each of the sections that she was teaching. It was also

an opportunity to observe if and how computers were being used in the classes. After each class was over, Professor Dillon introduced me and asked me to talk about my research to the students. I described the research and its purpose. I then asked for volunteers to participate in the study. Eight students signed up from the section where students communicated with one another on e-mail, and seven students signed up from the section where students only used word processors to write their dialogue journals.

I later contacted the students whose names were on the lists. One student from the e-mail group agreed to participate. Two students from the word processor group agreed to participate. The students who finally participated in the study were "Toni," "Audrey," and "Judy."

"Anthony," the fourth student in the case of Dr. Dillon, came to be in the study because I wanted to pursue certain leads from Professor Dillon's interview. During the first interview, Professor Dillon informed me that three of her students from previous years were still participating as staff in the Playschool project. She had mentioned, as evidence of effectiveness of computer use in her class, that those staff had learned to use e-mail in three different ways. I decided to interview one of the staff. My assumption was that someone who had gone through the same courses that Dr. Dillon's current students were going through, and who had stayed longer at the Playschool, would have a better grasp of the situation than students currently taking the classes.

On my first visit to the Playschool as a participant-observer, I met and worked with "Jackson" and Anthony, two of the staff that Dillon mentioned. I later asked Anthony to participate in the study. I assured him that I would protect his identity just as I would the other students.

Selecting Students for the Case of Professor `Adamson'

I met "Josephine" when I went for the first interview with Professor Adamson at the college of veterinary medicine. Professor Adamson had asked if Josephine could

sit in on the interview. She was a clinical student attached to Professor Adamson for two weeks. Josephine was knowledgeable about computers and participated actively in our conversation about computer use for teaching in the college. She later became my link with the rest of the students that I interviewed, and she also gave me a guided tour of the computing facilities in the college.

"Rachel" and "Laura," two third-year veterinary medicine students, were the first set of students I met through Josephine. Both Rachel and Laura have had the opportunity to use some of the computer-assisted instruction programs that Professor Adamson developed. I interviewed the two students together because they did not have the time for individual interviews. As Josephine later informed me, third-year students have to take a lot of medical examinations, so they have very little time for anything else.

The second group of students that I met through Josephine were "Jackie," "Denise," "Stephanie," and "Debra." They were second-year students in the college of veterinary medicine. I included the four students in the study in order to find out what they think about the CAI programs developed by professors in the college. Many of the programs developed by some of the professors in the college were shared by their colleagues teaching the same course but with different emphases. Having the four students was also an opportunity to compare their perceptions with those of the third-year students who have been taught by Professor Adamson. Jackie, Denise, Stephanie, and Debra were also interviewed as a group, because they also did not have time for individual interviews.

Even though Josephine's identity was known to Professor Adamson, there was nothing in the interview that could put her at risk. I, however, stressed to her the importance of keeping the identity of the rest of the students confidential. Table 2.2 shows the case studies professors and their students.

Data Collection

Data Sources

Data collected and analyzed are from these sources:

- a. In-depth interviews of professors, students, computer resource personnel, and an administrator, using interview guides (see Interview Guide in Appendix C);
- b. Observation of classroom events for case study purposes (see Observation Guide in Appendix C);
- c. Documentation consisting of a teacher's lesson notes and Computer Laboratory publications;
- d. Field notes (see examples in Appendix C).

Table 2.2
Case Studies Professors and Their Students

Professor *	Discipline	Student *
Hake	Technology in Education	Rosa Connie April
Dillon	Teacher Education	Judy Toni Audrey Anthony
Adamson	Veterinary Medicine	Josephine Laura Rachel Jackie Denise Stephanie Debra

* Pseudonyms are used instead of participants' real names.



Interviews

The twelve faculty listed in Table 2.1 were interviewed twice formally, one initial and one follow-up interview. A series of informal conversations and electronic mail communications supplemented the formal interviews. Most of the informal conversations were with the three faculty in the case studies. Profiles of the twelve professors are presented in Chapter Three.

A total of fourteen students were interviewed, six of them in groups of two and four. The remaining eight students were interviewed individually. All the students were interviewed once formally. The follow-up interview included telephone and face-to-face conversations. These were supplemented with written comments that students returned with the interview transcripts sent to them. The group of four students (second-year veterinary medicine) could not be reached for any follow-up. As a result, I was cautious in using the data from their interview. I used a summary of their responses to corroborate information from the group of two (third-year veterinary medicine) and other sources, but I did not use any of their quotes in the analysis. Data from student sources were used only in the case studies to support evidence provided by faculty and other sources.

Three computer resource persons were interviewed about their work in the college of veterinary medicine. 'Matthew' was a technical person in charge of network, equipment, and software installation. 'Jake' consulted with and assisted professors in instructional development projects. 'Andrew' specifically assisted Professor Adamson in the development of computer-assisted instruction programs. Their interviews and the follow-up comments on the transcripts were used in building the case study of Professor Adamson in Chapter Five.

Dr. "Conway" was interviewed in his role as an administrator who facilitated computing in the college of veterinary medicine. His interview was also used in the case study of Professor Adamson.

Observations

The data obtained through observations were used to corroborate interview evidence in building the three case studies. Observation data were mainly my impressions and summaries of the three situations studied. I noted the events, the people, and the context. Details of how the observations were conducted is presented later in this chapter.

Teachers' Documents

Professor Hake's teaching notes were obtained as part of the observation session. The teaching notes consisted of his lesson plans and the assignments given to students. My notes, as I watched him using the lesson plan, and his comments during the second interview were pulled into the case data for analysis.

Other professors gave me articles and write-ups about their projects involving computer use in their classrooms. I used these documents in building their profiles.

Computer Laboratory Documentation

Documents obtained from the Computer Laboratory were used to construct the computing environment in which professors work at MSU. In order to understand the kinds of computing choices that professors made, it was necessary to describe the kinds of resources available to them in the university.

The Computer Laboratory, as one of the three branches of Academic Computing and Technology, publishes all kinds of information relating to computing facilities and services on campus. Some of the documents used included *Acronyms*, a computing and data communication newsletter published several times a year; the Computer Laboratory Annual Report; and information sheets announcing training, Hypermedia resources, and faculty facility for computing.

Informal Conversations

In the early phases of the study, I talked to a few people whom I considered knowledgeable about the status of faculty computing at Michigan State University. Persons interviewed informally included Dr. Paul Hunt, the Vice Provost for Computing and Technology at Michigan State University (10/28/91); Dr. Carrie Heeter, the Hypermedia Coordinator (12/3/91); and Dr. Patrick Dickson, a professor who also served on computing committees on campus (11/21/91).

Dr. Hunt gave me an overview of the computing resources on campus and their locations in various colleges, departments, and the Computer Laboratory. Dr. Heeter told me about the faculty that were using the Hypermedia resources and, in particular, about the first group of faculty that received ITCD grants. Dr. Dickson contributed his own perspective as a professor who uses technology in his teaching and from his work with other professors.

A Seminar on Faculty Computing

Dr. Hunt informed me about a faculty seminar taking place on October 31, 1991. He suggested that I attend the seminar with the purpose of better focusing my research topic.

The seminar was on the role of computers in writing courses at MSU. Faculty from various disciplines on campus attended and presented research projects involving the use of computers in writing. Problems that faculty might face when incorporating writing and computers into their subject matter was one of the topics discussed at the seminar. Two of the problems identified included time and subject matter. The professors at the seminar were concerned about where faculty would find time to integrate both computers and writing skills into an already overcrowded curriculum. Faculty time to learn to use computers was also a concern. From this I made a note to

ask professors in my study about the kinds of problems or challenges they face as they integrate computers into their teaching.

Field Notes

The notes that I took while in the field contained my impressions about the various situations I found myself in while in the field. I carefully documented what happened, what people said, and my reactions to things said and done (G. Spindler and L. Spindler, 1992, p. 77). I also took some notes during the interviews and when studying the transcripts of the interviews. The field notes were used to complement data collected from other sources (See Appendix C for extracts of field notes). Some of the points I noted later became the lead themes at the analysis phase.

The Instruments

The main research instruments used included interview guides and an observation guide. An interview guide was constructed for each of the four groups of participants in the study, namely: faculty, students, resource personnel, and an administrator.

Professors' Interview Guide

The construction of a faculty interview guide was influenced by the symbolic interactionists' perspective which states that humans act toward an object on the basis of the meaning the object has for them. In order to get at the personal meanings that professors who participated in this study attach to computer use for teaching, the interview questions focused on faculty background including influences on their computer use, the purposes and teaching activities for which they use computers, and the resources they have for computing. The faculty interview guide contained twelve

open-ended questions about professors' backgrounds, the ways they use computers for teaching, and their perceptions of the impact of computer use on teaching and learning.

Background.

The literature on teachers' thought processes reveals that teachers' beliefs about aspects of their practice greatly influenced their effectiveness in the classroom. The exploratory study conducted earlier suggests that factors like discipline, personal history of innovating, and experiences may be other influences. I decided to ask professors about early influences on their computer use for teaching to see if similar factors played important roles in their computing decisions.

Research Question 1:

In what ways are professors using computers for teaching?

A thesaurus of common words defines ways as method, means, technique, process, and procedure; and use as including application, function, or purpose. Implicit in these definitions are the activities with which a method, process, or procedure is used. J. Lofland defines (1971) activities to consist of action in a setting that spans a major duration like days, weeks, months--constituting significant elements of persons' involvement. Teaching is an activity that occupies a considerable portion of professors' time.

A review of the literature on academic computing revealed that teachers use a variety of computer applications for different teaching activities. Teachers' purposes for computer use include fulfilling educational goals and objectives, as well as solving some teaching problems. The interview guide, therefore, contained questions about the purposes of computer use, including educational goals and teaching constraints which computers alleviate, teaching activities, the procedures for using computers for teaching, and the computing resources, including hardware, software, computing support, and their sources.

Research Question 2:

Perceptions of impact of computer use on teaching, learning, and classroom interactions

Studies on academic computing show that teachers perceive impacts of computer use in three areas: their teaching, their students' learning, and the organization of the classroom. The interview guide also contained questions about faculty's perception of the impacts of computer use on their teaching, students' learning, and classroom interactions. See Appendix C for interview guides.

Students' Interview Guide

The construction of the students' interview guide followed a similar process as the faculty's guide.

Background.

B. Glaser and A. Strauss (1967) in *The Discovery of Grounded Theory*, stress the need to build understanding about the social world that is grounded firmly in the concepts and theories of persons studied. In order to understand students' reactions to computer use in their classroom, it was necessary to know what experiences students brought into the learning situation. Learning theories show that prior experience influences how much someone learns from a new encounter. Background information on students prior contacts with computers was solicited with Questions 1-2 of the interview guide.

Perceptions.

Questions 3-6 were about students' perceptions of computer use in the courses for which their professors were being studied. Students were also asked for their perceptions of the impact of computer use on their learning, that is, the contribution of computer usage to their learning of the course materials and objectives and the achievement of their overall educational goals.

The perception of affect also was sought from students. Questions of affect dealt with how students perceived the effectiveness of computer use in promoting certain beneficial relationships in the class; i.e., their views of their professors as role models, their own attitude toward learning and computers, and their relationships with other students.

Assessment of strategy used.

Questions 7 and 8 asked students to assess the totality of experiences that they associated with computer use in the class. It was a means of getting at their real feelings about computer use or the personal meanings it has for them. Whether or not they would do something differently if they were the professor or had the chance to change something, was an indication of their satisfaction with computer use in the course. It was also an indication that students were not just recipients of information, that they too constructed personal meanings out of the situations of learning. See Appendix C for students' interview guide.

Administrator's Interview Guide

Many change theories emphasize the importance of technical and process skills of a change manager in helping individuals, groups, and the institution to cope with change. There was no doubt that the administrator was an expert in his field. Therefore the interview was focused more toward understanding his process skills--how he helped people cope with change that computing represented.

The administrator's interview guide contained ten, open-ended questions dealing with his role as a facilitator of faculty computing in his college. The questions explored the history and importance of computing to the college, the overview of resources and support available for faculty computing, sources of funding for computing, and how resources were organized for easy access by users. Also explored were his perceptions of the impact of faculty computing on teaching and learning in the college and the

impact of computing efforts on the graduates of the college. His vision of computing for the college was of interest too. See Appendix C for administrator's interview guide.

Computer Resource Persons' Interview Guide

Many implementation theories and the literature of academic computing stress the importance of technical and user support for planned change to succeed. The resource persons' interview guide was designed to capture their perceptions of their role in academic computing.

Background.

Information about a resource person's background was necessary in order to understand the types of skill they brought into their jobs. I was particularly interested in the kind of training they had, how they became interested in computers, and how long they have been using computers, as a means of understanding the influences on their current job. Questions 1-4 of the interview guide addressed those issues.

Perception of work.

Questions 5-10 addressed the characteristics of the job that resource persons do, their perceptions of the computing facilities in the college, the ways computers are being used in teaching and learning, and their assessment of the challenges of their work. See resource persons' interview guide in Appendix C.

Observation Guide

An observation guide was used to collect data about the three classroom settings in the case studies. Both the physical characteristics and processes in the settings were observed. The physical characteristics of the classrooms included, hardware and software and the arrangement of equipment for class events. Process characteristics included mode of instruction, types of interaction, types of classroom events, problems

arising from computer use in the classroom, solutions to those problems, and unanticipated events. See observation guide in Appendix C.

Researcher as Instrument

According to L.F. Locke, W.W. Spirduso, and S.J. Silverman (1987), there is no strategy that can eliminate the routing of data through the perceptual processes of the investigator (p. 86). Seidman (1991) believes that the researcher's judgment plays an important role in the process of data collection and data reduction during analysis. There is a great reliance on the researcher's ability to sort out what is important. "The value and judgment of the researchers pervade their research report, from obvious declarations to the more subtle arrangement of material and choice of emphasis" (Hakim, 1987, p. 70).

In conducting this study, I was conscious of my biases which shape the tone and direction of the study. I acknowledged the fact that what I saw and heard in the field were my interpretations of a reality, interpretations that were influenced by my "values, habits of perception, intellectual presumptions, and personal dispositions." (Locke, et al., 1987, p. 86).

I went into the field having certain audiences in mind. I set out to find out about faculty computing in ways that would benefit me as a prospective teacher and increase my knowledge about how to teach with technology. I actively sought out information about technologies currently used by professors and the process of use. I also had in mind professors who were new or prospective users of technology. My interpretation of the kind of information that would benefit them include the processes of computer use, the more personal aspect of learning to use computers for teaching, and the trials and successes of the professors whose experiences were studied. Documenting professors' views about computing resources, the problems and challenges of computer implementation, educational goals that professors use computers to serve, and

anticipated future use of computers, were my interpretation of the kind of information that administrators need to plan ahead for in the twenty-first-century information society.

However, I took great care to insure that information presented reflected the perspectives of those studied. I used "member-checking" as a technique of checking with participants to see if what I marked as being of interest and important seems that way to them too (Seidman, 1991). I consciously looked for corroborative or contrary evidence of behaviors and events in which they occur. Such evidence was obtained from the same participant on different occasions and from other participants on the same topic.

In the Field

Intensive data collection began in the fall of 1992. The first set of interviews began in October. In preparation for going into the field, I obtained the necessary permissions to conduct the study.

Obtaining Permission from the University Committee on Research Involving Human Subjects (UCRIHS)

Part of the ethical consideration of the study was to ensure that the interests of the participants were protected and that they were duly informed of their rights and requirements of the study. Application to that effect was submitted to UCRIHS and permission was granted to continue the study (see UCRIHS letter in Appendix B).

Obtaining Written Consent from Participants

Consent letters attached to the interview guides were mailed out to professors and students who expressed interest in participating in the study. The consent letter served two purposes. One purpose was to inform participants of their rights and the

requirements of the study if they chose to participate. The second purpose was to allow participants the opportunity of reviewing the topics of discussion before they made a final decision about their participation in the study. Consent letters were signed by participants and were either mailed to me before the interview date or given to me on the day of the interview, just before the interview began. Sending the interview guide ahead also enabled the participants to organize their thoughts about the topics and prepare to address them during the interview.

Conducting the Interviews

The first set of interviews lasted one and one-half hours with each participant. The second interviews were mainly follow-up on issues that were raised in the first interview. Second interviews lasted an average one hour. Informal discussions and e-mail messages complemented formal interviews.

All of the professors' interviews were conducted in their offices or laboratories. Each interview situation was unique because of the different dynamics involved. In most cases it was only the professor and I. Only on one occasion was a student present who contributed to the conversation.

It appeared to me that the first five minutes of the meeting were very critical in setting the tone of the conversation or the relationship. While some professors waited for me to begin the interview, some just went right ahead and began talking. Some used the interview guide to organize their talk while some approached the topic from any point, weaving through the rest of the questions in the order they preferred.

For the first round of interviews, I let the professors talk about their computer use as much as they wanted to. Occasionally, I might interject comments or questions to clarify some points or to prompt them to elaborate on some issues they raised. For example, here was how Professor Hake elaborated on his solution to the problem of computer use in his classroom.

Hake:

Hardware and software problems, always. Disks don't read, things don't work, whatever. But usually we overcome them. I think the instructor has to be aware the technology has weaknesses and things don't always run like you expect them to.

Interviewer:

So when things do not run as you expect them to, what do you usually do?

Hake:

Well, I don't believe I should spend a lot of time in class solving those kinds of problems. So if it's a problem I can't solve in a minute or two, I just tell them, "Look, we'll skip that and move onto something else and I'll solve it next week." I think it's a waste of time to sit there and try to solve technical problems with 30 people trying to get some work done. I don't generally do much trouble-shooting during class. (Interview: 10/27/92)

Through the elaboration, I was able to get further insight into how the professor coped with situations that might arise in his classroom and his beliefs about what computers should or should not be allowed to do to a class. Through this probing for elaboration and clarification of concepts, a lot of the meanings that professors attach to their actions in the classroom became clearer to me and to them. In the process of elaborating or providing a reason for their actions, they were thinking about those actions, and they understood them better. Dr. Dillon, one of the three professors in the case studies, commented that the interview provided her the first opportunity to truly reflect on what she was doing with computers in her class.

The second interviews were more focused around matters arising from the first interviews. I made an appointment for a second interview after I had listened to the tapes of the first interview. I went into the second interview with a set of follow-up questions that I intended to ask. I still allowed professors to elaborate on their points, however, the direction was much more under my control.

Overall, my impression of the interviews with the professors was very positive. On a few occasions, I felt uncomfortable with professors who insisted on telling me

what they were doing with computers that was "different rather than similar" to other professors. Some of my attempts to bring them to address the questions in the interview guide were not very fruitful. Once or twice they countered my probe questions with comments that I interpreted as defensive, as this quote from Professor Johnson illustrates:

It's true, probably one can overdo this sort of thing too, because I'm not a great fan of computers in the classroom. As far as that is concerned, I like to develop the subject of my lectures. One could get carried away and I don't think one should. (Johnson: Interview, 10/29/92)

he kind of information that emerged from probing professors' statements proved very useful to me in building hypotheses about the relationship between professors' beliefs and computer use. How professors use computers in the classroom may be a result of a combination of factors, of which the beliefs they hold about computers may be the most powerful.

Interviews with the administrators and the computer resource persons followed similar patterns as those with the professors. There was mutual respect between us and an understanding of each other's time and needs. They were always prepared to talk as soon as I arrived. As with the professors, they were also very enthusiastic about showing me what they were doing with computers and sharing their thoughts about issues.

Probe questions were also very useful for clarifying issues raised by computer personnel. For example during the interview with Matthew, the technical person for the college of veterinary medicine, I heard him mentioned 'ToolBook' several times in connection with computer-assisted instruction programs being developed in the college. I was not sure whether he meant ToolBook the authoring systems, or if he was or using the name to refer to the CAI programs. I had also heard the same usage from other people from the college of veterinary medicine, namely Andrew, who was Professor

Adamson's personal assistant in CAI development, and Adamson himself. So I asked Matthew for clarification of what ToolBook meant to them.

Matthew:

We use ToolBook, so we have ToolBook located in a central location. That way when a faculty updates a ToolBook, we just put it there and all students can access it. In fact we have it set up so some faculty can update the ToolBook from their office and all the students have access to that almost instantaneously.

Interviewer:

What do you mean when you say the faculty updates ToolBook? I thought ToolBook was a development program?

Matthew:

Right. It's software construction set they call it. It's more than just educational, but most people use it for education. It's like HyperCard for Macintosh.
(Interview, 11/19/92)

Later I learned that because ToolBook was the major development platform for the college, most faculty, staff, and students have come to associate CAI programs with ToolBook and used them interchangeably. Even though ToolBook still retains its meaning as an authorware, it was much easier for users in the college to say ToolBook than to say auto-tutorial, which was another term frequently used for CAI programs in the college.

Interviews with students were much more difficult to conduct. We did not have a set location for meeting. I met with some students in their dormitories, in the cafeteria, and on one occasion at a clinic. I met with some students very early in the morning, and one person late at night. In some cases, we met between classes. On a few occasions, I had to reschedule appointments because the students forgot about the meeting. Despite, these inconveniences, I was able to gather very useful information to corroborate evidences from professors and other sources.

Like the professors, each student had a distinctive way of responding to interview questions. Many of them were very articulate. For example, Toni, one of

Professor Dillon's students in the teacher education program, seemed to know a lot about computers, and how she could apply them even though computer use in her current class computers was below her expectations. I was particularly interested in hearing her develop further her theory of making a cognitive connection with the physical diskette. So I probed her on her statement where that was mentioned.

Toni:

It makes me feel like I'm more organized because I have my disk for this class, a disk for that class, and I can have everything separated. A lot of times I can see where there are connections between the different classes by being able to have that stuff. I may not make it [the connection] that same day or that same week, or whatever, maybe at the end of the term, but I can ... it helps me store my knowledge. It's almost like a picture in my head, where I have this block of this and I have this block of this. It's easier to make the connections, which I think are really important when you're learning to remember stuff.

Interviewer:

So you think having a different diskette for different courses helps you learn things better?

Toni:

It's easier for me to look at that and connect it to my notes and make sure that I'm using the terms that make the paper more persuasive and stuff like that. It's a nice connection from my notes to something that I've created by myself.
(Interview, 11/3/92)

Conducting the Observations

I assumed the role of direct observer in two case studies and in one case, a participant observer. I went to each observation session with the observation guide. I also generated a list of things to observe about each classroom, based on the importance attached to them in professors' interviews.

I did not focus observation on individuals, but on the classroom processes involving computer use. I was particularly interested in what hardware and software

were used for certain events, the decisionmaking process, assignment of tasks and responsibilities, and other interactional processes.

Due to the differences in the context of the three cases, different kinds of information were gathered. In the case of Professor Hake, I observed live lessons of the professor and his students using computers. I went as a direct observer using the observation guide and my list to collect data. In the case of Professor Dillon, two types of observations were conducted. I was a direct observer in two of Professor Dillon's regular classes for one period each. The observation consisted mainly of listening and taking notes about class discussions. I wanted to see if computers played any role in the discussions.

The second observation involved my direct participation in the "Playschool" project. I visited the Playschool on two occasions as one of the "Big Sisters." I wanted to see computer use in the center from the perspective of the undergraduate students in Professor Dillon's class. As a participant-observer, I did not have the luxury of direct observation. I relied greatly on my memory of the events to complete field notes. However, I audio-taped a "debriefing" session by the undergraduates to complement my observation.

In the case of Professor Adamson, I did not observe a live class because Adamson was not teaching a class that semester. However, I obtained a video of his lesson in which he used computers as part of the instructional delivery system. The video-taped lesson was analyzed as part of the case study report in Chapter Five.

To complement the video-taped class, I observed Professor Adamson as he explained the process of developing his computer-assisted instruction programs, especially the decisions made about the design of the programs. The conversation was audio-taped and transcribed. In addition, I used the observation guide to collect information about the computing facilities in the college during the guided tour with Josephine, one of Dr. Adamson's students.



Withdrawing from the Field

By Spring of 1993, data collection was more focused on cross-checking evidence and validating the transcripts of interviews. All participants were sent copies of their transcripts for comment. They were told to take off any section of the transcripts that they did not feel comfortable about or which they would not like to appear in the report of the study. Except for the four second-year veterinary medicine students who could not be reached for comment, all participants returned their transcripts with comments, corrections, or confirmation that it was a true representation of the interviews.

By March 1993, I decided to close data collection and concentrate on making sense of the data. By this time, I had accumulated about 39 audio-tapes and over 400 pages of transcripts, field notes, and documents.

Data Analyses

J. Morton-Williams (1985) proposed a procedure for organizing and reporting qualitative data. According to the author:

1. The primary underlying structure is imposed by the objectives of the research which provides a conceptual framework within which the analysis can be organized.
2. A more detailed analysis can be done by:
 - a) a summary of the most salient points from each respondent's interview, which might include a straightforward notation of facts and views; and/or an overview that draws conclusions about underlying attitudes or motivations. It might also include classifying respondents in several ways in order to make comparisons between sub-groups.
 - b) taking certain key topics and summarizing each respondent's view on them. If the summaries are done within broad groups, then any major differences between groups



are readily seen. Such comparisons can provide indications of possible differences, not conclusive evidence because of small numbers.

3. Findings should be presented in the form of impressions gained, as hypotheses rather than firm conclusions.
4. There should be no tables (apart from those describing the sample composition) and no references to numbers or percentages. At most the researcher would use such phrases as "most respondents" or "around half," or "minority view was..."
5. The researcher should be mainly concerned with identifying and describing the range of behavior and opinions rather than to indicate whether people feel strongly or how many hold each view.
6. In all cases the description of beliefs, attitudes and motivations should be supported by evidence in the form of verbatim quotations from the interviews.

I adapted this approach for analysis of data in this study.

Preparation of the Transcripts

The interview tapes were transcribed verbatim. I transcribed some of the tapes myself to give me a feel for the data. Most of them were done by a transcriber with the instruction that she should record all the non-verbal signals such as laughs, pauses, telephone rings, and outside noises. The purpose was to help me reconstruct the experience of the interviews as much as possible later. This proved useful because during the analysis I used the non-verbal signals in the transcript as a cue to listen again to the portion it referenced on tape. I proofread the transcripts and filled in the missing gaps from the tapes.

Search for Coding Categories

Initial analysis was undertaken to detect categories under which interview data can be classified. Symbolic Interactionists and other qualitative researchers maintain that the object of analysis is to detect patterns among classes of things, people, and events (Woods, 1992; Jacob, 1987; Denzin, 1978).

The overall structure used was the categories of the interview questions. Each category was defined with instructions about the units of behavior that were acceptable as equivalents. Sub-categories also emerged that were subsumed under the major categories.

The first step was to read the transcripts and demarcate meaningful units. (Seidman, 1992, p. 89). Meaningful units included passages, paragraphs, or sentences that specifically addressed topics of interest, or which I judged to be interesting or important. I designated those with symbols, such that "TG" stood for teaching goals for which computers are used, "TA" stood for teaching activities, and 'I' stood for interesting or important. The example below was taken from the transcript of the interview with Professor Englebar. E stands for Englebar and I for interviewer.

ISL: I[mpact] on S[tudents] L[earning]

I: What would you say is different now than, say, five years ago?

E: The difference between my students now and my students four years ago when I started with this is that they understand a lot more about many things. While creating breadth of knowledge, we also create the depth, thus make possible a process which is more efficient and more closely related to what the students will actually be doing. The quality is different. Before they just have a bunch of stuff which didn't stick... It stays long enough for them to take exams. But now, hopefully, we could give them variety. The cynical part is that they spend more time on it which is made possible by the computer. The time they would have spent doing something else before, takes them off the street.

I[nteresting]

I: What were your recommendations for your colleagues who want to start using computers for teaching?

E: Well, I guess just to be ... be literate in the basic computer operating system of your choice, be it Apple or DOS or Windows or whatever you're using, and then the applications software that's required, like Harvard Graphics, Word Perfect and a spreadsheet program, or a specialized simulation program. But the skills ... just generalized computer literacy skills and problem-solving skills. Never allowing yourself to be defeated by the computer. Keep going at it and doing the stuff you got to do. Ask somebody who knows how to do it or trying things until you finally get it to work...Persistence at least. Yeah, there's a certain ... it's almost like a problem-solving methodology that you've got and develop intuitively....

For each transcript, I pulled all the meaningful units together and later sent them to the participants for confirmation and comments. Next, I devised a set of instructions for recognizing designated categories in the transcripts. From one of the transcripts, I inductively generated categories based on the responses to particular interview questions. Examples of categories and their definitions are presented in Figure 2.1. The full coding categories and instructions are presented in Appendix D.

The Search for Professors' Meanings

One of the assumptions of this study was that professors would use the computer because of the meaning it has for them. To increase the likelihood of finding professors' meanings, I used Cognitive Mapping procedures adapted from S. Jones (1985). Cognitive mapping is a method of modeling persons' beliefs in diagrammatic form. "In mapping we are listening for, and seeking to represent, persons' explanatory and predictive theories about those aspects of their world being described to us." (Jones, 1985, pp. 60-61)

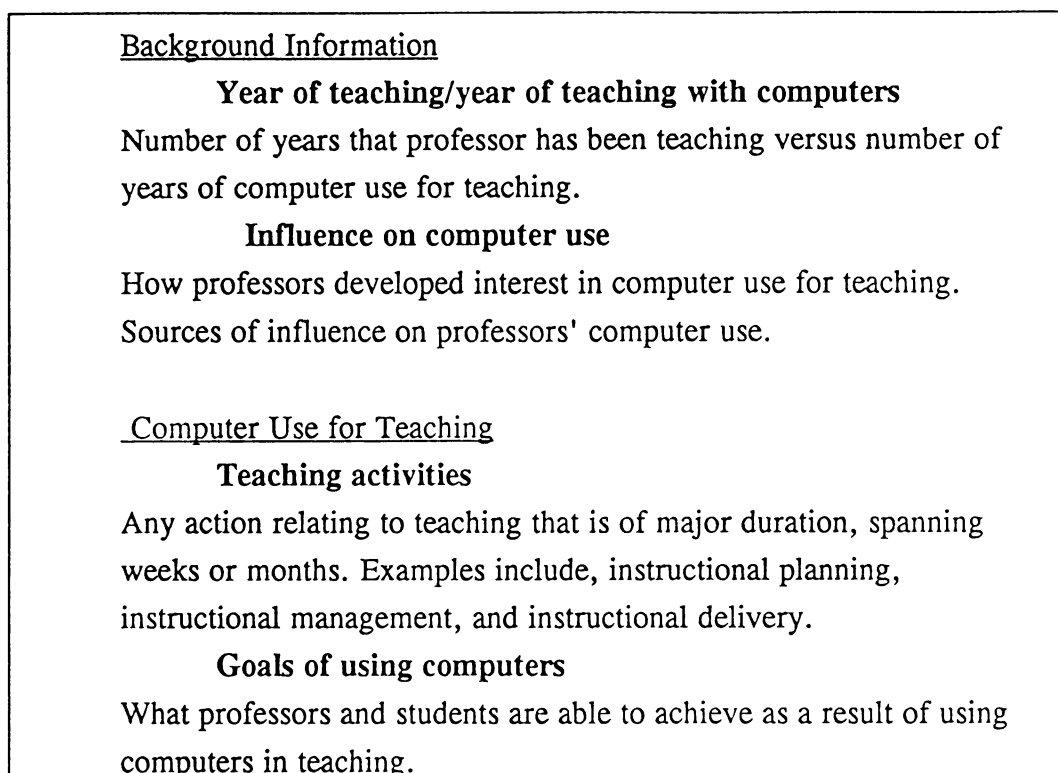


Figure 2.1
Example of Coding Categories

Cognitive mapping comprises two main elements: a persons' description of ideas in the situation being considered and beliefs or theories about the relationships between the ideas. The relationship is shown in the map by an arrow or simple line. An arrow represents a relationship where one thing leads to, or is explained by, another. A simple line represents a connotative, or non-causal link. Elaboration of meaning could be through contrast with some psychological alternative, explicitly stated or implied.

I adapted cognitive mapping to map the different levels of decisions that professors make about computer use. These include the decisions about the kinds of technology they use, the procedures for computer use, and the underlying reasons for their actions. Figure 2.2 is an illustration of how cognitive mapping works in bringing out the meanings that individuals may attach to their actions in relation to the tool used.



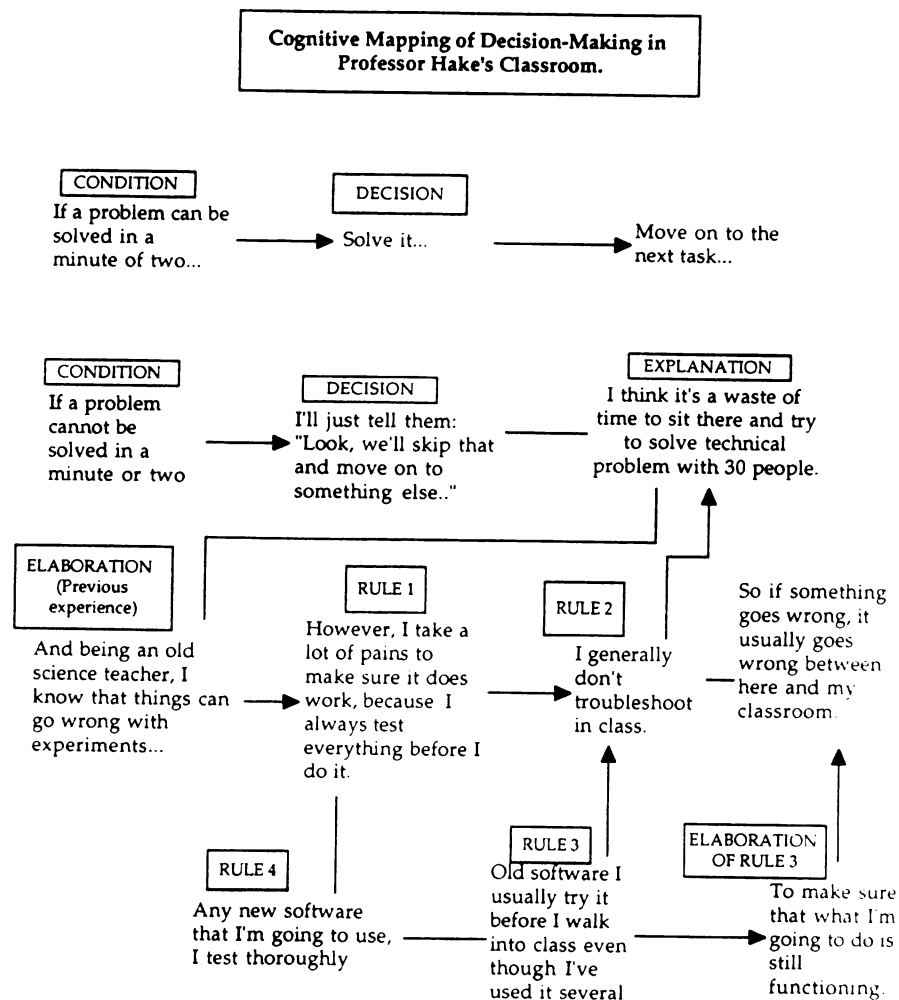


Figure 2.2
A Cognitive Map of Professor Hake's Decisionmaking

This example was based on Dr. Hake's explanation of his choice of a presentation software. Professor Hake uses MORE or PERSUASION as his presentation software [action], so that he could outline his lesson notes [reason]. This has the [outcome] of saving him the trouble of flipping through transparencies in class [reason: classroom efficiency]. It was also convenient [reason: convenience] to just take

a diskette instead of a bunch of transparencies. This was possible because the technology to support his decisions is available (LCD display panel and Macintosh computer).

Using cognitive mapping this way allowed me to pay closer attention to participants' "language" than I would have done had I used another method of coding. The language used to refer to an action or behavior in relation to computer use is an indication of professors' beliefs about computers and the weight they place on its use as a tool of work. Although the constructs generated are not fully developed at the moment, I hope to continue working on them beyond this dissertation. See Appendix D for more examples of cognitive mapping of the transcripts of the interviews.

Organizing Data

Data analyses were focused on determining similarities and differences within and between participants. Analyses were organized around each individual participant, the categories from the research questions, and the themes that emerged from the data.

Analysis by Individual Participants

The first approach was to treat each of the participants in their own right. I summarized each person's responses to the interview questions. These were used to construct the profile of each participant. Each profile was constructed around a central theme that captured the underlying attitude to computers, or motivation for using computers, expressed or implied by the participant.

Analysis by Interview Questions

Analysis of data by interview questions was for the purpose of identifying patterns across participants. Each interview question was treated in its own right, and participants' responses on them were summarized.

The next step was to look for data that addressed categories in the research questions. Data were reclassified several times according to the categories and subcategories into which they fit. The result of this analysis was displayed in tables and narratives. Some of the results are presented in tables in Appendix E.

Analysis by Themes

As I went through each transcript, I noted down themes that emerged as a result of using the cognitive mapping approach. Then I looked for themes that cut across many participants. Taking certain key topics, I compared participants' views on them. Selected quotes were used to support the analysis. According to Seidman (1991), the use of the participants' "voices" adds legitimacy and validity to a researcher's themes. Some of the themes discussed include professors' time to use computers effectively and their perceptions of whether computers take over or give them more control of teaching and how that affects their attitudes to computer use.

Observation Data

Data collected from each observation session were summarized and used to support other sources to build the case studies. Observation data for each case study were treated within the context of the case study on which it was collected. There was no comparisons of observation data across the three cases because of the differences in the situation of each study which affected the kinds of data collected.

Document Analysis

Documentation obtained from the Computer Laboratory and the notes obtained from professors were examined using a content analysis approach. According to Bray (1986), content analysis has, as its primary objective, the description of the content of communication. For this study, the documents obtained were examined for their content, purpose, and the role they play in the context in which they were created.

Computer Laboratory Documentation

The purpose of obtaining and analyzing the Computer Laboratory documentation was to understand the kinds of opportunities and constraints within the context that MSU faculty use computers for teaching. Of particular interest were the kinds of resources provided campus-wide, and how they are allocated for faculty access. The documents collected included many issues of Acronyms, a newsletter regularly published by the Computer Laboratory on its activities and services; the 1985-86 Annual Report, and information sheets announcing services provided by the Office of Academic Computing and Technology. The latest issue of the annual report was not available at the time of this study.

The documents were analyzed according to the purpose and the kinds of information they contained. Topics of interest from the analysis include: a) mission of Michigan State University, b) the role of computing in fulfilling the mission, c) status of computing at Michigan State University, d) facilities for faculty computing, e) other resources including funds, training, and personnel. The results of this analysis is presented in Appendix F.

Teachers' Documents

Documents obtained from professors include class notes, personal notes, syllabus, and CAI catalog. The documents were analyzed for purpose, content, and

structure, including text, graphics, the layout, instructional objectives, instructional activities, and strategies.

Professor Boss in the Arts department submitted personal notes which were his reflection on teaching. I used the notes to support interview data in building his profile. Professor Mattsen in Computer Science gave me a catalog of the computer-assisted instruction projects he developed. I took some quotes from the catalog to support interview data when constructing his profile.

I obtained teaching notes from Professor Hake. Major topics from the analysis of these notes included, instructional objectives, instructional activities, hardware and software, mode of instruction, problem-solving strategies, and assignments. During observation sessions, part of my attention was devoted to matching the intended use as it appeared in the teacher's notes with actual use. The result was pulled into the case study of Professor Hake in Chapter Five.

Presenting Report of Analyses

The major organizing framework for presenting the report of analyses is the research questions. The analysis of data addressing research question one, that is, the ways in which professors use computers for teaching, is presented in Chapter Three. Chapter Four contains the report of data addressing research question two, that is, the impacts of computer use on teaching and learning. Chapter Five contains the report of the case studies which explored further the impact of computer use in three selected settings.

The data presented in each chapter included descriptions and narratives of patterns among the participants in the study. Groups and subgroups were identified and compared through description, narration, summaries, and direct quotes of their views. Tables and figures were used to aid comparisons.

Description

Description was one major strategy used in this study to present data. There were descriptions of groups and subgroups to bring out the similarities and differences among them. In most cases, narratives and tables were used to aid the description. Groups or subgroups were denoted according to whether or not they responded to certain questions in the interview or had similar comments on themes that emerged from the data. For example, all of the professors in the study mentioned self-initiative as one of the major influence on their computer use, while only a few mentioned past training.

Profile

Constructing a profile of each professor was a means of summarizing the salient points in their interviews. Each profile consists of facts and views expressed by a respondent, built around a central theme representing my interpretation of attitudes and motivations underlying the professor's computer use for teaching.

According to Seidman (1991), crafting a profile or vignette of a participant's experience is an effective way of presenting interview data. It allows a researcher to present the experiences of participants using participants' own words. A profile should have a beginning, a middle, and an end, as well as some sense of conflict and resolution (p. 91). Using a profile to present data also allows incorporation of narratives.

Quality Control

Denzin (1978), Walker (1985), and Jones (1985) recommend using:

- a. multiple sources of evidence, that is, evidence from two or more sources converging on the same set of findings or facts;
- b. triangulation of evidence, to provide multiple measures of the same phenomenon;

- c. openness to contrary findings as a test of bias; and
- d. establishing a chain of evidence, that is, explicit links between the questions asked, data collected, and the conclusions drawn.

I adopted a variety of these techniques to insure quality in the findings and conclusions drawn from this study. Attempts were made to build quality into the study at the stages of design, data collection, and data analysis.

Quality in the Design of the Study

A review of the literature helped to establish the background for the study and the research questions. An exploratory study was conducted to try out the design of the study. Feedback from this initial study was used to refine the design of the final study.

Quality in Data Collection

The interview guide contained similar questions as those used in the exploratory study, thereby testing its usefulness for collecting relevant data. Both the interview and observation guides were shared with two professors in the college of education. Their comments and suggestions were used to revise the guides. I asked two professors who were not included in the study to answer some random questions in the interview guide. I was satisfied that the guide would yield the required data.

Before the interviews began, all participants were sent a copy of the guide to help them prepare. Most participants commented that the guide helped them in focusing their thoughts on the purpose of the interview. Moreover, each copy of the interview guide was accompanied by a letter explaining to participants the requirement of the study, and assuring them of the confidentiality of their identities. These steps were necessary, especially with student participants, to insure that trustworthy information was collected. I relied greatly on the professionalism and integrity of the professors in the amount of confidence that I placed on the information they provided.

After the formal interviews were completed, I sent the transcripts to interviewees for validation with instructions to delete information that they did not want used in the study. Additional data were collected from observations and teachers' documents for the purposes of triangulating the themes discovered in the interviews. The technique of direct observation allowed me first-hand knowledge of the relevant behaviors and the environment, and participant observation allowed me the perception of reality from the perspectives of those in the context of study. The value of a piece of evidence increases with the number of opportunities I had to record its existence.

Quality in Data Analysis

According to Jones (1985), analysis of data is a highly personal activity. It involves processes of interpretation and creativity that are difficult to make explicit. Searching for and carefully documenting the process of generating analysis categories was my way of making explicit the analysis process. I looked for categories from the literature and within the data using participants' "language" as indicators of important concepts. A category or concept was judged as such by the weight of evidence warranting its existence. According to Denzin (1978), a behavior or an observation was judged to be present by its frequency and observability. Frequency refers to the number of times a behavior occurs or a category is mentioned. The more times a behavior occurs, the stronger the indicator of its presence. Observability refers to the extent to which a category is based on publicly observable acts or activities. The more public the nature of the act, the greater its assumed validity.

Also, the presence of a category can be warranted by the multiple instances of such a category. For example, both professors and students in this study mentioned losing or gaining control of their teaching or learning to the computer. Almost all of the participants recommended that the control of teaching and learning situation should

not be left to the computer. Each category was illustrated with at least two quotes from participants, thereby strengthening the weight of evidence supporting it.

Summary of the Chapter

Chapter Two contains the design of the study. It began with an introduction and the plan of the chapter. Next, the two major and six subsidiary research questions were presented. This was followed by the description of the study's setting, the participants, and how they were selected. Data sources, the instruments, and how interviews and observations were conducted followed. Data analyses procedures and categories were also presented, followed by organization of the data and quality control. The chapter ends with a summary.



CHAPTER THREE

PROFESSORS' USE OF COMPUTERS FOR TEACHING

This study is about how professors use computers in their teaching. The purpose was to provide information on which other professors may base decisions regarding computer use for teaching. Administrators may gain insight into how to plan future computing initiatives that take into account faculty perspectives. Those in charge of faculty training may also benefit from the study in terms of knowing what to include in future training packages.

This chapter was written with these purposes in mind. It contains descriptions of computer use which include the types of applications and the kinds of decisionmaking involved in the particular situation of use. The report in this chapter is based on the analysis of data addressing research question one and subsidiary questions. They include:

1. *In what ways do professors use computers in their teaching?*
 - A. *For what teaching purposes do professors use computers?*
 - B. *For what teaching activities do professors use computers?*
 - C. *What are the processes of computer use for teaching among professors?*

Plan of the Chapter

The report in this chapter is presented in five sections. Section one presents a brief introduction of the professors in the study and the influences on their computing choices.

Section two contains the "profiles" of the professors. Each profile contains a summary of how the professor uses computers in his or her teaching. Section three

deals with the purposes of computer uses for teaching which include professors' goals, goals set for students, and the teaching problems which professors use computers to solve or alleviate.

Section four contains the teaching activities for which professors use computers. These include instructional planning, instructional delivery, grading, testing, and instructional management. In section five, the process of computer use for teaching is presented. The term process was further defined to include the procedures of computer use and the kinds of resources used. Sources of computing resources were also identified.

Section One - Background

In this section, the professors who participated in the study are introduced, who they are and a brief history of their teaching and computer experience. Influences on their computing choices are also presented as part of their background. Fictitious names were assigned to the professors to conceal their identity. However, all information regarding their computer use and their backgrounds is real.

Professors

Twelve professors from various disciplines on campus participated in the study. They are:

Professor Adamson is a professor in the college of veterinary medicine. He has been teaching for six years and has been using computers for three years. His main use of computers for teaching was computer-assisted instruction.

Professor Boss is a professor of design in the arts department. Boss has been using computers in the last twenty of his twenty-eight years of teaching. Computer use in his design classes include productivity software for word processing, graphics, and desktop publishing.

Professor Cain is a geology professor. He has been using computers for ten of his thirty years of teaching. In his course on chemical analysis of rocks, he uses computers to increase the efficiency of data collection and analysis during field trips with his students.

Professor Dillon is a professor of teacher education. She has been teaching for three years and has used computers in her teaching for two years. The use of computers in her classes includes E-mail communication and word processing.

Professor Englebar is a professor of telecommunication. He has been using computers for four years of his five years of teaching. Because his discipline involves technology use, he teaches his students a variety of telecommunication technologies as professional tools.

Professor Forester teaches in the department of crop and soil science. He has taught for twenty-five years. He started using computers six years ago to prepare his course and lesson notes.

Professor Hake is a professor of education who teaches prospective teachers how to use technology to improve education. He has been teaching and using computers to teach for twenty-five years. He teaches computer applications ranging from basic productivity tools to advanced technologies like videodisc and CD-ROM.

Professor Johnson is a professor of mathematics who has been teaching for twenty-five years. In the past three years, he has been using some of the computer programs he developed for occasional demonstration of mathematical concepts in his classroom. He also uses commercial packages such as Maple for his class demonstrations.

Professor Kandel is a professor of humanities who teaches different courses in the department. Professor Kandel has been teaching for over twenty-five years and has been using computers for teaching for eleven years. His use of computers for teaching involves productivity tools like a word processor for his lesson plans, spreadsheets and

databases for his grading and instructional management. He is currently working on a computer-assisted instruction project to help his students learn better in his survey course.

Professor Landon is a professor of pathology in the college of medicine. Landon has been teaching for fifteen years. In the past four years, she has developed a series of computer-assisted instruction programs to supplement her lectures.

Professor Mattsen teaches computer science. He has been teaching with computers for over twenty-five years. He has also developed many computer-assisted instruction programs for other faculty in the science education program.

Professor Smith, a professor of natural science. Professor Smith also has been teaching with computers for twenty-five years. He uses computers to produce his teaching materials, such as computer-generated maps, which are either stored on videotapes or transferred to overhead transparencies.

Table 3.1 shows the professors according to their department, the number of years of teaching, and the number of years they have been using computers for teaching.

Influences on the Professors' Computing Choices

In order to understand the kind of computing choices that professors make and the reasons behind those choices, the professors studied were asked how they became computer users for teaching, specifically, who and what influenced them. Their responses were summarized in Table 3.2. A discussion of the categories of influence follows. In addition, information about professors' discipline, teaching and computer experiences is also presented. The information about discipline and experiences was inferred from the interview data. The purpose was to verify the hypotheses that discipline and teaching experience may influence professors computer use for teaching.

Table 3.1
Professors According to Department, Years of Teaching, and
Years of Computer Use in Teaching

Professors	Department	Yr. Teaching	Yr. of Computer in Teaching
Cain	Geology	30	10
Boss	Art	28	20
Hake	Education	25	25
Mattsen	Computer Science/ Science Education	25	25
Smith	Natural Science	25	25
Kandel	Humanities	25	11
Forester	Crop and Soil Science	25	6
Johnson	Mathematics	25	3
Landon	Human Medicine	10	4
Adamson	Veterinary Medicine	6	3
Englebar	Telecommunication	5	4
Dillon	Education	3	3

Table 3.2
Influences on Professors' Computing Choices

[illegible]

Self-Initiative

All the professors in this study mentioned that they began using, and continue to use, computers because of their own initiative. They were not trained to teach with computers and many have not had any in-service training or workshops on how to teach with computers. They learned computing skills from friends, colleagues, or from other professionals at professional meetings. Some read about using computers to teach in books and magazines.

Among the reasons professors mentioned for taking the computing initiative were, personal desire to try something new in teaching, computer use became necessary in their fields, and awareness of the need to prepare students for the information society.

Previous Training

Four of the professors studied learned about computers and programming in graduate school. These included Professors Hake, Landon, Mattsen, and Smith. They all had science backgrounds and were asked to learn programming languages in graduate schools. It was easy to transfer their computer skills when personal computers became available for teaching.

Colleagues

Another source of influence on professors' computing were colleagues in their departments or colleges. Forester mentioned one of his colleagues as the technical person in his department whose service he used frequently. Landon worked with colleagues to develop her computer-assisted instruction programs. Johnson sought a colleague's help when he was writing his computer programs.

Trade Journals, Literature, and Magazines

Most of the professors learned about software or certain applications by reading through computer magazines, trade journals, and other literature. These professors included Adamson, Cain, Englebar, Kandel and Smith.

Professional Meetings

Although not as frequently mentioned by the professors, national meetings or professional conferences were sources of influence on professors' computing choices. Through these avenues, professors became aware of certain applications in their field. In this study, Professors Cain and Smith mentioned that they learned about a computer program through professional meetings and conferences.

Previous Technologies

Kandel used previous technologies such as slides with audiotape in his class presentations. Most of the content of his current computer-assisted instruction project was developed during that phase.

For most of my teaching career I've been involved with using slide projector, audiovisual, tape recording... In an early experiment in team teaching in 1971-72, a colleague and I developed a series of audiovisual packages that we took into the classroom--screen projection with tape recorder narrative. I taught a version of Humanities which was called Music in the Humanities, so I've been involved in the use of audio to present the music along with slides and artwork. So when the computer came along it was sort of natural. I started to turn to the computer for my own use, to be able to develop my lectures, keep track of my students' records, and to work with my research. (Kandel: Interview, 10/28/92)

Previous Employment

Englebar used computers in his previous employment to do data analysis and reports. He brought the experience into his current job, teaching about technology to undergraduate and graduate students.

Students

Englebar learned about certain applications from his students.

We use a grammar-checker program for papers. That was initially suggested by one of my students, I'd never heard about it before. They'd read about it in a magazine or heard about it through some of their computer buddies. I checked into it and thought it was a good idea so we bought it. Now we have all of our students run their papers through a grammar-checker. (Englebar: Interview, 10/21/92)

One of Boss's students brought the idea of using computers from another department.

In the early 70s I was attracted to the engineering department because we had a student here who went over there to teach drafting and he came back here and said there are computers over there (Boss: Interview, 10/20/92)

Availability of Technology

Professor Boss, in the art department, began using computers for teaching when a colleague received a grant with which they bought their first Apple computer.

Professor Landon in pathology, started using computers to teach when videodisc technology became available. She saw videodisc as an opportunity to use more pictures to illustrate concepts in her lectures.

Discipline

As shown in Table 3.1, participants were drawn from twelve different departments, colleges, or subject areas. Only Mattsen held a joint appointment in two departments. Departments or colleges represented include science, medicine, education,

arts, communications, and humanities. There were two major reasons for selecting professors from different disciplines. One was to provide a variety of examples of computer usage. Secondly, evidence from the literature and the results of an exploratory study suggest that discipline may play a vital role in professors' choice of computing.

Many of the professors in this study mentioned discipline related influences like their departments, colleagues, and the nature of their subjects as sources of influence on their computer choices. For example, almost all the professors mentioned that they were using the hardware provided by their colleges or departments. Most of professors' software considerations were based on the platform available and less on their preference. Also, the professors who developed computer-assisted instruction mentioned that the nature of their subject matter--such as volumes of information involved, the need to use pictures or other visuals to illustrate concepts--influenced their computing decisions.

Experience in Teaching and Experience in Computer Use for Teaching

Most of the professor participants are experienced teachers judging by the number of years they have been teaching. Of the twelve professors, eight have been teaching for twenty-five to thirty years. Teaching experience among the professors studied range from three to thirty years.

The computing experiences of the professors also vary. Very few of the professors have been using computers for as long as they have been teaching. The majority became users in the last decade when personal computers became available. The number of years of computer use for teaching range from two to twenty-five years. Three of the professors who have been teaching for twenty-five years have also been using computers in teaching for as long.

A comparison of the professors showed that experience in teaching may not be a factor in whether or not professors became computer users. Older professors are as likely as younger professors to use computers in their teaching. Younger professors are likely to begin early to use computers because "they grew up with technology."

Summary

Professors brought a variety of backgrounds into their computer use for teaching. Sources of influence mentioned include, self, colleagues, previous training, previous job, professional meetings, students, and the availability of the technology.

Section Two - Profiles of Computer Usage

This section contains the profiles of computer use among the professors studied. The profiles were a means of presenting individual professors' perceptions of themselves as they use computers in their teaching. Each profile was built around a single theme describing the attitude or motivation underlying each professor's computer use for teaching.

Dr. Adamson: Bringing Reality to the Classroom

Professor Adamson, a professor of veterinary medicine, began using computers in his teaching four years ago. Prior to that, he used a variety of computer applications such as spreadsheets, databases, and word processors for his own personal use. According to Adamson, his work involves teaching students how to save animals' lives. This requires students to learn different techniques, equipment, and procedures. Students also need to learn to make quick decisions about their patients. How to teach these skills effectively and efficiently was a concern for Professor Adamson.

The reason why I first started using the computer [for teaching] was because we used to have a situation where we would kill a dog every two weeks to demonstrate to students how to save a dog, to teach Canine CPR. And this is a waste. I thought it would be nice if we could do that with the computer, simulate what different types of death are involved and how students can try to save the animal... Also, whenever we have a live demo[nstration], it didn't always go right because some of the equipment might not work properly. So we thought with the computer simulation we could control the variables. So I thought if we could do a computer version that the students could look at anytime they want and it wouldn't interfere with their work responsibilities in the clinic. They could do it after hours by themselves if they want to. It wouldn't involve killing an animal, and they could see variations of the ways the animal could die, and they could save it. (Interview: 10/14/92)

The live demonstration will not be replaced by the computer programs, however, it can be done less frequently to save more animals. Also, the program will prepare students for the live demonstration or help them to review the procedure afterwards.

In addition to the CPR program, Professor Adamson also developed other computer-assisted instruction programs, including the "Anesthesia Equipment" and "Jeopardy" programs. Anesthesia Equipment teaches students about the equipment, procedures, and various concepts relating to anesthetizing a patient. The Jeopardy program helps students to review important concepts in veterinary medicine.

Both the CPR and Anesthesia Equipment programs made extensive use of visual elements including graphics, animation, drawings, and cartoons, in order to simulate the real situation as much as possible. Professor Adamson has the stand-alone version of the programs on the college's network so that students can access them anytime in any of the computer laboratories or in the library. There is also the lecture version which he uses for classroom instruction.

Dr. Boss: Using Computers to Promote Holistic Thinking

Professor Boss teaches art design in the arts department. Boss encourages his students to look at the world holistically, to get an education rather than training. To succeed as graphic designers, students need to have different kinds of knowledge and an understanding of their interconnectedness in order to solve problems which are represented in the design process.

When approaching an assignment, students must bring considerable knowledge and experience to bear on the analysis of the problem. The student must possess a warehouse of information about a wide range of subjects. The students must understand that design is largely something one does in one's head. The designer should be ready to experiment, play with change and alter forms and make statements of function and symbolic content with minimal means. (Dr. Boss's personal notes: 1992)

To Professor Boss, therefore, the computer is a tool which students can use "to broaden the base of their idea gathering" and refine the design process. The computer allows the designer to explore ideas and theories and to push the boundaries of the design process.

In his courses, Boss tries to strike a balance between what the technology can do and the limits of the design process. According to Boss, while it is important for students to be able to use the tools of trade when they are employed in the industry, it is not possible to teach them all they need to know. Tools become obsolete. But if students understand the theory behind the tool, they will be able to adapt when the technology changes. So:

We balance showing them different programs on the computer, in other words, how to use this program to get this result. We combine this with problem solving techniques. (Interview: 10/20/92)

Dr. Cain: Using Computers to Speed Up Education

Computers, to Professor Cain, are useful tools in his field and tools for him to teach effectively. As a geologist, computers allow him to do better now what he used to do by hand. Before, plotting and rotating data collected about geological phenomena was very tedious and time consuming, with the computer, the task became easier, faster, and more enjoyable. Now data can be rotated many times and with a different combination of factors without replotting them each time. Moreover, large-scale data can be processed within a short time.

Professor Cain usually takes a portable computer with him on field trips with his students. All data collected in the field are entered into the computer. Both he and his students plot, analyze, and model the data to see if they make sense. This was not possible prior to using computers for the course. Moreover, students are now given assignments involving real data. Because students can use computers to plot the data (a task which used to consume a lot of their time), they can now concentrate on asking important questions about the relationships among the data and the phenomena the data represent.

The focus of Professor Cain's teaching is helping students to develop the ability to process large amounts of information using available tools. The computer is fast becoming a professional tool for students too.

They are all going to end up using computers one way or another. They would have no choice. They all have to be able to collect data knowing that either they or somebody else is going to manipulate them... Most of our students are going into what we call environmental geology which involves being able to understand ground water and surface water, and the flow patterns of ground water and the introduction of contaminants to the ground water. They should be able to ask what happens to those contaminants when they get into the ground water; and what happens when you pump ground water out from the ground. All of these are modelled on computers now to get a very quick response.

... There is no doubt that it is a powerful tool and we will be able to do many things that should speed up education. It would create excitement, I think,

to pursue something different because it is a non-threatening instrument. It doesn't say you are wrong the way a person says you are wrong. Your personality is not threatened. (10/19/92)

Dr. Dillon: Computer as a Motivating Tool for
Students' Learning

Professor Dillon describes computers in her class as a motivating tool for learning. Her goal is that her students, who are prospective teachers, should at least have a working knowledge of computers and be able to use computers in their own classrooms when they leave college.

I want students to see computers as part of their lives, in one sense for the course work, and I want it to be a vehicle that's not static. Therefore I am trying to accommodate that with the disk [some students submit assignment on disk] so that when I insert something so it's not--it seems as soon as people put it on paper, it's like static and that is it. And I think I'll like to infuse that with a sense of revision, something flexible that they can change their mind and come back to it.

In regard to the students who are experiencing the 'Playschool', I think there, they see technology as an extension of curriculum so that they might see how they might use it in their own classrooms. (Interview: 10/21/92)

Computing in her courses includes word processing and electronic mail communication. In one course, all the students learn to use EUDORA as an electronic communication medium. Students post comments about the weekly reading assignments on e-mail for others to read and comment. The professor does not participate in this interaction. Students communicate with one another. In a second course, Dillon had asked students to use word processors to submit their dialogue journal [a weekly assignment], so that they "at least know the difference between the Mac and the IBM."

Professor Dillon does not believe professors should also be computer experts. The computer use is rather "peripheral and pretty tangential" to classroom instruction.



I think it is a little much to expect the professors to be experts in the content area as well as technology. One has to be at the forefront and one at the background. (Interview: 10/21/92)

Dr. Englebar: Computers for Developing Professional Skills

Professor Englebar believes that the computer is a tool for work in the information society, and students going out to work should be given opportunities to use such a tool before they leave college. He believes that his students should be very competitive and marketable in their chosen field.

The students are going to go out and work in an information society. The norm is going to be "Hi kid, here's your workstation. Sit down and here's what we're going to do." So I think the more we can do to orient them to that, even to the point of getting them used to the workstation experience, where they have an electronic mail account and that's their workstation and they do everything on that. I think that gives them an option, especially in situations where we can get them up to speed on software where they'd normally go through a big learning curve on the job. This way they can compete successfully with students from other universities that don't have it. (Interview: 10/21/92)

According to Englebar, computers are necessary in his field because of the nature of his subject matter and his students.

We teach about computers in telecommunications so that's one prime mover. Also, I saw some real potential to improve efficiency and technique in one master stroke. A lot of the courses I teach are along the line of trying to teach technical subjects to non-technical students, trying to teach them how telecommunication technologies work, which can get incredibly complex. (Interview: 10/21/92)

In addition to learning to use the basic productivity applications like word processors, databases, and spreadsheets students also learn to use electronic mail for submitting class assignments and receiving feedback from the professor. They also learn to communicate with people in any part of the world. Students learn to use

simulation packages and network design programs to practice how to create telephone networks. They learn how to problem-solve, using a combination of appropriate software.

For example if they want to create a telephone network between Toledo and Lansing using the package, they could design a network simulated performance that goes from--really integrating and synthesizing software applications to solve problems; because the students would go out to jobs in the industry that involve problem-solving in their day-to-day activities. For example working for MCI, they go out and talk to people, say in Chrysler Corporation and they asked "what have you got in voice networks and data networks, how many lines you've got, how many bits and bytes." And they take all that information, go back to the office and sit down with their network design software and see if there is another configuration that would be more efficient to implement. So it is part of what they do when they go out of here. (Interview: 10/21/92)

Dr. Forester: Computer as a "Liberating Tool"

Professor Forester teaches in the Department of Crops and Soil Sciences. He likes computers because he writes, and he likes to type. He uses computers to develop courses and lesson plans, which he regards as an important aspect of his teaching. His planning allows him to prepare adequately for class so that he can be more effective.

According to Forester, planning for a lesson is similar to writing a book. Every piece of writing should possess a certain quality--a textbook, like a course/lesson plan, should present subject matter in an orderly fashion. It should be readable, that is, simple and not complex. It should begin with a general structure or organizing topic. Then it can be broken into smaller topics, followed by an elaboration of each small piece. Elaboration of each part should contribute to the understanding of the whole.

Professor Forester sees the computer as a labor-saving tool. With the computer, the task of course or lesson planning is made "easier, faster, and painless. It gives you a professional product, and the task become more enjoyable."

My use of computers may not be very profound, it's very simple approach, but it is a very important approach to me. (Interview: 10/22/92)

Computers also become a tool for composing and organizing thoughts.

According to Professor Forester, it is more efficient than organizing thoughts on a notepad, because of the flexibility to change or move things around. It saves time in terms of transferring thoughts into typed text.

Another advantage of the computer is that it gives me independence from the secretary. I do not have to wait on her, I just go ahead and do it. On the other hand, it may mean that I can wait till the last minute to do it, I can procrastinate. I don't know how much it does for my teaching, but it helps me to be more flexible. But it helps me to be less organized too. This may not be desirable, but it reflects reality. It may be better if we are all so well organized that we never have to worry about deadlines because we'll always have everything prepared well in advance. Some people are like that, but I'm not like that. And it is not the fault of the tool that we procrastinate either, but it does allow us to be flexible enough to meet deadlines. (Interviews: 10/22/92 & 4/28/92)

Dr. Hake: "Empowering" Teachers of the Information Society

Professor Hake teaches computer application courses at the undergraduate and graduate levels. His undergraduate students are mostly in teacher education programs. One of his courses is about how teachers can use technology in their teaching. Computer applications in his course range from basic productivity tools such as databases, spreadsheets, and word processors, to advanced applications such as electronic mail communication, presentation programs, CD-ROM, interactive video, and multimedia instructions.

To Professor Hake, it is important that he "models" computer use in the classroom so that students can learn and begin to see it as a tool they too could use in their own teaching.

Since my subject matter is primarily computers, I try to model what I'm going to be talking about. So if I'm going to be teaching spreadsheets, I'm using spreadsheets. Now that we have good display devices that's the sort of thing I do. I'm using technology to illustrate how to do things. If using a computer for grades is hard for me, if I make it look hard, then I can bank on the fact that students will say, "I can't do that." If on the other hand, sometime during the term I can produce a report for each student that tells them everything they've done, where they are standing as far as their grade is concerned. And I use a mail merge whatever to do that, then when I teach that, when it's something I've used, then they can recognize it. (Interview: 12/3/92)

Professor Hake not only models technology use, he provides opportunities for students to practice what they have learned in class.

Their project in this introductory course is a semester-long project. It requires them, as a team, to take a look at an existing school or school system in the area and their use of technology and make a five-year plan for that school that looks at what kinds of technology they could employ and how they might employ it. They're looking at a variety of technologies and how they might be used, starting with what the school is now doing. So this whole planning project is used as a means to introduce lots of technology to these students and familiarize them to some extent with some subset of those technologies. (Interview: 10/27/92)

Dr. Johnson: Computers Should Have Limits in the Classroom

Professor Johnson started three years ago to use computers for an occasional demonstration of mathematical concepts in his courses. To Professor Johnson, computers should be used only when necessary.

It's true, probably one can overdo this sort of thing too, because I'm not necessarily a great fan of computers in the classroom. As far as that is concerned, I like to develop the subject of my lectures. One could get carried away, and I don't think one should. (Interview: 10/29/92)

For his courses, Johnson uses commercial software like f(Z) to illustrate concepts of "complex variables." Using Microsoft-BASIC, he wrote two "simple"

programs to illustrate concepts of "locus of points" and "where to look in a spherical mirror," because there were no commercial packages available to demonstrate these concepts.

Professor Johnson said he hopes that the class demonstrations with the computer give his students a better feel for the behavior of various "functions" in mathematics. It was nice being able to illustrate concepts graphically, and "students were curious and looked at them a little further." However, Johnson does not feel that students necessarily learn more from the computer programs than his lecture and class discussions. To Johnson, computers may have a role to play in the classroom, but he believes that professors should not spend too much time developing computer packages, except when they have the time and resources for it.

I think there are possibilities of the things that one could do. I don't concentrate much on computers. I have just done these things as they have struck me as interesting and worthwhile to do and there's been sort of an opportunity to do them. When there is a chance to do something, it is nice to do. But I don't break my neck preparing these things because it is time consuming. And you have to keep up with your teaching and with your research and your own work that you do. (Interview: 10/29/92)

Professor Kandel: Computers as a Tool for "Leveling
the Playing Field" in Education

As a professor of humanities, Professor Kandel has taught various courses on world civilization. Professor Kandel characterizes himself as a DOS-based computer user even though he is familiar with the Macintosh systems. He sees himself as very versatile in computer use for professional and teaching purposes. He does his instructional planning and grading on the computer. He has a very sound knowledge of the computer and its capabilities as demonstrated in the varieties of software that he has used or is familiar with.



Even though he does not use the computer as a delivery medium in direct classroom instruction, he has found a way to use computers to involve his students in learning. His handouts and course syllabus are developed on the computer. He is currently developing a computer-assisted instruction (CAI) program to help his students develop reading skills as well as learn the content of a survey course. At the time of this study, he has just completed a unit on ancient Hebrews. Professor Kandel has a philosophy that seems to permeate his teaching and his approach to computer use.

All my life I've been very concerned about the student who takes longer to learn something. I've been less concerned about the student who could get by the first time. It's always a boost to one's teaching ego to have honor students, that are challenging, that you can relate to, and they are almost on your level. I think too many teachers teach for that, totally ignoring the rest of the classroom. The student who is just a C average, and then maybe suddenly in their junior year the light goes on, they suddenly figure out how to do it and they go from a C average to a B+ or an A average. It's that kind of students that I want to reach.

I think the computer being non-punitive, repetitive, accessible would enable us to reach those slow learners more than our traditional lecture system which puts a premium on speed. Too many students go through school without speed or correctness. They don't know how to study, they don't know how to take notes. Somewhere along the line nobody ever told them how to think... The linkage in the course is this--I can walk into a class of three hundred students, with the assumption that they are going to be all on the same level with each other in terms of course assignment, mastery of material, understanding, and learning. They are all going to be on an even equal playing field as I start to lecture, equal with each other and with me. But I can only assume this if I know that they have had access to the materials in a way that allows all of these variables among them to be somehow evened out. If I give them a textbook, I cannot assume that that is the equalizer because I have no way of knowing how many of out of a class of three hundred are not verbal or verbally skilled. I don't know how many of them have that analytical verbal skill.

...If I have these computer units however, and I know that all three hundred students are going through the units in the computer lab, I can look at their progress by turning my computer on and calling up their records. I could see what each one of them are doing. I can react individually to what they've written at my pace. I don't have to have a schedule that is competing with time all through the day or all through the week or through the month, where

students and I may or may not be able to get together. When I feel like it, when I have an open slot, at midnight, I can call up the computer and look up the student's record if I got a free moment ... I can't do that live. So that's the linkage. The students, all of them, have the same access to the computer. But the students who aren't equal, the slower learner, the ones about whom I cannot assume their analytical skill, they can spend more time on the computer and acquire that equality, that equal standard, that master.

If I see a student failing also in the computer record, I can mark that student for special attention. I can call in my graduate assistants and say, "alright this week we have got a list of students here that are having difficulties with the unit on the `Hebrews.' Here is their names. When they come into the lab, sit down with them, and try to figure out what their difficulty is." I know who needs special attention because I can see their record on my computers. That's the link...I want to create a learning environment where even the slowest can keep up with the pace of the program without slowing down the pace of the class. And where the standards are not set only by the most advanced...No we won't equalize people. We equalize the playing fields. (Interview, 11/3/92)

Professor Landon: Computers as Tools to Enrich

Teaching and Learning

Dr. Landon teaches neuro-pathology in the medical school. She has a strong background in computing. She did some programming in BASIC in college and FORTRAN in graduate school. It was therefore easy for her to learn to use the new hardware and software on her own.

I've always been interested in computers. I think I got my first one probably 10 years ago when they had Apple II+ computers. Anyway, I had an Apple II+ computer. My husband likes computers too, so together we've had a series of them and used them. So I've been interested in computers. Then with the availability of the videodiscs, it just seemed like a natural mix to be able to teach pathology. As software authoring systems became available, it became easier to actually set up programs that would link the computer and the videodisc. (Interview: 10/27/92)

Her knowledge about the potential of computers in teaching enables her to make computing choices that she feels are appropriate to her field. Her choice of computer-

assisted instruction was mostly influenced by the requirements of her subject matter, "pathology teaching requires visual images." So when a colleague who has a background in instructional design was working on a project, she seized the opportunity to work with him.

The project I've worked on to develop the hypercard stacks started about 4 years ago, when there was a videodisc available called "Slice of Life." That was produced at the University of Utah and it's a cooperative disc. A lot of different people from a lot of medical schools sent slides in to be put on the videodisc and then the images were available for everybody to use... We thought that [videodisc] would be a good way of making a variety of images available to students on an individual interactive basis. So I started to think about the best way of making those available to students and started working with two pilot projects...

The specific format that we used sort of evolved over the first year or so. Now we have 12 different topics developed: Neoplasms, Cerebrovascular Disorders, Trauma. For each of those topics, there's a lesson which has the materials that students need to know for the exam. Then there's a pretest and posttest and a glossary. The glossary can either be used separately or there are links between the text and the lesson in the glossary.

Then there are case studies which are meant to let students go through and do some problem-solving and apply what they've been learning and integrate to an actual patient case. Those are the basic features that I tried to get at. So students can use the program both for learning basic concepts and also at the next level of learning, applying information and integrating it to a case. The review questions and posttest questions were set up to be multiple choice because that was a simple format. But there's feedback for each of the answers so students can get an explanation of why the right answer is right or the wrong answers are wrong and then get reinforcement. They can essentially go through and spend as much time as they want and as they need to understand the concepts and make sure they remember all the important ideas. (Interview: 10/27/92)

A lot of flexibility was built into the programs, both to allow the professor and her colleagues to modify or to develop other programs using the same format. The programs were also flexible from the students' point of view, "so they could jump around and have total control over where they were in the program..."

These [CAI programs] have been used in a variety of ways in the different classes that we teach. For the most part, they've been supplemental to the class. Most of the same material has been covered in lecture. I share neuro-pathology teaching with a colleague, so we take turns with different lectures in different classes. We cover the material in lecture most of the time, but these programs have been available as a supplement so students can go in and see additional visual pictures and diagrams and test themselves to see if they understand the material...(Interview, 10/27/92)

According to Professor Landon, computers have their role in the education process, just as professors do.

I do not think that computers can, or should, replace contact with instructors. Contact with experts in a field, talented educators, and role models provide a dimension to education that cannot be replaced by the computers. The combination of approaches can enhance the educational experience and provide students with the best training for future careers. (E-mail conversation, 4/7/93)

Dr. Mattsen: The Computer as a Medium for Students
to "Explore" Science

Dr. Mattsen teaches a course in the computer science department. His course involves students learning to design and write computer programs. In addition to his computer science course, he is involved in a project with the computer-assisted instruction group in the college of natural science. For over twenty years, this group, co-directed by Professor Mattsen, has been developing computer-assisted instruction for undergraduate courses "across all scientific disciplines."

In that project we use the computer to have students explore domains of scientific knowledge. The way we've described that is by saying we want the students to play Newton, Mendel, Darwin, Einstein. That is, given a body of theory, to be able to apply that theory to solving a problem. (Interview: 11/16/92)



Professor Mattsen's philosophy is that students should come out of school broadly educated. They should be armed "with a large stock of theory" that enhances their understanding of their subject matter and their tools.

I'm on the side of those who say that people who understand the theory behind what they're doing are much more likely to be able to survive a rapidly changing technology. (Interview: 11/16/92)

Professor Mattsen has been teaching computer and computer-related courses for almost twenty-five years. The content of his teaching seems to evolve with the computer technology. In his computer science course, he updates his students' knowledge as new software and hardware becomes available to keep them abreast of developments in the field. He encourages students to become comfortable with the DOS machines as well as Mac and NeXT computers. Students learn to use e-mail as a communication tool in addition to doing programming.

One of the challenges of teaching this course is getting the students to think and work like professionals in their chosen field.

The challenge is to try to help the students understand that the hard part of programming is the design stage. It's not at the coding stage. The design stage is where you think through and try to problem-solve and that's where we place the majority of our emphasis. Once the students get to the point of programming, we think it will go pretty quickly. So throughout the course you have a lot of programming exercises where we have a problem and we supply some library functions that handle input and output. The students have to design a program, for example, calling library functions to solve a particular problem. So that places the emphasis on design and that's what I see as the biggest challenge. Real programmers don't write programs. That's one of the very surprising facts. What real programmers do is solve problems, write as much of the program as they need to write and get everything they can get out of libraries. (Interview: 11/16/92)

In the computer-assisted instruction project, Professor Mattsen and his colleagues develop simulation programs on various topics in science. Professors

teaching those courses write their assignments to take advantage of the programs. The programs are placed in selected laboratories where students can access them to complete their class assignments. The catalog of courseware contains over 40 simulation programs on topics ranging from toxicology, human genetics, evolution, and ecology to stratigraphy (Geology). The following is a description of one of the simulation programs.

Topic - TOXICOLOGY Title - BIORISKS [P = networked]
 interactive (not batch)

Students study toxicology of various real or hypothetical substances on five different test animals: mice, rats, guinea pigs, hamsters, and rabbits. Given only a limited budget, students must determine LD50's and make recommendations to the EPA (Environmental Protection Agency) about the safety to humans of the substance in question. Students do not understand what a logarithm is, so the LD50 data are presented graphically as well as by actual values. (Center for Integrative Studies, General Science: Computer Assisted Instruction Catalog of Available Software, 1991-1992)

Dr. Smith: There Must Be a Philosophy Behind

Computer Usage

Professor Smith teaches in the college of natural science. Smith is one of the experienced professors who has been using computers to teach for twenty-five years. His philosophy is that computers should make it easy for teachers to move the class to the students rather than having the technology push the class. Teachers should not use technology for its own sake. There must be a philosophy behind every teacher's use of computers for teaching.

I'm concerned about how we might better use computers in education. I guess I use computers in my life every day, so I have a major computing system at home and work. So I sort of live in a computing environment. But I don't know that I translate it properly to the classroom. There are many ways that we could

do that. We could bring computers in to the classroom or you can, when you're lecturing, use materials that are generated by computers. I guess I do both. But I think that the facilities, certainly the ease of using computers in the classroom, are a constraint because of the technology and because of the sizes of the classes that one teaches. It's not always easy to have 50-60 students sitting at a computer terminal and so on. You end up having the technology pushing the class as opposed to having the class, the concepts of the class being moved out to the students. So I tend to stay away from sort of on-line demonstrations of computers in the classroom, except in special activities.

...The way that I use computers in the classroom is primarily through visualization demonstration. I have all these transparencies that I use for describing things. There's the honey bee population maps that are all computer-generated material. I've got a series of things here that I use for teaching, 90 percent of which are all computer-generated. So the idea is to try and not necessarily have to use computers on-line in the classroom per se but to go ahead and use the products of the computer. (Interview, 10/28/92)

Dr. Smith believes that using computers in teaching is inevitable because it is a useful teaching tool as well as a tool of work in the information society. Through his background in systems science, Professor Smith views the world from a holistic perspective, and computers have a big role in this perspective through problem solving, a tool which helps people to understand life. A holistic perspective is what he tries to impart to his students.

... There is an interrelationship among different aspects of life. That just happens to be my philosophy and that comes back to my training and background in systems science. Systems science helps you with the framework to build toward problem-solving and defining solutions to problems. That's my whole reason for being in the university, wanting to teach courses like this, because I think that we don't have enough of a systems science perspective. And that perspective will provide us with a better view of life and the world and how we live on this planet. (Interview: 10/28/92)

Summary

These profiles present twelve examples of computer use and twelve different ways of thinking about computers as tools for teaching. The professors in this study see

computers as tools for bringing reality to the classroom, tools to speed up the process of education, tools to encourage students to look at the world from a holistic perspective, and tools to learn professional skills including information processing. As a teacher's tool, computers provide professors with opportunities to have more control over their work. Computers can be used to increase learning opportunities for slow learners and increase students' access to professors. However, computer use should also be kept in perspective. There are dangers in concentrating too much on the computer and lose sight of the important goal of teaching. The computer has a place in education, but must not substitute for the interaction and expertise of professionals.

Section Three - Teaching Purposes for which Professors Use Computers

This section answers the first subsidiary question under research question one, that is, the purposes for which faculty use computers in their teaching. Analyses of data revealed that professors use computers for two major educational purposes, namely, to serve educational goals and to overcome some teaching constraints.

Educational Goals

One of the hypotheses formulated during the exploratory study was that professors would differentiate between teachers' goals and students' goals of computing. Evidence from the data confirm the presence of two categories of goals, namely professors' goals, and students' goals.

Professors' Goals

Professors in this study use computers to serve several teacher goals or objectives. Those goals include increasing the efficiency of teaching tasks, enhancing

effectiveness of teaching strategies, enriching instructional situations, modeling the use of computers, and developing students' computer and information processing skills.

Table 3.3 summarizes the teacher goals mentioned by the professors.

Efficiency of teaching tasks.

Some teaching tasks have always posed a challenge to professors. According to Professor Kandel, many professors continue to lecture from old notes because the task of creating new notes every year or semester is very tedious and very time consuming, more so because such tasks are usually repetitive.

Four professors, namely Englebar, Forester, Hake, and Kandel mentioned that they use word processors, databases, and spreadsheets to develop and store their course and lesson materials in electronic form. Whenever they need to update the teaching materials, they do not have to start all over each time. They can move text around, add new materials, delete outdated information, and keep old versions for reference.

Professor Cain has automated most of the task of data collection and analysis. Using geological software, Cain can plot, rotate, and model data in three dimensions. Performing these tasks prior to computers was a very tedious and time-consuming process. The tediousness of manually plotting data prior to computers diverted attention from the essence of the analysis, which was students' ability to ask important questions about the relationships in the data collected. In doing chemical analysis of rocks, for example, having the computer plot the data allows students to "look at variation from one rock to another to see how they are genetically connected."

In Professor Hake's case, using computers is for convenience as well as efficiency purposes.

I tend to put my notes on something like MORE or PERSUASION for outlining and then I have all my transparencies on the computer rather than flipping through transparencies. For example in most of the courses I'm teaching now, all my notes are on presentation programs. So that I don't have to carry a bunch of transparencies with me. (Interview: 10/27/92)

Table 3.3
Teachers' Goals for which Professors Use Computers

[illegible]

Boss sees computers as a means for students to broaden the base of idea gathering, creating an extensive database of information that is very important in art design. Kandel seeks to remove the mystery of reading for students through a computer-assisted instruction program that is problem-based and interactive.

Enriching instructional situations.

Related to effectiveness of teaching strategies is the goal of providing enriched instructional situations for students to learn. Adamson's goals are to be able to provide an environment where students can actively engage the learning materials and to be able to expand the concept of education beyond what is taught in the classroom. By bringing information from real-life situations, such as using the idea of a popular game show to help students review lecture materials, Adamson encourages students to see education beyond the limits of the classroom.

Professor Kandel uses technology to provide an environment where students can absorb and manipulate factual information and use information to solve problems.

My teaching goals that I hope to use the computer to fulfill would be to lay down the foundation, the informational level, how to absorb important parts of the course and how to use that information to make judgements, and to solve problems. (Kandel: Interview, 11/3/92)

In the case of Professor Landon, using computers to make a variety of images available to students on an interactive and individual basis is one of her major goals. Pathology teaching requires showing a lot of images, and the pace of lecture is too fast for students to have any meaningful interaction with the images. By making the images available through videodisc, and creating an opportunity for students' interaction with the images through computer-based case studies, students can access the information at their own time and pace.

Modeling professionals skills.

A sizeable number of the professors in this study believe they are role models to their students. In their teaching, they wish to promote to their students, what professionals do in their chosen fields. According to Mattsen, Landon, and Smith, professionals think, solve problems, and explore scientific phenomena. Computers provide them with the opportunity to broaden the scope of the kinds of environments they can create for their students to develop those skills.

Modeling computer use.

Related to the goal of developing the professional skills in their students is the goal of developing computing skills. According to these professors, computers are new tools for professionals in their field. So, developing computing skills is a new goal they want to promote in their students. One way of achieving this is to use computers themselves. Through them, their students may begin to see how computers can be used in their own professional lives.

Among the professors that mentioned using computers to develop students' professional skills are Hake and Englebar. Both professors teach students about a variety of technologies that they can use in their own work. According to Hake:

I want them to begin to see that these tools are very powerful tools that make my work easy or easier and could make their work easier. So there's no reason for them to look at this as something they're just taking because they have to. They ought to be looking at this as a course that will give them a lot of power in the classroom. (Interview: 10/27/92)

Students' Goals for which Professors Use Computers

The professors in this study mentioned several students' goals they use computers to promote. As shown in Table 3.4, the number of goals or objectives mentioned by the professors studied range from two to seven. Understanding of

knowledge seems to be the most popular students' goal, with about five-sixths of the professors mentioning it. This is followed by computer skills, mentioned by three-fourths of the professors. What is interesting is that all the goals mentioned by professors are cognitive in nature. Only one affective goal--team skills--was mentioned by a professor.

Understanding and application of knowledge.

Some of the goals set for students by the professors in this study are discipline biased. However, discipline goals seem to be coupled with computer skills in most cases. To Professor Kandel, understanding of information through critical reading and listening are skills that students in humanities need to survive in the information society. With well-designed computer programs, students can learn to identify important factual information in historical narratives, explain the relationship among facts and concepts, and make critical judgements based on evidence.

Similarly in Professor Mattsen's class, computer science students need to understand what a computer program is, how it works, how it is designed, and what computers can and cannot do. They should be able to apply this knowledge in building a computer program that works. Hake and Englebar, who teach about technology, put emphasis on students' understanding of technology, its uses and weaknesses, and its potential in their professional lives.

Thinking and problem-solving.

Quick thinking and decision making are necessary skills in medical disciplines. Adamson mentioned, that in Veterinary Medicine, quick thinking and quick decisions are essential in order to save a patient's life. Similar skills are required in other branches of medicine too, according to Professor Landon.

Table 3.4
Students' Goals for which Professors Use Computers

Students' Goals	A d a m s o n	B o s s	C a i n	D i l l o n	E n g l e b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t s e n	S m i t h
Understanding		x		x	x	x	x	x	x	x	x	x
Application of knowledge				x	x					x	x	x
Problem solving		x	x		x				x	x		
Critical Thinking	x	x	x						x	x		
Critical reading									x			
Notetaking skill					x				x			
Research skill		x					x					
Visualization	x	x	x									x
Creativity		x									x	
Exploration/ Experiments			x								x	
Holistic perspective			x									x
Information processing and computer skills	x	x		x	x		x			x	x	x
Team skill												x
Professional skills	x				x		x	x				x

Problem-solving skills that students of design need, according to Professor Boss, include the ability to look for information, that is, research design ideas; the ability to listen and interpret correctly clients' requests and link them with design principles; and the ability to select and use appropriate tools. Computers can help students with these skills. They can gather ideas faster and improve their visual perceptions and creativity because the flexibility of the computer allows them to experiment with various design ideas. That way, students can develop a holistic attitude toward the design process and computing.

Holistic perspective.

A holistic approach to knowledge is what Professor Smith also feels his students need. The ability to look at large-scale data and the interconnectedness of biological systems are essential skills for students to have. Students should learn to use computers to develop the ability to visualize and look at problems on a large scale and from systems perspectives. Students need to understand how biologists use the computer to manage massive amounts of data and develop the ability to work in teams to solve problems.

Research and note taking skills.

According to Professor Boss, students need extensive information in order to be good designers. An essential part of their professional knowledge, therefore, is the ability to gather useful information from various sources. Students therefore need research skills. Boss sees computers as a means for students to gather ideas faster and in a more organized fashion. Professor Hake also promotes the research skills of his students. Part of the project in his class involves students going out to schools to collect information on the use of computers.

Inability to take good notes has been a problem that Professor Kandel observed in his students.

When I see students taking lecture notes from my lecture, I compare their notes with the note I got in front of me, it's always a source of surprise that they don't know what they are doing. When I look at what I read, and yet I look into their notes and I said where did you get this? Or they could put down something that seem to them important that I was just tossing away, and completely miss the point that I dwell on for ten minutes. It seems to me that we've got an opportunity here with this technology to demonstrate how a student can acquire what the professor wants or considers to be basic in a lecture and yet not stifle the student's own creative potentials. (Kandel: Interview, 12/12/91)

Visualization, creativity, exploration, and experimentation.

Ability to visualize 3-D objects, model phenomena, and solve problems through critical thinking are the mark of true learners. True learners are what Professor Cain hopes his students become. With these skills, students can test what-if hypotheses and trouble-shoot.

If they have some data they can say, "well, here is the model I am using, let's see what will happen if I did pump this or I did introduce a contaminant at this point, what would happen to the rest of the system?" And those systems usually have some variables which they can change. Or "supposing I got the wrong value for this particular layer of rock, let us change it and see what happens." (Cain: Interview, 10/19/92)

Professor Mattsen wants his students to become scientists by doing science. For his science education students, therefore, the important goals are the ability to apply scientific theories to problems and to use theories to predict the outcomes of scientific experiments. Computers allow him to simulate different conditions for students to explore science.

Cooperative learning.

Promoting cooperative learning was not a frequently mentioned goal among the professors studied. Only Professor Smith specifically mentioned team cooperation as one of his teaching goals. Yet as Smith mentioned, students are more likely to work as members of teams in the information society. One of his instructional approaches was to assign students projects in which they use computers and also work together as a team.

Although Professor Hake did not specifically mention cooperative learning as one of his goals, it was inferred from the data because of my observation of his class, and his description of the kinds of assignments he gave his students.

Teaching Constraints which Professors Use Computers to Solve

Professors also use computers to solve or alleviate instructional constraints in the context of teaching. Table 3.5 summarizes the kinds of constraints mentioned by the professors studied.

Among the teaching constraints are the limitation of previous teaching tools, previous teaching strategies, students' learning, and institutional constraints. Limitation of previous teaching strategies was the most frequently mentioned (almost half of the professors mentioned it), followed by students' learning problems (mentioned by a third of the professors). A third of the professors mentioned no teaching problems at all, while the remaining two-thirds mentioned one to three problems each.

Limitation of Previous Teaching Tools

Computers provided a more efficient alternative to previous teaching tools for professors Boss and Adamson. According to Boss, prior to computers, students had to complete their book design with handpresses. However, handpresses have limited type faces. They also lack flexibility in that editing the design layout can be very time-consuming. With computers, students now have hundreds of fonts and typefaces at their disposal. They can play with different fonts of different sizes to make the best design choices. They can also change things around within seconds.

Inability to control an experimental situation was a problem for Professor Adamson. It was not only wasteful to have to kill an animal every two weeks in order for students to learn CPR procedure, it was also inefficient to have to shut down the clinic each time the experiment was performed. This wasted resources as clients could not be attended during the experiment, and in some cases, the experiment did not always succeed because of the inability to control some variables in the experiment. The CPR computer program was a means for Adamson to overcome these problems.

Table 3.5
Teaching Problems which Professors Use Computers to Solve

	A d a m s o n	B o s s	C a i n	D i l l o n	E n g l e b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t s e n	S m i t h
Teaching Problems												
Limitations of previous teaching tools and strategies		x	x		x	x				x		
Students' learning problems					x				x	x		x
Institutional constraints									x			

Limitations of Previous Teaching Strategies

Professor Cain and his students used to plot and rotate data by hand. This put a limit on the number of variables they could work with at a particular time, and the number of hypotheses they could test. This limitation was removed by using the computer to automate these procedures.

Having to rely on his secretary to type his syllabus was a concern for Professor Forester. With the computer, he could make the syllabus and edit it himself at his own time and pace. For Professor Landon, the inability to show students all the necessary images within the time frame of a lecture was a problem. Moreover, his lecture's pace was too fast for detailed study of the images during class. With videodisc technology, Landon was able to make the images available to students for study at their own pace and time.

Students' Learning Problems

Students' learning problems were another major problem that professors in this study mentioned. In the case of Professor Englebar, his students complained that they could not read his handwritten notes on the overhead transparencies. He now prepares his transparencies on the computer, using fonts that are readable to his students. From his transparencies he also prepares a note taking guide for his students so that they can study ahead of class and be able to follow his lecture without being distracted with taking notes.

Students' inability to understand pathological concepts was a concern to Professor Landon. Also, medical students have many exams to take, so they are always pressed for time. Computers allowed Landon to provide multiple opportunities for students to interact with those concepts through computer assisted instruction programs.

Professor Kandel was concerned about the inability of his students to take useful notes during lecture because they lacked critical listening and reading skills. He built into his computer-assisted instruction program, case-based problem-solving exercises to enable students to identify and use important information, discriminate between relevant and irrelevant information, and make judgements regarding competing alternatives.

Institutional Constraints

The university timetable and large classes which impose limits on the amount of time available for teacher-student interaction were two of the constraints that Professor Kandel mentioned. The university timetable stipulates the number of hours per week that professors meet with students in the lecture hall. With so much information to cover in a semester, there is no time to go into details. But the majority of students need the detail in order to grasp the concepts being taught. With the computer-assisted

instruction program being developed, students have another opportunity to interact with lecture materials.

Also, in a class of 300 students, there is very little the professor can do to help all students within the available office hours. With the computer, Professor Kandel can extend his office hours beyond the physical office time to meet with students on e-mail. Through e-mail, he can respond to students' messages at his own time and diagnose from students' electronic records those who are having problems with the tutorial and mark them down for further help.

Summary

There are two major teaching purposes for which the professors studied use computers. They include educational goals and teaching problems. Educational goals include teachers' goals, that is, the teaching goals that the professors use computers to achieve, namely efficiency and effectiveness of teaching. They also include instructional goals which the professors set for their students. Students' goals that the professors mentioned are understanding of knowledge, application of knowledge, problem-solving, critical thinking, research, and computer skills.

Professors in this study mentioned four categories of teaching problems that they use computers to solve or reduce. They include the limitations of previous teaching tools and teaching strategies, students' learning problems, and institutional constraints.

Section Four - Teaching Activities for which Professors Use Computers

This section answers the second subsidiary question under research question one, that is, the teaching activities for which professors use computers. Teaching activities are defined as professors' actions relating to teaching that span a major

duration, including, but not limited to, instructional planning, classroom instruction, and management. It excludes professors' research, electronic communication, and other activities that are not teaching related. Table 3.6 shows a summary of the major categories of teaching activities mentioned by the professors studied. The categories include, instructional planning, instruction, testing, grading, instructional management, electronic communication, and information storage and retrieval.

The most mentioned teaching activity was instruction. About three-fourths of the professors said they use computers for instruction. This was followed by instructional planning. A sizeable number of professors use computers for electronic communication that is teaching related. Information storage and retrieval is the least mentioned, although it may be inferred from the data of those who use databases among the professors.

Table 3.6
Teaching Activities for which Professors Use Computers

Teaching Activities	A d a m s o n	B o s s	C a i n	D i l l o n	E n g l e b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t s e n	S m i t h
Instructional Planning					x	x	x		x			x
Instruction		x	x		x		x	x		x	x	x
Electronic Communication	x			x	x		x		x			
Testing					x		x					
Grading					x		x		x			
Information Storage and Retrieval			x									
Instructional Management							x		x			

Single-Activity versus Multiple-Activity Computer Uses

About one third of the professors mentioned only one activity for which they use computers in their teaching. Forester, the professor in crop and soil science, uses computers for only instructional planning, Dillon in teacher education uses it for electronic communication, while Adamson in veterinary medicine, Boss in arts, and Johnson in mathematics use computers for instruction.

The rest of the professors mentioned multiple teaching activities for which they use computers. Professors Hake and Englebar, the two professors who teach about technology, use computers for six aspects of their teaching. Among the multiple-usage professors, teaching activities range from two to six.

Instructional Planning

Instructional planning was mentioned by about half of the professors studied as one of the teaching activities for which they use computers. However, it may be inferred from the data of the rest of the professors who did not mention it specifically, because they all prepare their lectures, and if they use computers for other activities, they are likely to use them for lecture preparation.

Professors Hake, Forester, Kandel, Englebar, and Smith use computers to develop the structure of their courses and prepare handouts and lecture notes. In addition, Hake prepares the slides of his lecture notes on outlining software. Englebar prepares his lecture notes using a graphics software and transfers them onto overhead transparencies. Smith also makes overhead transparencies for use in his lectures.

Instruction

Computer use for instruction was mentioned by almost all the professors in this study. However, they defined computer use for instruction differently. Some defined computer use as on-line instructional delivery in the classroom or laboratory, while

some consider as instructional the use of computer products such as computer-generated maps that are transferred to a videotape or transparencies. Among the on-line classroom users are those who do occasional demonstrations as well as those who use computers as part of their everyday instructional delivery tool. Computer use for the review of lectures was also considered instructional.

On-line instruction.

As a tool for regular instructional delivery, computers are used to aid professors in presenting their teaching materials. Professors Hake and Englebar, for instance, use the computer and the LCD panel to project class notes on to an overhead screen to enhance class discussion.

On-line demonstration could also be occasional events, as in the case of Professor Johnson. Johnson developed two basic computer programs to illustrate some mathematical concepts. Occasionally, he took the programs to class for demonstration during lecture. He also used some commercial packages for the demonstrations. On one occasion, Johnson felt an assignment by one of his students was unique, so Johnson asked the student to present it in class.

Professor Cain regularly took the computer on field trips with students to collect and analyze data. In the field, they used the computer to analyze some of the data collected on rocks. Sometimes they looked at the data together during lectures.

Computer-assisted instruction.

Professors Landon and Adamson occasionally incorporate part of their computer-assisted instruction program in their class presentations. Landon mentioned that she needed to show a lot of images of human pathology to her students during lecture. A computer-driven videodisc was a less cumbersome and more effective means of presenting those images in class. In the case of Professor Adamson, computer simulations allowed him to demonstrate motion in his lectures, for example, the effect of changing the blood flow to the lung when applying anesthesia to a patient.

Computer-generated materials

Professor Smith used computer-generated materials for presenting his instruction. "...I have all these transparencies that I use for describing things. I've got a series of things here that I use for teaching, 90 percent of which are all computer-generated." (Interview, 10/28/92) Englebar made note taking guides for his students out of his lecture notes generated on the computer.

Review of instruction.

Adamson, Landon, Mattsen, and Kandel developed computer-assisted instruction programs. Mattsen developed a series of computer-assisted instruction as review programs for students to review what they learned in science classes. The CAI were developed to complement specific courses taught by other professors. Professor Kandel's program was still under development. When completed, it will be used to complement survey courses in the humanities. Both Professors Adamson and Landon's CAI programs had stand-alone versions that students used to review materials already covered in class.

What made all the CAI programs useful for review instruction were elements of simulation and case-based problem-solving exercises. Students were presented scenarios about certain problems. Then they were asked questions based on the case scenario. Each problem-solving exercise required students to make decisions regarding best actions or the kinds of resources to use in solving the problems.

Instructional Management

Professors Hake and Kandel mentioned instructional management as a teaching activity they use computers to serve. Both Hake and Kandel developed databases of students' attendance records, students' grades and reports, and students' advisement. Professor Hake mentioned that occasionally he provided students with status reports of

their progress in his course. Professors Kandel and Forester mentioned that they kept records of the research that they do in order to develop their teaching materials.

Testing

On-line computer-based testing was not among the frequently mentioned teaching activities of the professors studied. Only Englebar and Hake were using computers regularly for testing. Professor Forester tried computer testing once and discontinued it because he and his students did not feel comfortable with the random presentation of test items.

As part of learning the course, Professor Hake had a series of master tests for his students. Once they had completed a topic, students were tested on it. To help his students prepare, Hake usually put a practice test on the class' file server, which students were expected to retrieve and practice with prior to the testing date. All testing was done on-line, especially since the course was about the use of technology in education.

Professor Englebar, another professor who teaches about technology, uses computers to administer tests in all his courses. Some of the tests are multiple-choice items which students could take in their own time. This solved the problem of having to schedule over 75 students into the lab at once. On his essay tests, students retrieved the test questions from the mainframe through their e-mail accounts.

Grading

Three professors, Kandel, Englebar, and Hake, mentioned that they used computers for their grading. They scored the test manually and used spreadsheet and database software to record and manage the grade. In addition, Englebar mentioned that he used the computer to produce personalized feedback when grading his students' papers.

Communication

Among the professors studied, almost a third used electronic mail for purposes relating to instruction. Englebar, Hake, Adamson, Mattsen, and Dillon used electronic mail communication regularly with their students. It was one of the main instructional strategies in Professor Dillon's class. Professor Kandel had a one-time experiment with e-mail in one of his courses. He hoped to continue in the future when he has learned more about using it to teach.

The main instructional uses among the professors were to send or receive messages from students concerning class assignments. Some of the professors, like Englebar and Hake, also kept their practice test items or information on the bulletin board. Students were expected to receive the message or retrieve practice test items from the mainframe. They were also expected to post comments on the bulletin board for other students and their professors.

In two of Englebar's courses, students received and submitted their assignments through e-mail. In one of Professor Dillon's courses, students communicated with one another on class readings. Professors Hake, Mattsen, and Adamson's students sent them e-mail messages whenever they were having difficulties with their assignments.

Information Storage and Sharing

Professor Cain, in addition to his other uses of computers, devised a means of sharing teaching materials with his colleagues.

...This is the videodisc approach to computer technology. What we did about a year ago was to collect slides from everybody in the university who was willing to give them. So there is an enormous list of slides here and the images were first of all transferred to a tape and then to a disk. So now I have a videodisc here, and I have a whole series of my slides stored on it. ... The idea behind this is that we have a large collection of images both tutorial, words, formula,

or whatever which we share with our colleagues. And once there is a list of what they are, professors can look through that and say I can use this one and this one and miss out that and use this. They can make a small sub-file of the selected slides on the computer, take it into the classroom...The video projector has a computer attached to it and they slot in their disk and the slides come up in the order that they have been programmed. And that gives you the freedom to make a slide show out of an enormous number of possible slides quite quickly. (Cain: Interview, 10/19/92)

Summary

There are various teaching activities for which professors used computers. They used computers for instructional planning defined to include course development, lecture notes, lecture materials such as slides, and transparencies.

Computer use for instruction was defined variously as on-line delivery or demonstration, using computer-generated materials, and/or using CAI as review of previously delivered lectures. Instructional management included keeping of students' records in database programs. Other teaching activities included testing, grading, electronic communication, and information storage and retrieval.

Section Five - Process of Computer Use for Teaching

This section contains the report of the data analysis addressing the last subsidiary question under research question one, that is, the process of computer use for teaching. Process is defined as including the procedure and means of computer use for teaching. Means implied resources. So the resources used for computing by the professors and their sources are included in this section's report.

Procedures for Computer Use

There are different procedures for computer use described by the twelve professors studied. Even when similar teaching activities were involved, description of use differed from professor to professor. For the purpose of this study one or two examples are presented to illustrate each teaching activity described above, namely, instructional planning, instruction, instructional management, testing, grading, and communication.

Procedures for Computer Use in Instructional Planning

Two examples of how professors use computers for instructional planning are presented. The examples were taken from interview data of Professors Forester and Englebar. While both professors described the same activity, they emphasized different aspects of their planning. Forester emphasized the elements and steps in his planning, while Englebar emphasized the function of his planning.

Example 1: Professor Forester

[When I'm planning] I think about what I believe is important for students to know. Then I prepare my syllabus based on what I believe is important. And that is because of my experience and training and my intuitive or my subjective feelings about it. I don't look at the student and say well what is he interested in and therefore what should I teach him. I look at him and say well this course is in seed science, here is what I believe to be important. And that is what I try to teach. [What I believe is important is based on] my experience, my familiarity with the literature and my interaction with professionals, my peers. In essence, what is out there in real life. That is what I try to structure and influence...

And I have a central subject or organizing topic. Then I break it down into parts. Then take each subject and break it down into its various parts, simplify it, organize or simplify it by organizing it. And elaborate on each part thereby coming to a better understanding of the whole.

... In my own mind I have compartmentalized it and pretty much it depends on what I have written. Some of my books are written from my lecture notes. I organized the books the way I like to teach. I approach all my writing as teaching. And I try to approach that historically and functionally and then in



a systematic way to develop an understanding of my listeners about my subject in a way to fit my bias.

I usually put the manuscript/lecture notes on WordPerfect. ...I almost always prefer to use the computer. I might write a few notes on paper before I use the computer, usually on small bits of paper if I think of something and want to write it down quickly. I like to use the computer to compose. Then I can use the computer to move things around quickly. If I do not want this paragraph here and I want it there, I just do cut and paste. The computer gives you a fast way to do that. (Interview, 4/29/92, 5/8/92)

Example 2: Professor Englebar

I use the computer to create graphics for my classes. For all my regular courses I produce booklets like this. They are made in Harvard Graphics and they are the lecture notes I work from. I just create overhead transparencies of those, show them in class and then the students sit there and take notes in their notebook. Now the next step, which I've been trying to pull off for years now, is to use the computer as the projection system for the slides.

....I also give students the lecture notes, so that they can serve as advance organizer for them. So they can look at it and do the reading, should they ever decide to do the reading, so they come into class theoretically, already briefed on what we're going to cover that day. Then we repeat it again, then they've got the notes on it that they study from so they have a few repetitions out of it. That helps them get a little time to let it sink in. (Englebar: Interview, 10/21/92)

Procedures for Computer Use in Instructional Delivery

Two examples of computer use in instruction, taken from the data of Professors Hake and Adamson, are presented below. In both examples, computers are used to complement professors' instructional strategies, rather than as the delivery medium. In the first example, Professor Hake described the procedure for using computers as a tool to help him in his presentations. Professor Adamson in the second example used his CAI program as an aid to classroom presentation. Students also used the programs to review his lectures.

As in the examples presented under instructional planning above, Hake and Adamson also focused their description of instruction on two different aspects.

Professor Hake emphasized the interactive nature of computer use in his classroom, while Professor Adamson emphasized the function of the analogy he chose as his instructional strategy.

Example 1: Professor Hake

In his class, Professor Hake used computer-generated slides of the outlines of his lecture notes, projected with the LCD panel on to an overhead screen, to aid class discussion.

I interactively work with them [students] on ideas. For example, I'll throw some skeletal ideas up there and then ask for class discussion and then I add those to the notes. So it's interactive--they see their notes going up on the screen and then I print that update for them for the next week. Which is much nicer than writing it out on a transparency, because if they don't get it and I don't copy it, it's gone. Now I write it on the computer and we both have it. Right in class, any notes that we might take, I just add right into the computer. We still discuss orally, but then I might summarize as we're talking. Rather than make points and adding them onto the transparency, I might summarize up there and they may say, "No that's not what we meant," and we'll fix it and agree.

..For example, last week we were talking about various uses of computers in schools. [The students] were supposed to go out into the schools and see what kind of uses they found of computers. I had a heading, "Uses of Computers in Schools." I had put a couple of uses up there as a kind of seed, but then as the class discussed, we added a whole lot of uses until we had a fairly rich description up there of various uses they found of computers in the schools. Then I'll print those out and give them back to the students. (Hake: Interview, 10/27/92)

Example 2: Professor Adamson

In this example, Professor Adamson describes the function of the grain elevator analogy that he used in his computer-assisted instruction program. According to Adamson, the analogy illustrates the effect of changing the blood flow to the lung when applying anesthesia to a patient.

The effect of changing the blood flow to the lung and the way that would influence how the animal would handle the anesthesia. If the blood flow is very high, and that would be in the case when the animal is very excited or when the animal is not well sedated, then when you go to the next task, it is difficult to anesthetize it. Because the blood is flying by the lung so fast so that when it breathes in the anesthetic, the blood goes through the lung without getting a very high concentration of anesthetic in it.

I have explained that to the students and they don't yet understand it. So what I did on the computer program was that I had train cars moving along on the computer screen. And I said, "think of a train going underneath a grain elevator and it drops down grains into the train cars. And when a car fills up, the train moves a little bit forward and the grain elevator drops grain into the next train car." So I have on the computer program a train going underneath this grain elevator. I said the train is analogous to the blood going by the lungs. And if its going very fast and the grain is falling through the elevator at the same rate, the level of grains in each train car will be very low. If it is going slowly, then each train car would have a very high level of grain in the cars. And the level of the grain in the car is analogous to the concentration of anesthetic in the blood. If the blood is going very slowly, you can fill up the level of anesthetic in the blood very rapidly. On this simulation, I have a train going by and there is a control for the students to slow down or speed up the train's speed so that they can demonstrate how the level of the grain in the cars get changed.

One other issue is that the way the animal breathes will affect the anesthetic. If they don't breathe at all, they are not going to get any anesthetic to the lung. Going back to the train analogy, in the second example, I had the train going at the same speed this time. But the students, by moving the control on the computer, they can alter the rate at which the grain is falling from the grain elevator, which is analogous to the breathing of anesthetic into the blood. If you breathe in rapidly in deep breathes, that would be analogous to the grain falling fast and which means you get a lot of anesthetic in the blood. In another example, I have a dog on the anesthetic machine and showing how changing the oxygen flow rate affects the anesthetic concentration in various parts of the machine. I have a control on the screen in such a way that when the students move the mouse, they can just change the actual flow rate and it visually displays what concentration would result in each part of the machine when they do that. (Adamson: Interview, 10/14/92, 10/16/92)

Procedure for Computer Use in Testing

The example of testing with computers presented here was taken from the data of Professor Englebar.

Example: Professor Englebar

...This is something that I do in three of my other courses as well. We have the software that is designed to administer questionnaires. You see the question on the screen and then it gives you the answers and you enter the letter. It's an electronic multiple choice test really... Well, the software is a commercial package that's usually used for telephone interview. I just adapted it. Instead of a telephone survey, I just created an electronic version of a multiple-choice test that the students could take. It doesn't gain a whole lot versus doing the computer scoring in terms of the faculty time involved. But we can turn it around relatively quickly. It also gives students a good preview of the types of questions that they get on the midterm. That's one thing I've done with that. They take this test on top of that which I give them in the first week of the class and use that as a pretest. Then when we get the midterm results and the final results, that's the posttest. And there are enough items in common so I can look at gains in scores across the class or any unusual students.

One advantage of that relative to paper and pencil administration is we can do it on an individual basis. So a student can go in there when they have the time, take the test and we can check their files via the security system we set up. So it really facilitates that kind of input in a sort of pretest diagnostic way. ... One time, I did -- this really baffled them -- I did personalized exams for them. Each individual's exam was printed up with their name and there was a nice graphic header. And once more, the content of the questions varied according to what their interests were. And I just did that by making a mail merge file in WordPerfect and then keyed in the student's names and their interest areas and a couple of other individual variable pieces. In essence everybody had their own personal exam. That was fun. They almost lynched me. (Englebar: Interview, 10/21/92)

Procedure for Grading

Two procedures for grading described below are taken from the data of Professors Kandel and Englebar. In the first example, Kandel described how he used computers to manage his students' grades. He still does his scoring manually, however, calculating the weighted averages and producing the final score is left to the computers. In the second example, Englebar described how he used computers to give feedback to students on their essays or papers.

Example 1: Professor Kandel

The way I structure my course, I give three exams: two 1-hour exams and a final. And then the teaching assistant gives a number of quizzes, the quizzes count at 25 percent of their total grade. The hour exams count for 35 percent of the total grade, and the final counts for 40 percent of the total grade. I have an area on the database into which I enter the formula, the program takes the hour exam scores, add them together and multiplies that by the weighting factor. The database program does all my calculations for me, adds the scores, multiplies the weighted factors, computes the final score, and then can print out for me a scale of scores from the highest to the lowest with the mean in the middle. All I have to do is draw my curve, reenter that back into the computer and then it would do the final grades for me. (Kandel: Interview, 11/3/92)

Example 2: Professor Englebar

When I grade papers now, I create a file which has a few general things that you wind up telling all students usually or most of the students on a paper. You know, like "needs more internalization, more logical connection between the premise and the conclusion," the stuff that's true of everybody. But instead of writing that 30 times, I just create boilerplate files and the end, the usual--"you did a great job." And then as I grade papers, I just select out the parts that don't apply to each individual student. Like I might have, "did a great job." And the other boilerplate might be "you did a bad job, you ought to go back to high school." Depending on what the papers are, I just erase the other one from the file, personalized feedback, as opposed to personal feedback. That is, it gives quite honestly the illusion of personal feedback when in fact, it's just boilerplate. (Englebar: Interview, 10/21/92)

Procedure for Electronic Communication

Two examples of electronic communication for teaching are presented below. They were taken from Professors Englebar and Hake's description of e-mail use in their course. Even though it was not the major medium of instruction, e-mail appeared to play a substantial role in the teaching and learning processes in both professors' classrooms. E-mail was being used to give assignments to students, to provide feedback to students, and to communicate with students on other class-related activities.

Example 1: Professor Englebar

Now last year in one of the courses, I took it a step further and said, "The entire course would in essence be administered on the computer." So each individual student, when they register for the course, we gave them an electronic mail account that we have in the laboratory and then all the assignments that they did, including the exam, were completed down there and were turned into me via electronic mail. And also the feedback that we gave to the students in terms of the grades also was mediated via electronic mail. (Englebar: Interview, 10/21/92)

Example 2: Professor Hake

So everybody in the course has to have an e-mail address and we exchange ideas and so forth. One of our objectives in this course is to search out relevant information and, as we find information, we share that with each other on the e-mail--both bulletin board and individual mail. When we find something out that only one person's interested in, we send it to that individual. We have a bulletin board set up for that class, and we also have a file set up where we can dump stuff into the file on the server, so everybody can get at that file and pick up things as they need it. (Hake: Interview, 10/27/92)

Resources Used in Computing

The professors studied mentioned five categories of computing resources they used in their teaching. These are software applications, hardware, technical support, training, and funding. They also mentioned the last two categories, that is, training and funding, in terms of future need for those resources.

Computer Applications/Software Used in Teaching

Professors in this study mentioned fourteen groups of software applications that they use in their teaching. Table 3.7 in Appendix E shows a listing of the software applications used by faculty in this study according to their categories. Table 3.8 also in Appendix E shows the different software used by each professor, what they were used for, and the reasons for their choice.

The categories mentioned include, word processors, databases, spreadsheets, presentation software, geological package, desktop publishing, communication software, programming languages, animation software, graphics packages, geographic information systems, authoring systems, videodisc, and teacher-developed CAI/CBI and demonstration programs. Within the fourteen categories, over forty-two were commercial software packages, and eight locally-developed courseware by professors. Some of the software were discipline-related, while the majority were generic as they can be used for similar tasks across disciplines. Each professor mentioned more than two applications or software they use for teaching.

Uses.

The professors studied used a lot of different software in their teaching. Most of the professors used computers as tools of teaching, although for some, computers and technology were also subjects of teaching. Those who taught about technology like Professors Hake and Englebar, used and demonstrate a variety of applications in their classrooms. These ranged from the basic productivity tools like spreadsheets, word processors, and databases, to advanced applications like CD-ROM, quicktime, hypermedia, network design packages, and interactive video. Those who used computers to teach, selected the aspects that fit their needs based on their computing skills and knowledge.

For an activity such as instructional planning, Professors Kandel, Forester, and Hake used word processing programs like WordPerfect, Microsoft-Word (both DOS and Macintosh based), and Microsoft-Works. In addition, Professor Hake used outlining programs such as MORE or PERSUASION to prepare slides of his presentations.

For grading and grade management, Professors Kandel used spreadsheet programs like MS-EXCEL and LOTUS 1-2-3. Those professors who used electronic mail communication with their students, namely Adamson, Dillon, Hake, and

Englebar, used communication software like EMC² on the MSU Mainframe, EUDORA, and PRODIGY.

Of the four professors who developed computer-assisted instruction, Adamson and Kandel used ToolBook (DOS-based) as their authoring system. Landon used HyperCard, a Macintosh-based authoring system. Mattsen used different kinds of programming languages, including Visual-BASIC for DOS, and Knowledgeware's CaseTool.

Apart from generic tools, there were discipline-specific tools like Rockware's STEREO-PC, geological software that Professor Cain used for data collection and manipulation on field trips and in the classroom. Professor Smith used geographic information systems, mapping, and animation software for research and to teach about biological systems.

Reasons for choice of software.

Professors in this study chose their software for various reasons. Most of the time, their choices were based on the characteristics of the software. Sometimes the professors chose software because there was no other alternative or because the software was compatible with the systems in their departments or colleges.

Hake chose MS-Works for his class because it is an integrated package that has spreadsheet, word processing, and database capabilities, in addition to being easy to use and learn. He chose MORE for doing his presentation materials because MORE has the capability of automatic numbering and automatic conversion of outlines into slides. Cain chose Rockware's STEREO-PC for collecting plane and linear data because he saw a demonstration of its capabilities at a national conference. Mattsen chose Visual-BASIC for DOS as a programming language for his class because of its graphical user interface capability.

While some professors chose their software because of flexibility, some chose what was available. Only Englebar mentioned that his choice was based on professional

considerations. He chose software that his students are likely to work with as professionals in their field.

Computer Hardware and Peripherals Used in Teaching

Many types of computer hardware and peripherals were mentioned by professors in this study. Table 3.9 shows a list of the categories of hardware, while Table 3.10 shows the types of computer hardware and peripherals used by individual professors and the reasons for their choice. Both tables are in Appendix E.

Computers.

Macintosh, IBM, and IBM compatibles were the most common types of personal computers that professors use for teaching. Only Mattsen, who is in computer science, used NeXT computers because of its multi-tasking capability. In addition to his IBM PCs, Smith also had a small lab of UNIX computers on which he developed his computer-generated maps and sometimes held his on-line demonstrations. Cain owned a Zeos Notebook IBM compatible portable which he took with him on field trips with his students. Most of the e-mail users went through MSU's IBM mainframes, except for Mattsen whose students were on the VAX platform.

Peripherals.

There are peripherals that professors connected with their computers in order to perform various teaching tasks. Professor Hake had a science laboratory interface which he used in his IBM computer laboratory to illustrate how science teachers can teach science in their schools. With the Proxima LCD display panel, he projected his class notes on to the overhead screen to enhance classroom discussion. His students were also taught to use CD-ROM and interactive videodisc players and other equipment. In Adamson's class, there was a scanner that transmits slide images to students' workstations so that both the professor and his students could be looking at the same slide in their respective workstations.

Among the professors who worked with video-related equipment are Smith and Boss. Smith had a video camera, ET-Vista video board, and a VCR which he used to transfer computer-generated images to either a videotape or transparencies. The equipment was very useful in his mapping projects on the honey bee population and satellite imaging. Boss also used a video camera, VCR, color and black and white scanner for his design courses.

Reasons for choice of hardware

Professors chose their hardware for a variety of reasons. Capability of the computers was one of the main reasons for their choices. Professor Boss, for example, chose Macintosh computers with lots of memory and laser printers because he needed equipment with graphic and color capabilities. Graphics and color takes a lot of memory space in a computer, and they are two features that a designer needs for professional products. Hake chose Macintosh because of his personal preference, which was influenced by the fact that the Macintosh has more user-friendly software and a shorter learning curve for his students.

Professors' choice of hardware was also influenced by external factors such as the sources of their funding. Most of the professors studied used the hardware that their departments or colleges provided. Professors who obtained funds from other sources, such as the university or outside donors, seemed to base their choice more on their personal preference and the characteristics of the equipment.

Facilities for Computing

The majority of the professors whose computer use involved their students either taught their classes in computer laboratories or required their students to use computer laboratories. Most of the laboratories were public and are operated by the MSU Computer Laboratory.

Professors Hake and Mattsen had their classes scheduled in the public computer laboratories. Even though Professor Dillon did not use the laboratory for teaching, she required her students to use it to complete their assignments. Professors Adamson, Landon, Englebar, and Boss had their computer labs housed within their colleges. Smith had a mini-lab in his office which he occasionally used for on-line demonstration.

Apart from the computer laboratories, other facilities provided by the university through the Office of Academic Computing and Technology included the Instructional Media Center, where professors borrow equipment like overhead projectors, and the Software Collection, where professors can borrow software for teaching. Details of computing facilities at Michigan State University are in Appendix F.

Technical/User Support

The professors needed or used technical support including hardware, software, and networks. Most of the time, professors needed help with equipment breakdown, bugs in software, or networks difficulties. Some of the professors used resources like video-editing services, programming time, and equipment loan.

Many of the professors felt that they had adequate technical support for what they do presently. However, because the technology was changing rapidly, they needed someone to keep up with it on their behalf in order not to be overwhelmed, given their own work load.

Training

All the professors in the study stated that they taught themselves to use computers for their current purposes. Even those who had computer or science backgrounds believed their current usage could be attributed to their personal efforts. Only Professors Cain and Kandel mentioned that they had one or two short courses or

workshops on computing. Cain had his short course at a professional meeting while Kandel attended some of the short courses or workshops offered by the staff of MSU Computer Laboratory.

A few professors expressed no desire for further training, while some were willing to go for training whenever they had the opportunity. Professor Adamson, in particular, felt he needed some training in courseware evaluation.

Funding

Funding was the third major support mentioned by the professors studied. Many of the professors received teaching funds from their departments or grants in equipment and software, either from their departments, college, or the university. For those who developed computer-based teaching materials, some of the grants were programming and studio time.

Sources of Resources

Professors in this study mentioned four major sources of resources for their computer use for teaching. These include professors themselves, their departments or colleges, the university, and sources outside of the university.

Professors

Most of the professors considered themselves as the primary source of resources for their own computing. In terms of training, most of them said they taught themselves to use computers the way they currently do. About one fourth of the professors mentioned that they served as their own technical experts and only in rare cases did they approach the Computer Laboratory for help. Some of them mentioned

that they bought some of their own software once their department provided them with the hardware.

Department or College

More than half of the professors studied mentioned their department or college as the provider of their personal computers. In addition, almost all the departments or colleges had in-house technical personnel that helped professors with technical and usage problems.

Apart from the full-time technical personnel, graduate and student assistants were another source of support for faculty who use computers for teaching. Knowledgeable students were employed by a college or department on a half-time or quarter-time basis to help professors with teaching tasks involving computer use. Most of the professors who developed computer-assisted instruction mentioned that they had graduate assistants working with them.

In addition to providing hardware and student assistants, some departments or colleges allocated money for teaching, which the professors may use to purchase software.

The University

Many of the professors in this study did not mention the university as their major source of technical support. Less than a third mentioned that they used the technical resources provided through the Computer Laboratory. The services of units such as the Hypermedia Unit were mentioned by more than a third of the professors, including those who developed computer-assisted instruction programs. Only one professor mentioned the equipment loan services from the Instructional Media Center.

Funding was one of the most utilized university-wide resources. More than half of the professors studied received funding, namely, the Integrated Technology

Curriculum Development Grant (ITCDG) through the Office of the Provost for Academic Computing and Technology. The grant was in the form of money, equipment, studio time, and programmer's time. The grant is the university's effort to encourage professors to develop technology-based curriculum.

External Sources

The professors studied also looked for funding from outside of the university to support their efforts to teach with technology. Some of the professors received equipment funds from companies like IBM, Zenith, and Apple Computers, Inc. Some received software grants from companies such as Autodesk and Knowledgeware.

In addition, professors received funding from government agencies like the U.S. Office of Education, National Science Foundation, U.S. Department of Education, and Michigan Department of Agriculture.

Summary

This section contains the report of the process of computer use in teaching. Process was defined as the procedure, computer resources, and sources of the resources used in teaching. Procedures for using computers in teaching were described in terms of the series of actions or decisions taken by the professors while using computers for teaching. Computer resources mentioned by professors include software, hardware, technical support, training, and funding. Over forty-two generic and specialized types of software and courseware were used in teaching. Hardware used include IBM, Macintosh, IBM compatibles, UNIX and NeXT computers and peripherals such as scanners, LCD panels, and VCR. Computing support came from four sources including the professors themselves, their departments or colleges, the university, and external funding agencies.



CHAPTER FOUR

IMPACTS OF COMPUTER USE

This chapter presents the analysis of data addressing research question two and its subsidiaries. The purpose of research question two was to find out whether computer use has an impact on teaching and learning. This chapter may contribute to understanding of the kind of effects associated with computer use for teaching in higher education.

The major research question guiding this report was:

2. What are MSU professors' perceptions of the impact of computer use on their teaching, students' learning, and classroom interaction?

The subsidiary questions are:

A. What are MSU professors' perceptions of the impact of computer use on their teaching?

B. What are MSU professors' perceptions of the impact of computer use on students' learning?

C. What are MSU professors' perceptions of the impact of computer use on classroom interaction?

Plan of This Chapter

The report in this chapter is presented in five sections. Section one deals with the perceptions of the professors studied regarding the impact of computer use on their teaching. Section two presents the professors' perceptions of the impact of computer use on their students' learning. In section three, the perceptions of the professors on the

impact of computer use on classroom interaction is presented. Classroom interaction was defined as the kind of interaction taking place between students and their professors, among students, and between students and computers. Section four presents professors' perceptions of the kinds of problems and challenges associated with computer use for teaching. Section five contains professors' perceptions of the future of technology in education.

Section One - Perceptions of Impact of Computer Use on Teaching

Professors in this study perceived a variety of impacts of computer use on their own teaching. As shown in Table 4.1, seventeen major impacts were mentioned by the professors. The most mentioned impact involved professors' instructional strategies. More than half of the professors mentioned that computers provided them opportunities to enhance their instructional strategies. Increased efficiency in the performance of teaching tasks is the next popular impact.

Enhancing Instructional Strategies

Many of the professors in this study believed that computers enhance their instruction by making it possible for them to adopt different instructional strategies. Computers made it possible for Professors Englebar, Hake, and Forester to share syllabi and teaching notes with their students. The teaching materials helped students to prepare for class and enhance learning of the subject matter on their own. Englebar believed that sharing teaching notes with students and classroom demonstrations resulted in a shorter learning curve for students.

Table 4.1
Professors' Perceptions of Impact of Computer Use on Teaching

Impacts on Teaching	A d a m s o n	B o s s	C a i l o n	D i l l o n	E n g l e b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t e n	S m i t h
Increased efficiency of performing teaching tasks	x	x	x		x				x			
Makes some teaching strategies possible	x	x	x		x					x	x	x
More regular evaluation of instruction					x		x					
Using computers for instruc. mgt allows more time for other teaching tasks		x					x					
More control over planning of syllabus, lecture, and teaching materials	x					x						
Increased access to more information sources						x						
Professional looking teaching materials						x	x					
E-mail increases communication with students											x	
Increased computer skills	x											
Storing materials on disk saves office space and allows keeping of more materials									x			
Can attend to concern of slow learners									x			
Individualization of learning opportunities					x					x		
Makes teaching more fulfilling and easier					x	x			x	x		x
No impact on teaching							x		x			

Computers also provided professors with opportunities to add new dimensions to their teaching which would not have been possible otherwise. For the professors in the physical, natural, and medical sciences, the ability to visualize objects or phenomena in different dimensions was very crucial to students' understanding of certain concepts.

Some of the techniques we used to do can be done on the computer and some of the visualization that was difficult. The computer can do 3-dimensional rotation of crystals which helps them [students] to perhaps absorb these things more efficiently. The next is modeling of course, to be able to say, well if this happens what would be the result. (Cain: Interview, 10/19/92)

Using computers for modeling and simulation allowed professors to provide a variety of learning situations for students that are rich, realistic, and interactive. The simulation programs in Professors Cain, Mattsen, and Adamson's classes allowed students to find out information for themselves. Also, because of computers, professors were able to bring into classroom large-scale and more realistic problems for problem-solving exercises.

How it was done before was by giving all the students one model, one problem or perhaps one of a small number of problems and asking them to solve the problems. But in this case, essentially each student has a different problem, because, for example, in the genetic example that I was talking about, we randomly generate the entire population of bugs to begin with. So that each team is working with an entirely different bug. (Mattsen: Interview, 11/16/92)

Working with large data sets was also an opportunity for professors to shape the direction of students' learning, helping them to look at the world from a macroscopic rather than microscopic perspective. According to Smith:

We're becoming more than you think a computer age. The computer technology is witnessing almost an exponential increase and has been in terms of speed. But not only in speed because what's happening now is that the computing facilities have become more able to process large amounts of information. And there are people now recognizing that we need to be gathering all kinds of data almost on a global scale to be able to understand what's happening to the world and to food productivity and to population and to land use and to sustainability and to chemicals in the environment and all those sorts of things. They're all becoming widely recognized as problems that are out there that can't be solved unless we look at big-scale pictures of the world and how it operates in this little microcosm. The world is relatively small if we look at it from a universal perspective. I think we almost have to. We've been looking at it from a much more myopic point of view until now. We need to scale up. (Smith: Interview, 10/28/92)

Professors Englebar and Hake used the computer to change from lecture to discussion method in the classroom. Both professors felt that discussion was a better instructional strategy because they were able to get more students to participate. Professor Landon felt that computers provided her college with the opportunity to begin to evolve a new mode of teaching. The responsibility for learning definitions and basic concepts in pathology was gradually being shifted to students through the computer. Professors could then spend teaching time on helping students to apply the concepts they already learned on their own.

Control of Teaching

Most of the professors believed that computers have not increased teaching activities. Computers only make teaching better.

It helps me to do the same thing faster, with more enjoyment and effectiveness. It takes less time and wastes less paper because I can make changes without printing it out first. (Forester: Interview, 4/29/92, 5/8/92)

Professors Kandel, Adamson, and Forester mentioned that one of the advantages of computers in their teaching was the flexibility of updating old teaching materials and developing new ones.

If you look at the kinds of work that I needed to do before, I wonder how I lived so long without using a computer. I can write a lecture this semester, putting it on a disk would allow me to go into it immediately and change it the next semester, thanks to a word processor. Whereas before, the task of going in and changing a lecture, just the mere physical act of typing it out, was so horrendous that you keep putting it off. (Kandel: Interview, 11/3/92)

Professor Forester believed he had more control over preparation of his teaching materials because he no longer relied on his secretary for typing. As a result, he was more flexible in his preparation. He could develop or update his teaching materials at his own time. He could make last minute changes to incorporate new materials in his lecture. This, according to Forester, made his teaching richer and more fulfilling.

Computers for Instructional Management

Many of the professors mentioned that using computers for instructional management, such as, keeping student records, lecture notes, and test banks, freed up their time for other aspects of teaching. Being able to use computers to manage instruction helped professors to reassess their roles in the classroom from that of lecturers to students' mentors. Boss said computer enhanced his demonstration of art designs and with hands-on approach that he adopted, he was able to concentrate on helping individual students to develop professional skills.

For Kandel, being able to store teaching materials and student records on diskettes saved him some office space. More materials could also be kept as a result.

Because Professor Hake could use computers to manage instruction, he had more time for regular evaluation of students' learning.

Opportunity to Individualize Instruction or Learning Experiences

Apart from the opportunity for innovation and creativity in teaching, computers allowed professors to individualize instruction for students.

In terms of the lab classes,... there you get into all the natural advantages of computers. You are able to individualize things. You don't have to keep the entire class at the level of the slowest student. For example, this term we make the Monday classes mandatory. You have to be there when we introduce the new problem for the week. And then some students are able to complete that on Monday and not come back for the lab class on Wednesday. The ones who do need more time come back and get more help. I think that's something that's very much a part of computer technology. (Englebar: Interview, 10/21/92)

The computer-assisted instruction programs developed by Landon, Adamson, and Kandel helped in the individualization process. The professors were able to structure lesson or review topics to meet the preferences of individual students. Through the CAI, students had more opportunities of interaction with lesson materials, and could access those at their own time.

I think just the availability of something that can provide the exposure to images, which is very important in students' understanding the concepts, understanding the terminology and also provides an interactive way for students to learn and then to test themselves because they have to answer questions as they go through. They don't get graded on it, but there is a definite intent to make them think about issues as they go along, when they get review questions or in the case studies. So I think that opportunity to do that on their own, when they can take as much time as they need, instead of being locked into the pace of a lecture or locked into the time of a lecture. I think it's probably a very important impact, to meet different learning styles and different learning needs that the students have. (Landon: Interview, 10/27/92)

Englebar and Mattsen were able to personalize testing with the aid of computers. Students could take the tests at their own time and pace. As a result, some of the anxiety that students attached to taking a test were reduced.

The students' quiz was individualized, so for example if there were questions about wave length of light, each student got a different problem. That's what makes it so intriguing. It wasn't simply one quiz for everyone in the course. Every student had a different quiz. (Mattsen: Interview, 11/16/92)

The quality of the feedback that professors provided to students on their papers improved and computers made it easier for professors to personalize such feedback.

I think it increases efficiency and it improves the quality of the feedback to students. I can concentrate more of my effort on the specific things in their paper as opposed to getting the general things that tend to go across every paper. So I would argue that it's been very helpful. (Englebar: Interview, 10/21/92)

Efficiency of Teaching Tasks Performance

The professors studied perceived that computer use as an opportunity to "speed up the process of education." According to Kandel and Cain, their efficiency in teaching task performance increased because they were able to automate repetitive tasks and saved time.

Under the old system, if I have a stack of lecture notes, I'll have to sit down to a typewriter, and I'll have to rewrite the whole thing because I couldn't change page 3 without affecting all the pages. Or I'll end up with page 3a, 3b, 3c. Now I can just go on and rearrange the lecture, add new material, delete old material or save it as a new lecture. If I want a reference, I keep the old version on disk, and I can always compare them or print them as I need them. And instead of file folders, I've got disks. I can keep more materials. It's far more efficient. (Kandel: Interview, 11/3/92)

Prior to computers, it took Professor Adamson more than a week to prepare for one lecture.

I think now it's more efficient, much more interesting and fun. I can put a presentation together in one half hour and bring my disk down to the lecture hall and show my students. Before the computer came along I had to make slides, which would take a couple of days and then often they would come back with spelling mistakes. And somebody else would enter them into the computer. Then I'd have to send them back and there's lag time of another couple of days while the edited slides came back. I would have to plan for at least a week to prepare a lesson. Now it's a matter of minutes, so it's really efficient. Interesting and efficient--two things. (Adamson: Interview, 11/5/92)

Professor Boss saw the computer as a tool that extended his and his students' artistic ability. The use of computers enabled him to consider projects for his students that were impossible without the computer. In addition, he could teach more students because of his new role as a mentor.

...I can teach 500 students now not 50, but 500 because I have the media to help me. And I walk around helping these guys to get more out of them or whatever you do as a mentor. (Boss: Interview, 10/20/92)

Increased Computer Knowledge and Skill

Professors' knowledge of computers as teaching tools increased. Professors Hake, Adamson, Kandel, and Smith mentioned that the more they interaction they had with computers, the better they became at integrating technology into their work life. They were able to develop assignments that enhanced students' ability to learn the subject matter more efficiently as well as learning computer skills. The professors mentioned that they became their own technical experts as their ability to solve minor

hardware and software problems increased. Adamson's knowledge of networking also increased. For example, he could update his teaching materials on the college mainframe from his office without seeking technical assistance.

The use of computers in teaching increased professors' awareness of changes in technology and the changing characteristics of students entering college. As more students came to college already computer literate, the need to teach computer literacy had diminished. The focus of teaching was now more on the applications of technology (Hake, Boss).

Ten years ago, we were teaching programming, primarily because there wasn't any software that did much. So if they wanted to do anything with computers, they had to program it. Five years ago, we were teaching the word processing, the utilities software--databases and spreadsheets and how to use them in education. And I still feel that's a very important thing for people to know, because the productivity software is software that never wears out, software that empowers them to do a lot of things. So they ought to know how to do that. But in addition, now, they need to know the newer technologies that are out and how those can empower them. (Hake: Interview, 12/3/92)

In the beginning we had to show them how to turn it [the computer] on. We had to show them the mouse goes this way and that way. Now you don't have to do that. There are computers all over and they all know how to turn them on... Some of them are brighter than others in that they have all these things at home. And that is difficult because in teaching your time is meant to show them these things and now you don't have to do that. So what do you do with that time? You have to substitute activity for that time. You have to rethink classroom activities to fill the time they would have spent on introduction to computers. (Boss: Interview, 10/20/92)

No Impact of Computer Use on Teaching

While many of the professors perceived impacts of computer use on their teaching, a few did not perceive any effect at all. Both Professors Dillon and Johnson perceived no difference in their teaching.

I like to develop the subject in my lectures, rather than get carried away with computer demonstrations... For me there have been no major differences in terms of students understanding the course content. It's just nice mathematically to be able to illustrate some things graphically, so it is nice to have these programs available. I usually comment on the pictures of what is happening and I hope that it enhances their [students'] understanding. (Johnson: Interview, 10/29/92)

Summary

The professors in this study perceived changes in their teaching and in themselves as a result of computer use. Computer use enabled them to be creative and innovative in their teaching, by providing them the flexibility and opportunities to enhance their teaching strategies. Through computers, the professors had been able to individualize instruction for their students, while encouraging cooperative learning through group assignments. Computers increased professors' access to more information for teaching, helped them to gain more control of their teaching, and increased efficiency of instructional management and performance of teaching tasks. A few professors perceived no impact of computer use on their teaching.

Section Two - Perception of Impact of Computer Use on Students' Learning

Most of the professors perceived changes in their students' learning as a result of their computer use for teaching. Active participation, increased learning, computer skills, meeting national standards, and marketability were some of the perceived impacts of computer use on students' learning. Table 4.2 shows a list of some of the effects mentioned by the professors.

Increased Quantity and Quality of Learning

Professors in this study believed that computers enabled students to learn more of the subject matter. Professor Hake mentioned that his students learned a lot of technology and predicted that they would learn equally well if his subject matter was science. Mattsen reported that students compared favorably with the national standards. Most of the students who used Professor Landon's CAI programs to study for their waiver exams passed.

The feedback from students has been very positive and very rewarding. So I get a positive feeling from students that they appreciate this and it's really helped them in meeting the objectives that they need to meet. So that's been rewarding in many ways personally to me, in terms of teaching impact and just the process that I've gone through. Just knowing that students have been able to learn more efficiently and better because the programs have been there. We've done evaluations both quantitative evaluation and then asking students for general comments. All that has been very positive in terms of these actually helping students learn the material and meet objectives and maybe do better on the exam or just knowing they know the material better for future use. (Landon: Interview, 10/27/92)

In addition to subject matter, professors believed their students learned a variety of skills and acquired certain knowledge as a result of computer use. Students were able to absorb a lot of information more efficiently. Students' ability to model objects or phenomena, trouble-shoot, or solve problems also increased. Professors Cain, Dillon, and Mattsen believed computers helped shape students' perception of information. The flexibility of moving information around within a document and changing data from one form to another enabled students to see data processing as dynamic rather than a static process.

Table 4.2
Impacts of Professors' Computer Use on Students' Learning

Impacts on Learning	A d a m s o n	B o s s	C a i n	D i l l o n	E n g l e b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t e n	S m i t h
Enables to learn more subject matter more efficiently			x		x		x			x		
Students adopt problem-solving approach to learning		x	x				x					
Students show positive attitude and are motivated to learn	x		x				x	x				
Promotes group work among students							x				x	
Increased computer and information processing skills		x	x	x	x				x			
Graduates compete favorably in jobs		x			x							x
Students compare favorably with national standard											x	
Students participate more actively in learning experiences	x									x	x	
Promotes thinking and visualization skills	x				x					x		x
E-mail increases students interaction with professors									x		x	
Some students were frustrated with computers	x		x								x	
No effect of computer on students' learning of subject matter				x		x			x			

The quality of students' learning was also different. According to Professor Englebar, the use of computers enabled students to develop experiences closer to those of professionals in their fields. Professors Landon, Adamson, and Hake also believed that students were learning how computers can be used for professional purposes, as well as learning professional skills.

Increased Student Participation in Learning Experiences

A few professors in this study reported that computers increased students' involvement in the learning process. According to Professor Mattsen, students asked more questions about their class projects and assignments through e-mail or during class interaction. Professor Adamson perceived that his students using his CAI programs were "more alive" than those who were passively listening to lectures.

I wish I had video-taped the two groups when they were hearing the presentation. Let me tell you what it looks like. The ones that were listening to lecture, guess what was the posture of most of them--hand on their heads like this, many of them were reading the newspaper, gazing off, and some of them were sleeping. Some were taking note but typical you know what it is like. The ones on the computer program were two students looking at one computer--they were talking about it, they were arguing, some of them were laughing because I had some jokes tucked in it. They were really having to think about it. They were calculating stuff with paper because I had mathematical equations in there. They were really using there brains. And I thought that was just much more challenging to them and I thought that group is much more alive than the ones that were just staying there with there hands on their heads or hands on their laps listening to the lecture. (Adamson: Interview, 10/16/92)

Increased Positive Attitude and Motivation to Learn

To many of the professors studied, computer use appeared to increase students' motivation to learn. According to Professor Cain, his students were more excited about learning whenever they had access to a computer. They were motivated to spend much

more time on their assignments. Increased interaction with subject matter may translate to more learning for students, according to Englebar and Landon.

Students also seemed to benefit from using computers to improve the efficiency of learning. Because computers could be used to plot data, a lot of the efforts that were previously spent on data plotting were now focused on asking serious questions about the data, testing hypotheses, and solving problems.

Many of the professors said that they perceived a positive attitude to learning in their students. Professor Hake perceived his students adopting a problem-solving approach to learning and solving computer problems.

What I'm pleased with them about is that they're approaching this with the attitude that, "yeah, I know it's got some bugs but I'll work through it." (Hake: Interview, 12/3/92)

Computers provided Johnson's students with the opportunity to initiate learning beyond class requirements.

I did have a term project for each of the students to do. One of the students was quite adept at computer science, and even though he didn't use a Macintosh, he did produce a nice program which would take a line or a circle in the plane, map it to a sphere by stereographic projection. He produced a program that would do this, and then we went to a computer lab where there is a large monitor. I took the whole class to the room and he presented it to the class. It was a nice presentation on the student's part. (Johnson: Interview, 10/29/92)

Professor Boss reported that his students were making better design choices because computers provide them with a variety of options, including many fonts and typefaces. In addition, computers provided flexibility in moving things around. Students were able to experiment with different design options and came up with better products. Moreover, computers made information available to students with which they

could diagnose and solve design problems. As a result, students' designs were much more unique and professional.

Thinking and Verbal Skills

The professors in this study believed computers enhanced the thinking skills of their students. Professors Adamson and Mattsen reported that the problem-solving exercises in their CAI programs encouraged students to think about the subject matter.

Professor Dillon reported that asking her students to communicate with students in another university through e-mail improved their verbal skills. Knowing that they were communicating with colleagues from different backgrounds and different subject areas, the students became more specific and articulated their points more clearly.

Enhanced Students' Competence and Marketability

Students' computer skills and their ability to compete successfully with peers were two of the most reported effects by professors in this study. Professors Boss, Dillon, Englebar, Hake, and Kandel mentioned that their students learned computer skills from their courses. Simply getting students to use technology was a means of familiarizing them with tools of work in society.

In terms of the lab sections that we do, I think the major benefits to the students is just getting familiar with software that they can go use in the work place. They're getting skills that they can apply when they get a job, because we use the same software employers use. (Englebar: Interview, 10/21/92)

Computer skill was partially credited with graduates' success in securing employment. According to Professors Englebar, Smith, and Boss, the students who graduated with computer skills were able to secure employment faster than those



without such skills. They were also more likely to get better jobs than their counterparts who had no computer skills.

Oh, I think I could identify four or five [students] who have gotten jobs they wouldn't have gotten otherwise by virtue of the extensive computer exposure that they got. I think that even where it hasn't made that kind of critical difference in terms of the skill level and familiarization, computers have opened up new doors to them in terms of thinking about their own life chances and opportunities. (Englebar: Interview, 10/21/92)

Negative or No Impact of Computers on Students' Learning

Not all the perceived effects of computers on students were positive. According to Professor Boss, computers helped to "corrupt beginning arts students." Students were so impatient to begin designing on the computer that they sometimes missed the necessary steps in design process.

You still have to have the skills of seeing, you still have to have the skills of drawing to go on the machine. And I think that's where we are in trouble right now because the student wants to go into that room and do every thing on the screen and you can't. You have to have ideas first, you have to visualize in front of you and then take it onto the machine. (Boss: Interview, 10/20/92)

Moreover, there were still many students who had anxiety about using computers. According to Professor Adamson, many students, because of their anxiety, did not see computers as another medium of learning. Some students, according to Landon and Englebar, found it difficult to be comfortable around computers.

A few of the professors could not attribute students' achievement to their computer use for teaching. Dillon perceived no impact of computers on students' learning of the course materials because computer use was "tangential to the course." Forester's computer use did directly involve students. However, computers helped him to provide the course materials to students ahead of time to help them prepare for class.

Johnson indicated that computer use in his class did not contribute directly to students' learning.

With the demonstrations, some students were curious and looked at them a little further. They were welcome to stay a few minutes after class and play with it themselves. But I don't know if it necessarily generated that much more discussion than the lecture might have in general. (Johnson: Interview, 10/29/92)

Summary

Most of the professors in this study perceived a positive impact of their computer use on students' learning. According to the professors, computer use for teaching increased students' active participation in classroom events, quantity and quality of learning, and positive attitude and motivation to learn. Computer use also improved students' thinking and verbal skills and their competencies and marketability. A few professors perceived no impact or some negative impacts on students' learning.

Section Three - Perceptions of Impact of Computer Use on Classroom Interactions

Most of the professors in this study reported that computer use for teaching had impact on the interactional processes in the classroom. Computer use helped the professors to promote different kinds of interaction and roles. Table 4.3 summarizes professors' perceptions of the interactional processes in their classrooms.

Kinds of Interaction

Most of the professors in this study mentioned that computers enabled them to integrate three kinds of interaction in their classrooms. These include whole class instruction, individualized instruction, and cooperative learning.

Table 4.3
Impact of Computer Use on Classroom Interactions

Impacts on Classroom Interactions	A d a m s o n	B o s s	C a i n	D i l l o n	E n g l e b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t s e n	S m i t h
Make possible hands-on experience		x			x		x					
Enhances whole class instruction					x		x					
Make possible to introduce new teaching strategies		x										
Increases students' interaction with subject matter through computer-based assignments			x		x		x					
Encourages more group projects, as well as individualized learning through autotutorial	x	x					x			x	x	x
Networks allow one-on-one interaction between professors and students	x								x			x
Increases opportunity for students' feedback	x				x				x		x	
Encourages mutual learning between students and their professors												x
Some students do not like computers					x					x		
No impact on classroom interaction				x		x		x				

Whole Class Instruction

According to Professors Englebar and Hake, computer use enhanced whole class instruction. Through a hands-on approach, it became possible for the professors to attend to individual needs of students while other students were busy at their terminals. Also, prior to computer use, lecture was the dominant method of instruction. With the availability of projection equipment like the LCD panel, the professors were gradually shifting the method of instruction from lecture to discussion. The professors involved believed that discussion method was a better means of getting more students to participate in classroom events.

Individualized Instruction

Opportunity to individualize instruction was one impact reported by a sizeable number of the professors in this study. Professors Adamson and Landon believed that the CAI auto-tutorial programs enabled them to set up an instructional situation that met the individual learning needs of their students. Students could control the pace and time that they interacted with the computer programs.

Cooperative Learning

According to Professors Hake, Mattsen, and Smith, the use of computers encouraged more cooperative learning among students. Because the tool was available, the professors gave more computer assignments that involved students working in groups. Through in-class group projects, professors could focus interaction on small group instruction.

In the lecture, there are group projects with four or five students and those take 15 or 20 minutes and are generally, but not always, turned in at the end of the class hour. Where we pose a problem, students have to pose a solution. There are also programming assignments that are done in the class in teams of two and those students work together and they turn in a design at various phases of the

project and ultimately a computer program, and they are graded as a team. Then we have a lot of direction by electronic mail. (Mattsen: Interview, 11/16/92)

Sometimes it was necessary for students to work together, either because of inadequate facilities or because of the support that a functioning group provided for students.

The fact is if we have a room that has 16 computers and we have 30 students. Most of the students are going to have to work together in teams. If they don't wish to, they can certainly finish and turn in their own programs on their own and some students do elect to. But most students in the computer science course find it very helpful to work with someone else. Once in a while it doesn't work because one of the partners simply isn't doing the work and then we break up the programming teams and form another team, but that's also true in the work environment. (Mattsen: Interview, 11/16/92).

Working in groups also added vitality to students' interaction. If you see them in the class, they're very actively discussing what they're doing, how they're going to solve the problem, exchanging ideas and suggestions, trying things, keeping track of mistakes. They're extremely busy. (Mattsen: Interview, 11/16/92)

Modes of Interaction

There were three modes of interaction mentioned or implied by the professors. These included lecture, discussion, and hands-on experience for the students.

Lecture

Most of the professors studied still lectured while students took notes. However, computers allowed professors to introduce more visual materials to illustrate concepts during class presentations.

Discussion

Professors Hake and Englebar who used computers as presentation tools perceived their teaching shifting from lecture to discussion. With the LCD panel, they could project their lecture notes on the screen to guide class discussion. To Professor Hake, typing out the points raised during class discussion in a word processor was a means of keeping a record of the class discussion and sharing the notes with his students.

Hands-on Experience

Almost all the professors gave assignments that involved students using computers. Most of the professors believed that the hands-on experience resulted in more student learning.

Patterns of Interaction

The professors in this study perceived a change in student-to-student interaction, student-to-computer interaction, and interactions among them and their students. The change occurred in the mode and volume of communication, the ease of communication, and the roles in the classroom.

Student-to-Student Interaction

Student-to-student interaction increased as a result of the use of e-mail and the increased computer assignments given by professors. The professors were not certain how much interaction among students went on outside of the course, but according to Professor Smith, his students were learning to work in teams which was what they would do as professionals in their field.

Student-to-Computer Interaction

The professors in this study believed that their students spent more time on the computer as a result of computer use in the classrooms. Professor Hake reported that the class project in his course required students to use computers often. In one of Professor Dillon's courses, most of the student-to-student interaction were conducted on e-mail. The professors believed that their students enjoyed completing their assignments on the computer. Some students still had anxieties about computers. For most of the students, however, computers had become a tool of learning.

Professor-to-Students Interaction

Adamson, Englebar, Hake, Mattsen, and Kandel saw computers as a means of increasing the amount and quality of interaction between them and their students. The constraint of limited office hours was removed because students now had more access to their professors through e-mail. The opportunity for one-on-one interaction also increased as students could request help or made suggestions to professors through e-mail communication.

Students are less inhibited because all they see on the screen are the words they are typing. They don't have to look me in the eye, so they don't have to be afraid of my reaction or possible disapproval. They can come on strong... I made a lecture on eighteenth-century Europe--the development of rational thought, and I mentioned people like Jean Jacques Rousseau, the French eighteenth-century writer and thinker. And I got a message on the e-mail from a student challenging my comments on this man. And I wrote back and said what he knows about Rousseau was quite right and that I didn't mean to imply in my remarks that I was contradicting, but offering another point of view to it. I was talking about Rousseau in another context. Unfortunately he never came back with similar dialogue on the e-mail, it could have been nicer if he and I could have kept things going more on e-mail. (Kandel: Interview, 11/3/92)

Professors Adamson, Smith, Englebar, and Kandel believed computers provided them an opportunity to learn from their students as students were learning from them. The e-mail provided a forum where students could provide professors with feedback on their teaching. More professors were acknowledging the fact that students might know more about computers than they. Professors perceived themselves more willing to accept help from their students (Boss, Englebar). According to Kandel, "learning is an interactive process. If you don't interact, you don't learn."

Feedback from students may not always be pleasant, but Professors Kandel and Adamson preferred it to no feedback. According to the professors, by hiding behind the "anonymity" of the e-mail to challenge professors' assumptions without fear of persecution, students could help make the instructional process better.

I had some students last spring who said this e-mail is a bunch of crap. And I sent back, I said sorry you think that way, why don't we discuss it. I wanted to see if I could bring them out. I couldn't, they dropped it. (Kandel: Interview, 11/3/92)

Roles in the Classroom

Most professors in this study did not perceive their role as teachers to have changed as a result of computer use in teaching. Most of the professors still perceived their major instructional task to be lecturing. Only Professors Boss and Hake reported that they are gradually shifting their role to that of a mentor.

A few professors reported that they were able to delegate authority to students to manage certain aspects of class interaction. It was not clear whether this was different from what the professors were doing prior to computer use. In Professor Hake's class, students directed some of the class activities through weekly presentation of their projects. Professor Dillon's students monitored e-mail discussions of class

readings, reported back to class, and lead class discussions. Boss asked a student knowledgeable in computers to serve as a mentor to other students.

No Impact of Computer Use on Classroom Interaction

Professors Dillon, Forester, and Johnson felt that computer use made no difference in interaction in their classrooms.

Summary

Professors in this study perceived some impact of their computer use for teaching on some aspects of classroom interaction. Professors perceived themselves giving more computer-based problem-solving assignments. This increased the frequency of students' interaction with computers, with other students, and with their professors. Students communicated more one-on-one with their professors through e-mail asking questions about class assignments. Lecture was still the predominant mode of class teaching, although a few professors were gradually shifting to discussion and hands-on approaches. Some professors were beginning to see themselves as mentors rather than just lecturers. A few professors perceived no impact of computers on interactions in their classes.

Section Four - Problems and Challengers of Computer Use for Teaching

This section presents the report of professors' perceptions of the kinds of problems and challenges associated with computer use for teaching.

Problems of Computer Use for Teaching

Among the professors in this study, the most frequently mentioned problems of computer use for teaching was time. This was followed by hardware and software



problems. Lack of skill or knowledge, access, and inadequate resources were some other problems mentioned. Table 4.4. showed the kinds of computer problems reported by the professors.

Table 4.4
Problems Associated with Computer Use

Problems of Computer Use	A d a m s o n	B o s s	C a i n	D i l l o n	E n g l e b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t s e n	S m i t h
Hardware and software problems		x	x		x		x				x	
Frequent loss of information due to lack of skill		x				x						
Bad documentation and unuserfriendly software				x	x	x						
Software licensing and copyright issues		x	x						x			
Network failure											x	
Lack of easy access to equipment			x	x								
Inadequate funding									x			
Inadequate facility					x	x						x

Hardware and Software Problems

Hardware and software problems mentioned by the professors ranged from bad disk drives to poor resolution of projectors, network failure, inadequate storage

memory, obsolete computer systems, virus-infected software, software that is not user-friendly, bugs in software, and inadequate documentation.

Then there's the usual problems of computers, you know, computers that break down and stuff like that. (Mattsen: Interview, 11/16/92)

Frustration is usually due to the fact that the program [software] is written by a person who doesn't exactly have the same thing in mind as you do. And you have to get to that meeting of minds before you understand why it was written the way it was and use it correctly. Sometimes there are problems with inadequate documentation, especially programs which are written by non-professional computer people. They write programs so that they can use them themselves and it is very hard to use because the documentation is poor. Sometimes professional programs have glitches in them which because I am not a computer programmer myself the first reaction to think its your own problem not the program's. Most of the time it's not that difficult, but they do exist. I think there is a tendency to consume a lot of time learning how to use a program. The program itself becomes the object rather than what you are trying to do with it. (Cain: Interview, 10/19/92)

Skill and Knowledge

Frequent loss of information due to lack of knowledge about computers was a problem for some of the professors. Forester described his first computer experience as very frustrating.

I couldn't do anything. I was scared. I was afraid that if I hit the wrong button it was going to blow up... I lost information, and I had to start all over. Until about a year ago, I was always erasing everything. I would hit the wrong button and then I would lose wordperfect and there went my document. There is a computer person downstairs and I would go down and say, "Dave, can you help me retrieve my files, I've erased them again." I had that happen about three times and it was very embarrassing. And I felt so helpless. (Forester: Interview, 10/22/92)

Both Kandel and Dillon mentioned that they lacked the knowledge of how to integrate computers into their courses. Adamson said he needed training on how to evaluate the courseware he developed.

I think perhaps an area I need to address is evaluation. When do I know it [CAI program] is a success. How do I evaluate it. Just having [students] fill out this small survey and again it was favorable comments, but I don't know if it is an appropriate way to evaluate it or not. That's one of the problems that a lot of faculty have, is how do we evaluate whether it is good enough. And you can't always rely on students' feedback because they are going to be influenced by whether they think they are getting graded on it. And just because it is entertaining doesn't necessarily mean it's educational. They may give you a favorable comment. They may like it because it is entertaining, but that doesn't necessarily mean it is of educational value. I think faculty needs to be trained on how to set up evaluation of courses. (Adamson: Interview, 10/14/92)

Access

The professors mentioned that lack of some equipment limited computer access in their classrooms. Also the prohibitive cost of licensing copyrighted materials (Cain, Kandel), public laboratories that did not meet the special needs of students (Cain), and limited access to projectors which made whole class teaching very difficult (Cain), were some of the access problems perceived by the professors.

Inadequate Funds

Some professors mentioned lack of funds to complete instructional development projects, lack of funds to expand laboratory space, and high turnover rate of student employees were some of the problems perceived by Professors Kandel and Englebar. Student staff who worked for Englebar always left for better paying jobs as soon as they have acquired some skills in managing the computer laboratory.

Student Problems

Professors Mattsen and Dillon expressed concerns with what they termed "computer phobia" in their students. Students needed to learn some basic skills to use computers effectively, but there were some students who were afraid to turn on the computers.

The professors believed that computers could sometimes get in the way of students' learning. There was a tendency for students to omit some basic steps in learning because they preferred to perform certain tasks directly on the computer rather than manually. According to Boss, "computer corrupts beginning art students."

All of a sudden when I am trying to prepare a student to be an individual and have his art work look different than the next student, the machine makes all the art work look alike. And I think that is not educational. It's just like training.
(Interview, 10/20/92)

Mattsen also experienced similar problems.

In both the computer science course and the college of natural science, we tend to hide the operating system from them. We want them to use, for example, Windows to do all of the formatting and files and so forth, use the Windows' file manager. The reason is we don't want them to have to learn the operating system. You know, all of the syntax of back slash and sub-directories and all this kind of thing, because that tends to get in the way of learning and we can spend several weeks teaching them the operating system before we get on to doing any real work. (Mattsen: Interview, 11/16/92)

Challenges of Using Computers for Teaching

Computer use for teaching posed certain challenges for the professors in this study. Among the challenges that the professors mentioned were, time, changing technology, matching computers with educational goals, university reward structure,

student acceptance, and keeping computers in perspective. Table 4.5. summarizes the challenges of computer use that the professors perceived.

Table 4.5
Challenges of Computer Use for Teaching

Challenges of Computer Use	A d a m s o n	B o s s i n	C a i l l o n	D i l l o n	E n g l c b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t s e n	S m i t h
Time	x	x	x		x		x	x				x
How to use technology to improve education							x			x	x	x
Changing technology		x	x		x							
Institutional factors	x										x	
Students' acceptance and attitude	x								x			x
Keeping technology in perspective					x							x

Time

Time was the biggest challenge that most of the professors mentioned that they faced in using computers for teaching. Time was defined variously by the professors. To Professor Dillon, finding time to read and respond to e-mail messages from over 60 students a week was a big challenge. To both Professors Hake and Englebar who used

computers as part of the delivery system in classroom instruction, preparation time was the challenge.

I spend about a day's preparation for each class. Getting my notes, getting materials ready, reading materials that I may want to look over. If I've done my homework, like I should ... for example, I work at home on Wednesdays and usually spend Wednesday preparing for Thursday's class. I usually work at home on Fridays, spend most of Friday preparing for Tuesday's class. If I've done my homework, maybe a 1/2-hour or 45 minutes is all I need to go over my stuff and make sure I've got everything with me that I intended to take with me and make sure that everything's working... Because while the computer saves you time in getting all those notes and everything like that, it costs you a lot of time in terms of gathering your software and making sure that everything's going to work and so forth. I suspect I end up spending more time than I did before when I just had my notes on paper. But I think it's a superior product so it's worth the time. (Hake: Interview, 10/27/92)

Professors Adamson, Kandel, Mattsen, and Landon who developed computer-assisted instructional programs, believed that initial development efforts require a heavy investment of time. Adamson approximated the time he invested in his first CAI project to be about 200 hours of design, development, and programming time.

Takes time. But it's getting less time as we go now, because we would take stuff from one program and cut and paste into another program. And we just get a better program as we go along. At the very first, it takes about 6 months. A second one of equal quality took about 2 weeks, maybe less than that. That is for a one-hour presentation or for students to sit down at it. (Adamson: Interview, 10/14/92)

Computers can consume users' time when it fails.

The downside of it is that sometimes you can just get totally flummoxed by the computers. You wind up taking five times as long to do something you could do like that with a piece of paper and a pencil. (Englebar: Interview, 10/21/92).

Changing Technology

Rapid change in computer technology sometimes posed a challenge to some of the professors in this study. According to Professors Cain and Boss, professors almost always had to learn new skills each time a computer was used because the technology was constantly changing. Boss felt that most professors were having a hard time choosing from among competing hardware and software alternatives without the additional challenge of keeping pace with the ever-changing technology. Moreover, the cost of updating hardware and software posed a challenge to a dwindling department/college's budget, according to Professor Englebar.

Matching Computers with Educational Objectives

Professor Hake, who was an experienced computer users for teaching among the professors studied, felt that there was no set formula for how best to use computers for teaching. He was constantly thinking about how to meet educational goals using available technology. How best to design realistic simulation programs was a constant challenge to Mattsen. Thinking of the best way to integrate visuals into lectures was a challenge to Professor Forester.

University Reward System

The practice in universities to emphasis research over teaching was a concern for the professors in this study. Professors who used computers for teaching had the additional challenge of having to market computerized teaching to their bosses. According to Landon and Adamson, professors almost always have to turn their CAI efforts into a scholarly product, such as a publishable paper, before they could get recognition for their efforts. Yet, according to Adamson, professors spent as much time

developing computer-based teaching materials as they did on straight research. Because of the time investment and the lesser weight placed on teaching in higher education, professors who were not yet tenured believed that it was a risk for them to engage in a time-consuming computerized teaching.

The one risky thing was I was assistant professor at that time and I hadn't got tenured. And I was afraid that if I spend time working on teaching things instead of on research publications, I might not be tenured. So that was a risky thing and I had to weigh that....It is difficult to quantitate the quality of some of these instructional work. For example, if I publish a paper in the journal of veterinary medicine, they will probably realize it is a good paper and that I spent some time. But if I make a computer program for students to look at, the dean or somebody mighthow can they realize how good or bad it is. So I think that for somebody who does computerized teaching, I almost spend more time trying to think of ways to market that teaching to my bosses and to prove to them that this is a good way of teaching. In computer program you don't know what your reward is going to be like. (Adamson: Interview, 10/14/92)

Students' Acceptance

Students' acceptance of technology as a learning tool was among the challenges that some of the professors faced. According to Professors Adamson, Dillon, and Kandel, many students saw their professors as the only source of "correct" information.

I had about fifteen percent of the class last spring that simply thought using computers in any form in the humanities course was inappropriate, wrong, and they refused to have anything to do with it. I don't really know how they got their exam questions. I put the exam questions on e-mail. So for students to find out what their essay questions were going to be, they have to go to the computer to get them. I didn't have the paper copy. I was criticized on the ground that I was trying to save paper which is too cheap. But I was only doing it to try to get them to use e-mail. A great many people last spring were not interested in using the computer, I think in some cases out of laziness. (Kandel: Interview, 11/3/92)

Thinking of how to get students to appreciate using computers as part of their daily lives became a concern to Professors Boss, Mattsen, and Smith. Professors Englebar and Landon, for example, had to make the computer component a requirement in their courses in order to get some students to use it. Teaching non-technical students, who are likely to work in a technical profession, to use computers was a challenge to Englebar.

Keeping Computers in Perspective

How to keep computers in perspective was one challenge that most of the professors in this study talked about. According to Professors Smith and Johnson, there was a tendency to forget the mistakes of the past and got carried away by the glories of technology.

And the challenge is to try and keep that all in perspective for me, of recognizing that there are good and bad things in the past that need to be ... the bad things need to be discarded and the good things need to be carried on. I don't know that we do enough thinking about that. We don't do enough of that, the real information melding we need to do to really be effective. I don't know that computers are going to solve that; maybe they will perhaps help. We have to be careful not to push the technology for its own sake but to begin to use--the computer to me is not much more than a pencil. I don't have to use computers in the classroom or haul all the technology into the classroom. I just need to take a transparency of a computer-generated satellite image into class and that is computer usage in the classroom from my perspective. The use of computers extends all the way from talking about them to bringing the products of the computer into the classroom, from bringing hardware in and doing the whole show on line. I'd like to be able to do some parts of that in the classroom, not just concentrate on saying I'm going to do everything on computer in the classroom. It relates to doing a total class on television. I don't like that either. I think you have to have some personal connection to the classroom, to the students so that they know there's a real body up there that makes mistakes and can provide information and knowledge. (Smith: Interview, 10/28/92)

Occasionally, computers may fail to perform to expectations. When that happens, professors may lose face with their students. Professor Englebar described his frustrations over attempts to introduce Integrated Services Digital Network (ISDN) in class.

Just about every time I try to get this thing [ISDN] going, it doesn't work. Last year we had one of these lines set up for the Northwestern room in the students union building where we had a big lecture class, about 100 students. So I was doing a lecture on the glories of new information technologies and I was going to show them a demonstration of an audiographic conference that you can do with all kinds of connections. You can use one of these huge overhead slides, but then with your mouse, you can annotate the presentation. In the class, I've always got my overhead transparency markers circling things, checking them off, stuff like that. With this system you can do the same thing with a mouse, so the person on the other end of the line could say, "Oh wait, go back and point at this topic." Anyway, it didn't work. I did three lectures in that class and all three times we tried to get the stuff set up and we just couldn't get it going. It was just too complicated. It was embarrassing. I was up there and the students assistants were trying to get it to work. Eventually I had to say, "Well, we'll have to cut this short." After three times, it poisoned the whole class. So when it doesn't work, it's real dumb. (Englebar: Interview, 10/21/92)

Summary

Professors experienced problems and challenges in their use of computers for teaching. Among the problems mentioned by the professors were hardware and software problems, lack of skill or knowledge about computers, student problems, and funding. Among the challenges were time to integrate computers into teaching, changing technology, the university reward system, students' acceptance of computers as another learning media, and keeping computers in perspective.

Section Five - Perceptions of the Future of Computers in Teaching

Despite all the problems and challenges, the professors in this study believed that computers have a future in education. According to the professors, the successes of computers use in their teaching outweighed the problems. Through their current uses, the professors were able to project into the future possible uses of technology in teaching.

Most of the professors were very current in their knowledge of new computer technologies and their implications for education. Some of the professors saw future use of computers in terms of further integrating the available newer computer-related technologies into teaching and learning. According to the professors, technologies such as networking, interactive video, simulation, DV-I, QuickTime, CD-ROM are likely to play a significant role in multimedia instruction and learning.

I think in the near future, we're going to see multi-media, a variety of sorts, taking over: QuickTime, DV-I, CD-ROM. In the first place, CD-ROM will play a very important role in archiving data, and that together with networking. So schools will have huge resources at their disposal that they haven't had before, and ways of getting information that are very different from what they've had before. Even things like the encyclopedia that's available on CD-ROM now, makes getting information for kids very different. It lends itself to browsing as well as finding specific information, because you can use boolean searches to find information. But that's just a drop in the bucket, because the world's information and resources will be at the disposal of any school and very reasonably too.

The interactive video will allow us to bring into the classroom more interactive multi-media resources. It will allow us to bring into the classroom experiences that we just couldn't bring in otherwise. I'm envisioning interactive multi-media somehow integrated with polling devices, like I was talking about ... We will in fact show on the large screen some scenario and students will react to that scenario by pressing buttons. Maybe they'll react as teams ...

Now we're still looking at teacher delivery. But then with these very powerful tools, I can have kids at any age begin to develop things like interactive video or QuickTime instructional material. So if I were to have a class that I'm having trouble with in some concept in physics, maybe instead of

teaching the concept directly I would say, "Look, let's make a QuickTime interactive video that would help others understand this concept." So I would get them involved in making this thing. And in the process they'd have to learn the concept in order to make the video. But the tool would become an instructional device. As they make this interactive video, they'll learn all about the physics that I wanted them to learn. We didn't have those tools before...

So our focus in education can now shift to problem-solving, can shift to inquiry, thinking skills instead of memorization of facts. And in the long-run, once teachers learn to do these sorts of things, our teaching should become very different. What we teach should be different; how we teach should be different. We've got huge resources. (Hake: Interviews, 10/28/92, 12/3/92)

Most of these newer technologies were currently available in the university, and professors were beginning to explore their possibilities. The College of Veterinary Medicine, for example, already installed "Quizmaster," a polling device that allowed immediate exchange of information between professors and their students in class. Professors could conduct a survey about the lecture and receive instant feedback from students as to whether or not they understood a topic. Professor Adamson also saw the Quizmaster as a means of administering and instantly scoring multiple-choice tests in class. Englebar had already adapted a similar device to administering multiple-choice tests in his courses.

Professor Boss was interested in exploring the possibility of a two-way communication by satellite for collaborative work between him and his colleagues in other universities. According to Boss, currently, electronic mail only allows transmission of text. With two-way communication by satellite, images could be transmitted for collaborative work.

Englebar was already experimenting with simultaneous transmission of data, graphics, and voice to multiple locations using the ISDN, a telephone-based technology.

ISDN is the new digital end-to-end system for telephone communication that's being used worldwide. The major improvement that it offers over today's telephones is that essentially we have three different channels that you can work with. You have your regular voice, then you can plug a computer into one--that's just a regular computer interface and that will let you transmit at speeds up to 64,000 bits per second. Then you have a second computer input that will allow you to transmit at 9600 bits per second. Then you can do all three at once. That's the major advance. In my case, I could be talking on the telephone, I can be sending my slides over the 9600 bit channel, which is adequate speed for that... You could have a second video graphic output, but also now they have video-conferencing geared for that speed. The potential would be there to simultaneously have a slow-scan video transmission of me and the class and then also still transmit the computer graphics and the voice at the same time. It's been hard getting it all to work at the same time. But we demonstrated that a couple of times. One time ... in fact, I originated a class here and then sent my voice and slides over to the Erickson Kiva to a big lecture class I was doing there. Now as the service becomes more widely available, I should be able--why do I have to be here? I should be able to be in Hawaii and send my class materials from there. (Englebar: Interview, 10/21/92)

Smith believed that proper integration of existing technology into the structure of the university and the curriculum is the next phase of technology use in education. He observed that there was a gradual shift in orientation from the personal computer to a workstation technology, which is more powerful.

Professor Boss predicted that the gap between the tool that students have to learn with and the tools they will work with when they leave school is likely to continue. Because education is under-funded, tools that students are likely to work with when they leave school will be more powerful and up to date. Using what is available in school intelligently will involve learning the theory about technology that is transferable to other situations.

Future use of computers may help to prove or disprove theories about teaching and learning with technology, according to Kandel.

We may be able to prove the exact opposite of what we are after, that it won't work, that the teaching of arts, philosophy, theology is better suited to a classroom of live people talking to each other...(Kandel: Interview, 10/28/92)

Summary

Through their current use of computers, professors in this study were able to predict future computer use in teaching. Most of the professors believed that future use of computers would involve further integration of the existing new technologies. Multi-media instruction is likely going to be the norm. Some professors predicted that tools of work in schools are still going to lag behind tools of work in society. Rather than teaching a particular technology, it may serve a better purpose to teach students the theory behind computer use which they can transfer to new situations.

Summary of the Chapter

This chapter answered research question two and its subsidiaries. It presented the perceptions of the professors studied on the impact of their computer use on teaching, learning, and classroom interactions. The report was presented in five sections. Section one addressed the perceived impact of computer use on professors' teaching, while sections two and three addressed the perceived impacts of computer use on students' learning and classroom interactions. Related to teaching impacts are the problems and challenges of using computers for teaching. These were presented in section four. In section five, professors' perceptions of the future of computers in education were presented.

Professors perceived mostly positive impacts of their computer use on their teaching, on their students' learning, and on classroom interactions. Computers presented faculty with opportunities to enhance their teaching strategies, shape students' learning, evolve new roles and communication modes, and enhance mutual learning in the classroom.

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A QUALITATIVE STUDY OF FACULTY'S PERCEPTIONS OF COMPUTER USE
FOR TEACHING AND THE IMPACT ON TEACHING AND LEARNING

By

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CHAPTER FIVE

CASE STUDIES OF FACULTY COMPUTING

Case study ...is a method for learning about a complex instance, based on comprehensive understanding of that instance obtained by extensive description and analysis of that instance taken as a whole and in its context (Jacob, 1989, p.9).

Chapters Three and Four contained professors' views about how they use computers for teaching and the impact of computer use has on teaching and learning. This chapter contains the report of the case studies. Three of the twelve professors who originally participated in the in-depth interviews were selected for detailed study of the context in which they used computers. Corroborating evidence were obtained from students, computer resource personnel, classroom observation, an administrator, and teachers' document to build the case studies. One of the common themes drawn from the case studies was that full implementation of computers in higher education will take place only when individual professors are willing to change their usual ways of teaching, and the institution is willing to restructure itself.

Plan of the Chapter

The report in this chapter is presented in three parts. Part one contains the case study of Professor Hake. Data for the case study are presented in three sections. Section one contains background information on Professor Hake and his students. Section two contains Professor Hake's and his students' perceptions of how computers were used in their classroom, and the effectiveness of computer use. Section three contains the report of classroom observation.

Part two contains the case study of Professor Dillon. Data for the case study are presented in three sections. Section one contains background information about Professor Dillon and four of her students. Section two contains Professor Dillon's and her students' perception of computer use in their classroom and the impact of computer use. Section three contains the report of classroom observations.

In part three, the case study of Professor Adamson is presented. The data for the case study are presented in four sections. Section one contains background information on all the participants in this case study. Section two describes the computing resources at the college of veterinary medicine where Professor Adamson worked. It also contains computer support personnel's perceptions of computing in the college. In section three, Professor Adamson's and his students' perception of computer use in their classroom. Section four presents the report of classroom observation.

THREE CASES

Three cases were chosen to examine closely the various elements, personal, interpersonal, and institutional, that influence professors' computer use and the consequences.

Case study one focused on Professor Hake, an experienced teacher and experienced computer user. His was also an example of professors who teach about technology and use technology as an instructional delivery tool. His computer use for teaching was perceived to be effective in influencing students' learning. Students also perceived the professor as an effective role model of computer use in teaching.

Case study two focused on Professor Dillon who is a beginning professor and as well as a beginning computer user for teaching. Inexperience in computer use and her beliefs about computers for teaching were found to be important factors in the outcome of computer use in her classroom. Students did not perceive her approach to computer

use for teaching to be effective in their learning the subject or in learning about computers. Students did not perceive the professor as an effective role model. Case study two is an example of the pitfalls that new computer users for teaching may want to avoid.

Case study three focused on Professor Adamson and the rich computing support that was available to him and his colleagues for teaching. The setting is an example of an integrated computing environment that adequately supports its faculty in terms of facilities, personnel, and administrative support.

Students' reactions to computer use in the college were mixed. Some students perceived the case-based problem solving exercises to be very useful in their review of lectures and for examination preparation. Some students perceived the way computers were being used to be disruptive in their learning. Given that Professor Adamson started using computers for teaching five years ago, and that computing facilities in his college were relatively new, such reactions from students may be expected. All the students who participated in this study believed that computers should be used to review lectures rather than being used to introduce new topics to students.

Part One

Case Study One

Case study one was about Professor Hake. Professor Hake was selected for the case study because of his experience in teaching and in computer use for teaching. He was also selected because he taught about computers and used computers regularly in instructional delivery. I wanted to see if teaching with computers would be different for a professor whose subject matter was computers than for those who taught other subjects.

To corroborate evidence from Professor Hake's interview were interview data of three of his students--"Rosa," "Connie," and "April." I conducted a classroom observation and analyzed Professor Hake's teaching notes for additional evidence.

Section One - Background

This section contains background information about Professor Hake and his three students--Rosa, Connie, and April.

Professor Hake

Professor Hake taught courses in technology use to undergraduate and graduate students in the college of education. One of the courses was "Teaching and Technology," which he taught to undergraduate students in their senior year. Most of the students who took the course were in the teacher education program and were preparing for their student teaching.

Professor Hake was an experienced computer user and teacher. He had used computers for over twenty-eight years and had taught computers as a subject for about 20 years.

I've been using computers since 1964 or 65 when I did my dissertation on FORTRAN [programming language]. It was the old batch days, nothing but cards and such. When the micros first came out in 1977, I was at the Teaching Center at the time, and we bought one of the very first Radio Shack's micros that came out. So we started looking at ways we could use that in teaching. A year later, 1978 or 1979, I took a sabbatical for the purpose of studying the use of microcomputers in education because it seemed like all of a sudden they had a real potential. Up until then we were always looking at networking kind of things, buying time from a bank so that a school could have some terminals and do some things. It was a terribly expensive way of using computers. And so I took a sabbatical to look into them. Then I started teaching courses on the use of computers in education from that point on. (Interview, 10/27/92)

In addition to teaching technology courses, Professor Hake also had skills in developing technology-based teaching materials. He collaborated with colleagues to produce a series of CD-ROMs and interactive videodiscs. Also, Professor Hake mentioned that he served as his own technical expert because of his science background.

"Rosa"

Rosa was one of Professor Hake's students in the "Teaching and Technology" class. She was majoring in mathematics, science, and social studies in the Teacher Education program. Rosa took Professor Hake's class by chance because it was not one of the core courses in her program. According to Rosa, her program stipulated that she could take either "Teaching and Technology" or a computer science course as optional courses. Both courses introduced students to computers, but she decided to take Professor Hake's course because she was going to be a teacher soon, and she wanted to learn how to use technology in her own teaching.

Rosa was not new to computers. She had a computer class in 6th grade, although "they weren't the same kind that we have now." She was on the staff of their yearbook in high school and used PageMaker on a Macintosh computer for the yearbook design. Professor Hake's class was the only computer class she had had at MSU.

I haven't had any other classes really where the professors use computers at all. I mean you are lucky if you see them pass out their syllabus and you can tell it was done on a computer. (Rosa: Interview, 11/24/92)



"Connie"

Connie was also a senior in the teacher education program, with a major in Journalism and English. Like Rosa, she took the "Teaching and Technology" class by chance. It was recommended as an optional course that they could take.

Connie also had had some computer experience from high school. She had a BASIC programming class and a computer writing class. She did not feel she learned as much in the programming course, but "that's where I started." She also used computers to write papers at a friend's house. Professor Hake's class was the only computer class that she had had at MSU, although she has been using computers for her work because of her journalism background.

"April"

April, like Connie and Rosa, was a senior in the teacher education program, majoring in social studies, mathematics, and science. April confirmed that "Teaching and Technology" was not one of their core courses in the teacher education program. She wondered why computer courses were made optional for students who would soon be teachers in an information society.

Prior to her program at Michigan State University, April had had various opportunities to use computers. She had a computer class in 7th grade on advanced mathematics. April mentioned that all she could remember about the course was playing educational games on the computer. She also had a BASIC programming course in high school, which she thought was "totally irrelevant today." The only computer course she has had at MSU was Professor Hake's class.

Section Two - Computer Use and Its Impact in Professor Hake's Class

Computer Use for Teaching

Computer use in Professor Hake's class was driven by the instructional goals he set for himself and his students. Because most of the students were going to be teachers, Professor Hake wanted them to understand the use of technology in education. They should be able to use a variety of technologies:

To improve instruction in their classes, so that they can see that computers can become an integral part of instruction. It can help them manage instruction, it can help them make better instructional moves. (Hake: Interview, 10/27/92)

To achieve this goal, Professor Hake used himself as a role model for his students. He taught and showed them how computers can be used as instructional tools.

In my case, since my subject matter is primarily computers, I try to model what I'm going to be talking about. So if I'm going to be using spreadsheets, I'm using spreadsheets. Now that we have good display devices, I'm using presentation software. I'm really not teaching presentation software, but I'm still using technology to illustrate how to do things... If using a computer for grades is hard for me, if I make it look hard, then I can bank on the fact that students will say, "I can't do that." If, on the other hand, sometimes during the term I can produce a report for each student that tells them everything they've done, where they are standing as far as their grade is concerned; and I use a mail merge to do that, then when I teach that, and when it's something I've used, then they can recognize it. (Hake: Interview, 10/27/92)

Professor Hake taught the course using lecture, discussion, and hands-on approaches.

Part of that course is self-directed learning, for which they get no credit and that's the learning of word processors, databases, and spreadsheets. The parts that they do get credit for are how to use those three tools in instruction, as instructional support, either in large- or small-group. So that's one thing they get. Another thing they get is an introduction to a variety of technologies that they can use in enhancing education. The variety would include things like the use of interactive video disks, the use of CD-ROM, the use of scanning,



digitizing visuals, sound, communication software and the use of communication. They're all on e-mail now and they've learned to use FTP and presentation software. So they've gotten a variety of looks at how technology can be used to improve education.

In the context of all of that, they're using all those tools to produce a report to a school board on what they're doing as teams, on what that school ought to do about utilizing technology in the school. So they're not just using these various tools, but they are using them and thinking about writing this report. So if they're prepared when they go out and somebody asks them, "Well what would you do about technology in this school?" They now have thought about it and now in fact have a report. That report is written in presentation format so they can make a live presentation with the presentation software.

Most of Professor Hake's teaching involved Macintosh computers. His preference for Macintosh computer was based on the variety of software that were available for the Macintosh environment and because Macintosh software had shorter learning curve for students. Also, Macintosh was in the family of Apple computers which students are likely going to use in the public school system. In addition, he introduced students to the IBM environment, so that students could see that similar functions can be performed on IBM computers as well as on Apple computers.

I have an IBM lab that has the personal science laboratory equipment on it and I got that lab because of my science background. It has all the laboratory interfaces that allow me to gather data from the environment and then do graphing and that sort of thing. I use that to illustrate how science teachers might use this kind of equipment...so that we could, in fact, add another dimension to the way teachers could use technology. These laboratory devices sense temperature, sense distance and time, and pH and light. So we can immediately sense those things in some quantitative way and graph them. For example, I can set up an oscillating spring bulb like this and put my sensor down below it and immediately get the motion wave graph on it. So I can do things in a science class that I could not have done without that kind of equipment. (Hake: Interview, 10/27/92)



Professor Hake's Perception of Effectiveness of Computer Use
in his Teaching

Professor Hake perceived computer use in his class to be very effective. According to Hake, his students learned more about the subject matter and at a faster rate than they would have done without computers.

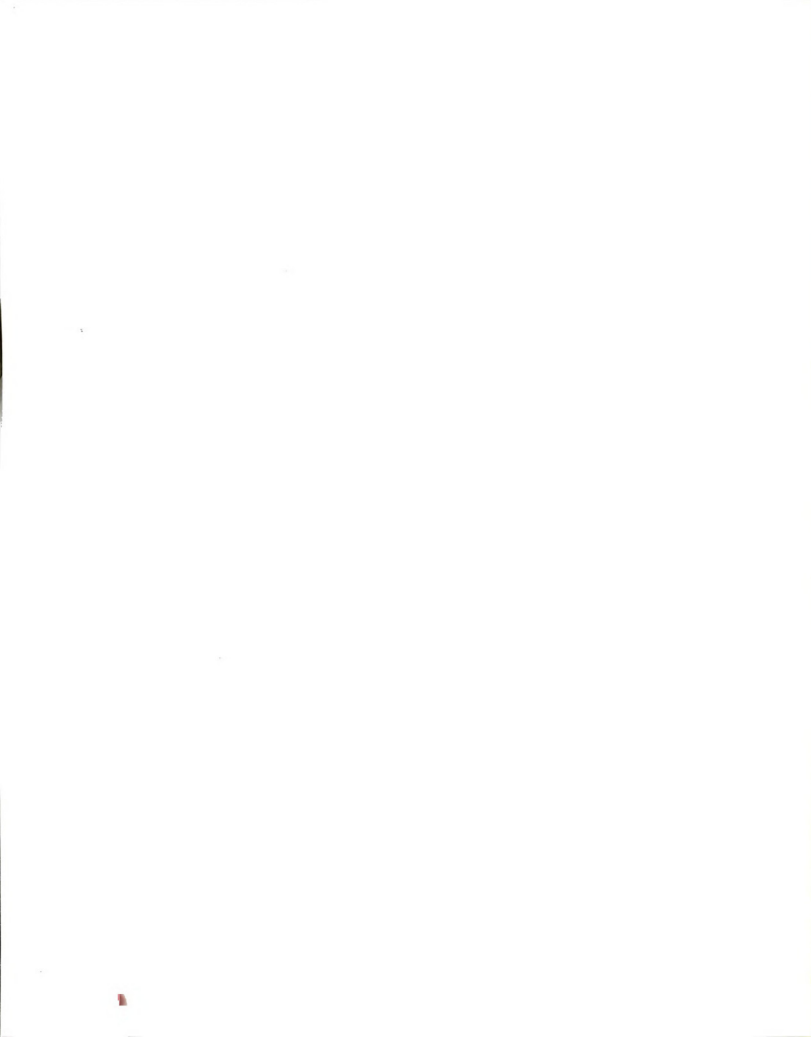
They learn a lot of technology but that's what they're supposed to do. Now if I were in another class, teaching science and I were using these lab interfaces that I was just talking about, then I think I could say that ... although I haven't done it, I'm confident that they would learn a lot more science as a result of having used these kinds of interfaces. So the impact of technology would be greater, I'm sure. If I didn't believe that, I wouldn't be advocating its use. (Hake: Interview, 12/3/92)

Students' attitudes toward learning were also enhanced. They take more responsibility for their own learning, and they approach computer problems with a confidence that is unusual for beginning computer users.

What I'm pleased with them about is that they're approaching this with the attitude that, "yeah, I know it's got some bugs but I'll work through it." For beginners that's tough, because usually beginners, when a problem arises, throw up their hands and quit. These people, when a problem arises, they kind of sit back and say, "well, what can we do about it?" I think it's a nice approach they're taking. We've tried to instill that. I've tried to point out that technology sometimes fails and we have to think about what we'll do instead and they seem to be grabbing onto that. (Interview, 12/3/92)

Students' Perceptions of Effectiveness of Computer Use in Their Class

Evidences of computer effectiveness were collected from Rosa, Connie, and April. The students' perceptions of computer use in their class were compared to their professor's in terms of the instructional goals achieved, the relevance of computer use



to course and students' educational goals, class interactions, and their perception of their professor as a role model of computer use.

Instructional Goals

Professor Hake described three major goals that his students were able to achieve as a result of computer use in his class. They included understanding of computers, applications of computers, and attitude toward learning.

Understanding of computers.

Professor Hake mentioned that his students understood more about computers' potentials and weaknesses. Rosa, Connie, and April confirmed this view. As a result of how the course was taught, the students were able to describe software applications and their potential uses in their lives and their own classrooms.

Rosa:

I feel like if I were to write a paper, instead of writing it down, typing and retyping it on a typewriter, I can do the rough draft [on the computer] and just fix it and it saves a lot of time... A lot of times I recopy my notes from other classes because that helps me remember what we talked about. I can do them on the computer and then it helps me to study also...In the classroom, I can use it to do all my handouts, to do my lesson plans, to summarize articles, letters, there are a ton of things. With something like HyperCard, you can make a game where it says, "press me if this is your answer, press this, press that". That's something that my kids would really enjoy. I really want to get into the software, because I think that's very interesting to try out and see if it's something kids are going to like. If it is going to teach them something, then that's a valuable tool. (Interview, 11/24/92)

April:

... I think because of this class I spent a lot of time [with the computer]. Before this class I had never used the computer on campus except for computer enrollment. So this class has really helped. And I have even started using it for writing letters or things that before I wouldn't even think of going to the computer center for...I feel like I have learned a lot and I feel like I'm not so afraid of computers anymore. I feel like ok if I have never seen this particular

kind of computer before, I can at least sit down and try to figure it out.
(Interview, 12/7/92)

The students were also aware of computers' potentials in other subject areas. According to Connie:

Computers aren't just for math and science. It can lend itself to any discipline. And it isn't just for word processing. (Connie: Interview, 12/16/92)

Connie, Rosa, and April demonstrated that they were aware of computer weaknesses too. They believed that computers would not solve all of their personal and professional problems, and that they had to continue to learn about the technology in order to use it effectively. According to Rosa:

I'm sure you have to spend a lot of time with it to understand it. And things don't always go right, as we know... (Rosa: Interview, 11/24/92).

Computer applications.

The second instructional goal that the students perceived themselves achieving in the class was computer competencies. The students were able to mention as many applications as Professor Hake. They were also able to describe the conditions under which they would use each software in their own classrooms, thus confirming Hake's perception of the effectiveness of his teaching.

Following were Rosa, Connie, and April's descriptions of the different computer applications they learned in Professor Hake's class.
Rosa:

We focused mainly on word processing, spreadsheets and databases. So the word processing I knew very well... You can do your lesson plans or handouts, instead of doing dittos and stuff like that. He [professor] showed us how to manipulate the computer to save us a lot of work, and you can write letters to all your students' parents and not have to do something separate for each one, by using mail merge. That is very helpful.

In the databases and spreadsheets, he [professor] showed us how we can do our grade books and do our weighted averages and how we can adapt games so if certain students are missing lessons because of absenteeism that we can



actually create programs, something like drills that the student can do to get back that time that they missed. We also do a lot of readings on how other teachers integrate the computer in their classrooms.

With the database, you can do sorting. If you want to check and get statistics on your class, you can sort it by grades and where they live instead of having to look up the data every time. You just make a couple of adjustments.

I like the other stuffs that he brought in. We did voice digitizing, picture scanning, and he had something that took the temperature. He measured light and distance. He put it [sensor] on the wall and then we stood some distance from the wall, and did the graph of the measures. They were kind of neat stuff that you can use in your classroom that kids would find really interesting. Just like he [professor] said, you could do a project with taking their temperature. You could use the sensor to detect changes in temperature. Or the one about lightness or darkness, you could measure how far the temperature dropped if a cloud went over. With the computer technology, you wouldn't have to keep disrupting your class and run out to check whether cold water freezes faster than hot water, with the computer, you would know. I think that was very interesting because I'm going to teach math, science, and social studies and especially science, it seems like there's a lot that you can do.

We also had the project. With the project we were supposed to be people trying to integrate computers into a school district, and we have to present it to the administration. (Interview, 11/24/92)

Connie:

With HyperCard, we were only working with a certain amount of the program. We started with the TLT Presentation Maker, but the Presentation Maker was somewhat limiting as to what you could do on the screen. You could only type so much on a card. With the HyperCard, you could program the script to what you want to do, you could make your button, you could sort and shift, and you don't have to worry about something being fixed. So I like HyperCard a lot. And the professor kept on saying there is so much more we could do. So when I get a chance, I'm going to go back and see what else I could do.

We got the chance to see some of the CD-ROM stuff, and it was only for one class. And I would really like to see what else I could do. I really want to learn more about spreadsheet for my own personal benefit. I like computers a lot. I wouldn't even mind knowing how different programs are created. I don't know where I'm going to get the time, but eventually I like to work towards that, since they said everything is becoming so technologically advanced, and this is the computer age. I will really like to learn as much as possible about it.

We also worked with spreadsheets and databases. Personally I didn't like spreadsheets and databases. There was one exercise that we did where we looked at the spreadsheet. We did a problem about the effects of the deficits, and so on. As far as calculations I can see its use, but I'm still more into the

creative things. Database, as far as keeping records, I can see it being very useful for classroom management, but that's about that. I know there is more to it than that, but trying to go beyond that is not ... It's probably more because there was not enough time to be able to explore them more, I think that's probably what affects my attitude about it.

I like e-mail. I like the networking. The instructor showed us different kinds of resources we can tap into to find different information databases-- the Gopher. I played with it a couple of times, but I want to go back and see what else I can come up with. It's just amazing that you could just type in a few keywords on the keyboard and you are able to pull down all this information... There is just so many things you can do, you just have to try to keep up with it. (Interview, 12/16/92)

April:

I feel like I'll like to use the spreadsheets and databases when I'm a teacher, because I think that would make my record keeping a little more easier. As far as the HyperCard we are working with, I really think the idea of planning some kind of computer programs to put in the school system is excellent. I have learned a lot in talking to other people in my group. I feel like, getting their ideas about where education is going and what you could do, I've really learned a lot from that...

I'll like to teach around the 4th grade. I really like the idea of developing a budget with students, I don't know if that is too early for their age, maybe if they get some allowance or something, that might be kind of neat to do. Professor Hake showed us how to do that on a spreadsheet, and see if you have any money left over or you are totally in debt. So I thought that was neat.

As far as databases, we got to see some different uses like different facts about presidents and animal classifications, something like that. I think that would be a nice idea. Instead of the students having to go look it up in the encyclopedia, they could just have it on the computer and see it on the screen. I think that will be a lot more beneficial to them.

-- He [professor] did take us to the DOS lab... I enjoyed that because we got to use a different computer which is a lot different from the Mac. But you could see that you could still do databases, you could still do programs, all those things you can do on the Mac. And we got to actually try some programs there. That was good. Maybe if we have handouts on really good programs like graphing, math or like more resources for us instead of just seeing them.

I like the stuff we have been learning with the Presentation Maker, but I don't like the Presentation Maker itself. I think in the first week or so, we have been exposed to CD-ROM or so. We also got to see Videodisc. I think we only got to use those for one class meeting, and I think maybe a little bit more exposure to those, and see how you can take what's on there and incorporate them into your presentation would have been nice. (Interview, 12/7/92)



Table 5.1. summarizes the computer applications and uses mentioned by Professor Hake and his students.

Table 5.1
Computer Applications Mentioned by Hake and his Students

Technologies Mentioned	Applications of the Technologies	H a k e	R o s a	C o n n i e	A p r i l
Word Processor	• Lesson Plans, handouts, mailmerge	x	x		x
Spreadsheet	• Grading • Calculate • Develop budget with students	x	x		x x
Database	• Sort information • Keep students' record • Class Management • Information storage and retrieval	x x	x x	x	x x x
HyperCard	• Develop tutotial • Create programs • Plan Project	x	x	x x x	
TLT Presentation Maker	• Make presentations	x	x	x	x
E-mail	• Network resources (Gopher) • Communicate with colleagues and professor		x	x	

Attitude toward learning.

Connie, Rosa, and April's evidence confirmed Professor Hake's perception that his students had developed a positive attitude toward learning as a result of computer use in his class. All three students demonstrated a willingness to take on the responsibility of learning more about computers for themselves. According to Rosa, she knew she had to keep on learning other things about computers in order to be an effective computer user.

Rosa:

I just think I've got to practice more, but that's with anything. The thing is, if you don't practice, it's really easy to forget, too. Right now, other than in class, I haven't done anything with the database or spreadsheets and that's something that I know I have to continue to mess around with just so I remember stuff. (Interview, 11/24/92)

Connie and April also expressed similar opinion. They believed that their professor gave them a lot of examples on which they could build.

Connie:

But I think a lot of the pulling together [of all the knowledge learned in the course] would depend on the student, because the professor was always telling us that there is more that you could do. And I do know that how much more you could do depends on your response to what you've been reading. So if you haven't been reading, you probably don't care too much about what is going on. I think the questions you need to ask yourself as a student is what more I could take away from this class because the resources are there, it depends on you to use them or not. (Interview, 12/16/92)

April:

I usually go to the computer center about once a week outside of the class, in addition to the group [meeting there]. The more you go, the more you know what you can do with computers. Sometimes in class, we tried to cover so much that we don't really get the chance to experiment with what he [professor] was showing us. So if I go on my own--in class I may think oh that's really neat and



having seen it I can do it, and then once I go on my own, I'll see that I can't do it. Or if I can, then I would think, okay this is how you do it, and I would write the steps down. I definitely think that is important, you have to do it yourself to see how that works. (Interview, 12/7/92)

The students also accepted computers as tools with limitations. Rosa, Connie, and April did not expect computers to solve all their learning problems. They recognized that computers did not always work. Whenever the students ran into computer problems, they looked for solutions. The students realized that they may have to use computer systems different from the ones they learned in college. April's suggestion was that:

I think probably any teacher, when she's found out what type of computers run in the school, would just have to really sit down for a little while and become familiar with everything on that computer. (April: Interview, 12/7/92)

Relevance of Computer Use

Apart from achievement of instructional goals, the students' also perceived that computer use in their class was relevant to their educational goals. Rosa felt that the class demonstration with the science equipment was very relevant to her goal as a prospective teacher of math, science, and social studies in the public school. She presented evidence that other members of her group in the class project agreed with her perception of the relevance of the class.

Rosa:

The thing is, this is something I know I can use. It's not something that I feel I'm learning and I'm never going to use again, so it makes me want to learn. I have a class where we're memorizing phonemes for words--the phonetic translations for words and I'm never going to use it. Yeah, I'm memorizing it for this class and I'm never going to use it. This [class] is something that I'm not memorizing but I'm learning and I know I can use it again. That to me is



very important. Makes you feel like you're spending your money on something worthwhile... A couple of my group members really think what we were doing was very valuable too. (Interview, 11/24/92)

Connie felt that the use of computers in the class offered her a range of possibilities in her career. As a prospective teacher, who would teach Journalism, Writing, and English in the public school, she learned computer tools like word processing and graphics that she could apply in her classroom. Moreover, having computer skills increased her marketability.

Connie:

Probably all the different possibilities, all the different activities that I could do in the classroom with the computers, with word processor, HyperCard, Presentation Maker. He also showed us the scanner, just to be able to use all that stuff too would be an immense benefit in the classroom. It's just learning to combine all those different techniques that would be the biggest contribution...

And being more marketable is really very helpful. And most definitely this course has enabled me to be that, especially if I take what I've learned and try to extend it further, keep on practicing what I learned, almost definitely it would. But if I just stop here and get into the school in a couple of years, I don't think it would be useful, but if I keep practicing, I think I will be able to use it. (Interview, 12/16/92)

The way computers were presented to her in class contributed to April's perception of its relevance. According to April, computers were presented as tools that she could use to enhance her work as a professional.

April:

We were not introduced to computers in this class as something you program, and the word tool is used a lot. So we came to see it as, you are not just learning about the computer, you are learning how to make teaching easier, more fun. Right away we were introduced to educational related ideas instead of "here let's just take this math program." But we see it more as something we could use in our classroom. (Interview, 12/7/92)

In addition to computer skills, the students learned research and interpersonal skills through their class project. They learned to interview professionals in the public school system, collect, and analyze data about computer use. This increased their knowledge of the public school system in which they will work when they leave college.

Connie:

Talking back and forth through the school contact to the school we were modeling the plan after, let us realize how important computer has become. We also learned that they still have their limits as far as budget. (Interview, 12/16/92)

Rosa:

Our school district [chosen for class project] has a computer room that has 9 computers. Now I really like using the Macintosh, but the ones in our school are the old Apples, the very first computers that I've ever used, but I don't remember all the commands and I don't think you can do the same things or not as easily as on the mac. So I wish we knew more about how to use those, because in class that's generally what you're going to see for now. A lot of school districts don't get what's brand new or on the market. I guess if I had that in my classroom and if I were to buy a computer and cost weren't a factor, I guess I would buy a Macintosh, but then I wouldn't be able to integrate that with what is available in the school. I'd have to either print it out at home because they're not compatible. So I think more knowledge about that [Apple II] would be interesting because that's what we're going to see a lot of. (Interview, 11/24/92)

Students' Perceptions of Classroom Interactions

Another measure of computer effectiveness was the kind of interactions that computer use promoted in Professor Hake's class. Class interaction is defined as the amount of time students spent on the computer, the frequency of interaction or communication among students, the pattern of interaction or communication between students and their professors, and the kinds of student and professor roles supported by computer use.



Rosa, Connie, and April reported that they spent more time on class materials because of computers than they did in other courses that had no computer component. They found the class to be enjoyable and beneficial.

Rosa:

I've used computers more than I've had to this term because I felt more comfortable about them. A lot of times I recopy my notes from other classes because that helps me remember what we talked about. I can do them on the computer and then it helps me to study also...(Interview, 11/24/92)

There were mixed reactions about the group project in the class. All the students agreed that the project was a good idea. Some students had problems with group interaction because of personality differences and scheduling of meeting time.

Rosa:

Quite honestly I haven't been really happy with the group just because it's very hard to get--we have 5 people in our group and it's really hard to get a time that fits in with everybody's schedule. Two of our group members are always busy, no matter what, so three of us who usually show up feel like we're carrying all the weight. (Interview, 11/24/92)

April, on the other hand, had a productive interaction with her group members. She felt that she learned a lot from them as they shared ideas on their class project.

The most profound effect of computer use, however, was the interaction through e-mail. April mentioned that she enjoyed the one-to-one communication with other students and her professor on e-mail. Even though e-mail was introduced towards the end of the semester, April used it and was excited about it.



April:

One day I had gone to use the computer and it wasn't working for me, so I sent the professor an E-mail. That was nice because I was studying for the quiz, and I never got to study with the practice examples that were in our computers, and I wanted him to know that I attempted to go. Later that day in class he said, "Yeah, I got your message." And he said he would take that into consideration which I thought was good. (Interview, 12/7/92)

Connie also was excited about being able to communicate through e-mail.

Connie:

You can communicate between schools. I have this friend in Cornell and as soon as she gets her account, we would start writing. I like that too. And just being able to communicate back and forth. And now I won't have to hunt down a professor, if they have an account, you can just write them a note. (Interview, 12/16/92)

Perception of Professor Hake as a Role Model of Computer Use

Professor Hake perceived himself to have successfully modeled computer use to his students. Rosa, Connie, and April confirmed this perception. All three students felt that Professor Hake was an excellent professor and role model.

Rosa:

A lot of times he would show us in the front of the class and then he'd say, "do it," and then if we have questions, he'll come around and help everybody, so that's a bonus. A lot of times you can't watch and do it at the same time and a lot of times, he might do it up there and that screen isn't that good, you can't always see where he's at. So it's good that, instead of just writing down what he does, we get to try it too so if there's something that we missed, then we can get it straightened out before we leave class. (Interview, 11/24/92)

Connie:

I think the professor's expertise really helped. I think he is really concerned that the students were getting what was going on as he introduced each topic. He would ask several times if there were any questions. During break he would



go from student to student to see how they were doing, and was available after class to talk about things. I think that really helped. Just seeing his commitment to computers and that's one thing I definitely will take away from this class--to know that everybody is not going to get it the first time, and I'm not expecting them to get it the first time. And being willing to be flexible and open to what is and what is not working because of the nature of the class. Just being flexible and open to what is going on in the class, points me into the right direction for my own teaching. (Interview, 12/16/92)

April:

As far as Professor Hake, I think one thing that has really helped is that he is so much into computers himself, and he talked about "oh, I've just purchased this computer," "oh, I've just got this kind of software" or "I tried this, I tried that." So we got to see, as students, that he is not just preaching something to us that he doesn't live by. I think he sets a pretty good example for us. I really like him as a professor, and it really helps when he gets to present examples.

I'm glad I had this class. Despite all the Presentation Maker problems, I really like the professor. He just is really excited about the subject, very enthusiastic. (Interview, 12/7/92)

Connie admired, in particular, the way Professor Hake worked to reduce computer anxiety in class.

Connie:

I think his being able to let us know that he didn't know everything also helped, because I was able to be much more engaged and not worried about making mistakes. (Interview, 12/16/92).

Figure 5.1 summarizes Connie, Rosa, and April's perceptions of the qualities which made Professor Hake an effective computer user for teaching.



- **Not the all-knowing professor**

Connie: "I think his being able to let us know that he didn't know everything also helped."

- **Concerned professor**

Connie: "I think he's really concerned that students were get what was going on as he introduced each topic."

Rosa: "I think he wants everybody to understand, he wants people to see what he sees in computers."

- **Role model**

Rosa: "He shows people how to use it as a tool and not be afraid of it."

April: "I think he sets a pretty good example for us."

- **Committed to teaching**

Connie: "He goes from student to student to help. He would ask several times if there were any questions. He's available after class to talk."

Rosa: "He goes out of his way to interest us."

April: "He reviews problems that everybody was having in class."

- **Competent and knowledgeable about computers**

Rosa: "He's knowledgeable about various kinds of computers. He's shown us a lot of software."

April: "He is so much into computers himself."

- **Flexible teacher**

Connie: "And being willing to be flexible and open to see whether this is working, whether there is anything that needs to be changed."

- **Helpful and understanding**

Rosa: "He helped us to figure out what to do when we lost our data. And he gave use time to re-do the assignment."

Figure 5.1
Qualities of Professor Hake as a Role Model



Section Three - Observation Session

Another source of corroborating evidence was the observation that I conducted in the class of Professor Hake. The observation session lasted three hours. It was the eighth class of the semester. The purpose was to see if I could gain further insight into the classroom process and to gather evidence to corroborate or disprove the verbal reports of participants in this case study. According to G. McCracken (1988) when properly used, observation can deliver data that are beyond the conscious understanding or implicit grasp of even the best intentioned respondent (p. 28).

Using the observation guide described in Chapter Two (see Appendix C for observation guide), I focused the observation on the general classroom setting, classroom activities involving computer use by Professor Hake and his students, and whole class activities rather than on individual students' behaviors or responses.

In addition, I obtained Professor Hake's lecture notes for the class observed (see Figure 5.2 in Appendix E). The purpose was to compare the professor's intention as stated in the notes with his practice of computer use in his classroom. The notes were in the form of an outline of classroom events. An analysis of the teaching notes revealed that the classroom events described in the observation session below correspond with major topics in the professor's notes.

When the class began, the notes were projected on to the screen in front of the class with an LCD panel attached to an overhead projector. Professor Hake seemed to use the note to direct the flow of activity in the classroom. As the class progressed, the outline was replaced by the content that Professor Hake wanted the class to see or discuss. The outline came on the screen at regular intervals to signify transition to subsequent events.

Classroom Setting

The classroom was equipped with fifteen Macintosh IIsi computers (Mac IIsx) arranged in three rows facing the professor's workstation. All the computers were connected through a network system. Software was made available to users through a file server residing on the Local Area Network (LAN) being managed by the MSU Computer Laboratory.

At the professor's workstation were a Macintosh IIsi and a Proxima LCD display panel that the professor used to project computer-generated images, including the outline of his notes. The LCD panel was used with an overhead projector, but instead of overhead transparencies, the projected slides were in the computer. There were also a Pioneer laserdisc player, a Sony monitor for projecting video images, a CD-ROM player, and a scanner. In the class observed, Professor Hake only used the Macintosh computer, the LCD panel and the overhead projector. Professor Hake's lecture slides were made in MORE, a presentation software. The students initially worked with a presentation software called TLT Presentation Maker. Later in the class, students were introduced to HyperCard because of some problems with the Presentation Maker.

A few minutes before the class, Professor Hake came in to set up his equipment. There was a class before his in the same room and this hampered his preparation.

Classroom Events

Professor Hake used a mix of lecture-discussion and hands-on method. While waiting for the LCD to warm up, Professor Hake began the class with a review of the problems that the students had from last class. Students had problems with the small fonts and limited flexibility of Presentation Maker (PM), a presentation software on which the students were developing their class projects. The program contained already

structured cards that students could not change, and students tended to lose cards from their stacks when they tried to make changes. It was also difficult for students to move around in the program. These problems added to the computer anxiety that students had.

Another problem the students had was disk space. The students did not know how to save a large file to a diskette through a compression process. Many of the students found out that they could not save their assignments to a disk, but did not understand that making their presentation with Presentation Maker took a lot of disk space. Professor Hake explained that students needed a utility software with compression capabilities when working with large amount of data, like the presentation they were making. With the utility program, students could compress a file of 752k to 475k. Using a high density disk might also help. However, high density disks could only work in the newer computers. Professor Hake then demonstrated the use of StuffIt, a shareware utility program that students could use to compress and uncompress their files. CompactPro was another software for compressing and uncompressing large files.

Professor Hake also used the StuffIt program to discuss ethical issues regarding shareware and other software use. For the privilege of using StuffIt, the students must send \$15 to the developer of the program.

Group Presentation

Group presentation of assignments followed the hands-on activity of compressing and uncompressing documents with StuffIt. One group volunteered to present the part of their project that was completed. There were three students in this group. Their presentation was based on what they observed in some of the schools they visited. The slides used in the presentation were made on Presentation Maker. These were projected onto the screen using an LCD panel. One of the students was using the

mouse to control the navigation buttons on their program, while his two colleagues took turns explaining each topic.

As the presentation progressed, Professor Hake and the other students asked the group questions or commented on aspects of their presentation. The three students in the group were very articulate and answered all questions confidently. Most of the questions centered on the research done at the school which the group visited. There were also comments about the small fonts of the text which were not readable from the back of the class.

I had a question about the graphic capability of the software, and I asked two members of the group after the class. I felt that most of their data could be better illustrated with graphs. The group admitted that they did not have time to learn about the capabilities of Presentation Maker and all its capabilities before they began using it to make their presentations. Most students in the class felt that they lacked knowledge of Presentation Maker.

Professor Hake admitted that the software had lots of bugs in it that needed fixing, but that it could be a very useful productivity tool when the bugs are fixed. Because many students expressed similar concerns about Presentation Maker, Professor Hake asked if they would like to change to HyperCard instead. HyperCard is an authoring system which the students could also use to develop their presentations. Professor Hake explained that HyperCard is much more flexible and easy to understand than Presentation Maker. He offered to convert the part of the project that each group has completed from Presentation Maker to HyperCard stacks for next class.

Class Discussion

The discussion session was based on that week's assigned reading and the other students' observations of the schools they visited. The main ideas of the discussion as

summarized by the class and typed into the computer by Professor Hake were as follow:

- "1. How many computers per number of kids in the school?
1 computer to 30 children. By implication, 1 computer per class. This does not mean that there is software to run the one computer per class. The computer may not even be in the class, it may be in the lab.
2. Teacher training.
Average of 10 hours of instruction for teachers, which is barely enough to enable teachers to use computers effectively in schools.
3. What would it cost to have 3 kids sharing a computer in the public school system?
Roughly \$4 billion.
Opportunity cost - \$4 billion would also put 400,000 kids through college.
Others - what else would the money buy - national health insurance?
Reduce national debt?"

Class Assignment

Part of the next class was going to be used for one of the regular quizzes which was part of the competency requirement of the course. Professor Hake distributed the practice quiz so that students could go through it during the week, and if they had any difficulty, contact him.

There was a deliberate attempt on the professor's part to use the assignment to reinforce topics taught in previous lessons. The assignment, in addition to asking students to practice some computer skills like copying and pasting of documents, also discussed CBI or CAI thereby reinforcing those concepts for the students. See Figure 5.3 in Appendix E.

My Impression of the Class

It was very interesting to watch the students and their professor as they jointly constructed the discussion points. The atmosphere was free, honest, and everybody felt that their points counted. This was a class where students were learning to use technology and were truly using technology. They were motivated to learn, and they rose to the challenge of learning to make technology a tool of work in their personal and professional lives.

I was very impressed about the different ways Professor Hake addressed the computer anxiety of his students. He guided his students to solve problems by showing them how to do it. He admitted that computers do not work all of the time, and that even professors do not know everything. This seemed to help in increasing the students' confidence in their own ability. It was easier for the students to feel that it was the computer and not them who were stupid. So when problems arose, they were able to focus more on solving them rather than worrying about other students or the professor thinking that they were stupid. This observation confirmed the interview evidences of Professor Hake and his three students--Rosa, Connie, and April.

Summary

This case study focused on Professor Hake who taught about teaching and technology to undergraduate seniors preparing for their student teaching. Section one of the case study presented background information about Professor Hake and his three students. Section two discussed computer use for teaching and learning in Professor Hake's class. The impacts of computer use as observed by the professor and his students were also reported. Section three contained the report of my observation of the events in Professor Hake's classroom. Part one ended with a summary.

In Professor Hake's class, computers served as instructional delivery tools as well as the subject of teaching and learning. Hake believed that his students learned

about technology use to improve instruction. Rosa, Connie, and April, three of his students, confirmed Professor Hake's view of the effectiveness of computer use in his class. All three students testified that Professor Hake's computers use for teaching had a positive impact on their learning. They now view computers as tools for work and learning, and as a tool that increased their competence and "marketability." They perceived their professor as a good role model of computer use. My observation of the classroom events corroborated their view.

CASE STUDY TWO

The focus of case study two was Professor Dillon. Her story was that of a beginning computer user who was also a beginning college professor. Professor Dillon, in describing her computing experiences, called it "the chronology of my infantile naiveness." I call it a story of courage about a teacher willing to risk being vulnerable to her students and the erosion of her authority in the classroom. I chose this case to illustrate the kind of struggle, mistake, and success involved when people begin to use technology for teaching and learning.

Another criterion for choosing Professor Dillon was the different computing opportunities she provided for her students. In addition to encouraging her students to use computers for their assignments, she also involved them in a research project--the "Playschool"--where they may learn to use computers as professionals.

To corroborate evidence from Professor Dillon's interviews were interview data of four of her students--"Toni," "Audrey," "Judy," and "Anthony." Observations of classroom events in Professor Dillon's class and at the "Playschool" provided additional data for this case study.



Section One - Background

Professor Dillon

As a professor of teacher education, Professor Dillon teaches two methods classes on reading and writing in the college of education. Most of the students who take these classes are in their senior year. At the time of the first interview with Professor Dillon, she had taught and used computers for teaching for two years. She, however did not see herself as an expert in computers. She had a very rudimentary understanding of what computers could do because she did some word processing and statistical analysis in her graduate program. Beyond that, she was learning to use computers for teaching at the same time she was introducing her students to computing.

About three years ago, Professor Dillon became involved in a science literacy research project called the "Playschool." The "Playschool" was a national research project to study the effect when science learning is "deschooled." According to Dillon, the Playschool research was a joint effort of experts from different disciplinary backgrounds such as education, sociology, and sciences in institutions all over the nation. The research project has sites located in selected cities across the U.S. Professor Dillon was coordinating the project at "Okemos," Michigan. Further details about the Playschool are presented later in this case study.

The Playschool was important to this case study because it was one of the class project options that Professor Dillon provided for her students in her courses. At the Playschool, computers were used as a motivating tool for children to learn science. Professor Dillon thus saw it as an opportunity for her undergraduate teacher education students to have classroom experience, as well as learn to use computers to work with children.



"Toni"

Toni was a senior in the teacher education program preparing for her student-teaching. She was taking the "reading and writing methods" course from Professor Dillon at the time of this interview. Toni was not new to computers. She had had a BASIC programming class in high school, which made her afraid of computers:

Because I was more into writing and more on the creative side. And I felt like it was something to do with numbers. (Interview, 11/2/92)

Toni transferred to MSU from another university. At her other university she learned to use computers as a tool for creativity. That experience, to her, was "really empowering." At MSU, the only class she had had in which a computer was used for teaching was in Dr. Dillon's class. Like Professor Hake's students, Toni wondered why computer application courses were not made an essential part of their teacher education program.

"Audrey"

Audrey was another student in Professor Dillon's reading and writing methods course. Just like Toni, Audrey was in her senior year in the teacher education program. She was also preparing for her student-teaching like the rest of the students in this study. Unlike the other students who had had computer experience elsewhere, Audrey's first computer experience was in Professor Dillon's class. According to Audrey, she started using computers just a month ago because she felt she should "really seize the opportunity to learn to use it."

I could have gotten around using it like I have been doing in other classes. But I will be teaching next year and chances are that I may have to show my students at least the basics of computers. (Interview, 11/12/92)

"Judy"

Judy also was in her senior year in the teacher education program. Like the rest of the students in this study, she was also preparing for her student-teaching. Like Toni, she transferred to MSU from another university where she had had extensive computer experience.

Judy had a computer class in elementary school and a lot of classes about computers in high school. Also in high school, "I aided for a computer teacher a couple of hours a day, so I have a lot of experience." Her sister had a computer at home, which she also used. At her other university, she had some computer courses which were specifically designed for teachers. According to Judy, "MSU has no program like that," and she wondered why. When I told her that there was a course called "Teaching and Technology" in the college, she said she was not aware of it because it was not part of the required courses in her program. Her only computer course at MSU was in Professor Dillon's class.

"Anthony"

Anthony was in Professor Dillon's reading and writing methods class the previous year. I decided to include him in the study because Professor Dillon mentioned him and three other former students as her staff at the Playschool. It became necessary to ask someone who had gone through the program earlier because Professor Dillon's current students seemed not to be pleased with how computers were being used in their classes. I was hoping that including Anthony in the study may provide further corroborative evidence of computer effectiveness in Dillon's classroom.

Anthony had had computer experience prior to Professor Dillon's class. He remembered that his father had a computer at home which he was trying to get him to use. "I sort of acquired some aversion to computers because of that." Anthony had some BASIC programming classes in summer school and high school, which he did not like very much because, "I'm not very much into math anyway and the language seemed very technical." He later did some word processing on his father's computer. Professor Dillon's class "last year was the first time I used it for anything other than programming and word processing...We used e-mail."

Section Two - Computer Use in Professor Dillon's Class and Perceptions of its Impact

Computer Use

Professor Dillon's belief about computers appeared to influence the goals and computer use in her class. According to Dillon, computers should play a peripheral role in her classroom.

I don't think teachers need to teach computers, but they need to use computers as vehicles for content. (Interview, 10/21/92)

Based on this belief, Professor Dillon's overall goal was that her students should acquire some computer literacy skills and learn to apply computers in their own classrooms. Professor Dillon encouraged her students to have a "formative understanding" of the class reading assignments through e-mail conversation with their colleagues. In her second class, Professor Dillon wanted the students to see the computer as a vehicle that makes writing a dialogue journal a dynamic rather than a static process.



...So what I want them to get out of these in terms of computers is both the applications to classrooms and applications to their lives...I want students to see computers as part of their lives. (Interview, 10/21/92)

In addition, she wanted them to see her as a role model of how computers could be used in teaching.

I don't teach computers, I teach content and use the other as a hook-tail, as a model for what they might do in their classroom. So I'm trying to see that as being modeled in my class--that they [students] do it through me, and they do it through dialogue journals for a purpose, not because that is cute, but because it serves that purpose. (Interview, 10/21/92)

To achieve her goal, Professor Dillon set up three situations where her students could experience using computers as tools of work. Professor Dillon had a total of 67 students in her two courses. She asked students in one class to use word processors to write their weekly assignments (dialogue journal) and submit them on a diskette. This was the "disk group." In the second class, students were asked to communicate among themselves on e-mail about class readings. This was the "E-mail group." A project option for the two groups was the "Playschool." The Playschool thus became the third opportunity for students to use computers in Professor Dillon's courses. Following is Professor Dillon's description of the three situations of computer use in her classes.

Situation 1: "The E-mail Group"

Dillon:

In one course, I had everybody learn how to do EUDORA [e-mail on the Mac]. During the week that I was gone, the graduate assistant taught them how to use EUDORA. Thirty students signed up for it. Of those thirty, twelve had decided to go visit at the Play School. Those twelve also sent me fieldnotes on EUDORA. The others [eighteen students] have conversations with one another. So in that course, everyone has a EUDORA account. Everyone is responsible for doing the reading and to post some kinds of synthesis or argumentation. They are to read everyone's entries for the week and respond to them. They are not to go in with preconceived ideas but to respond back and forth to one

another's ideas. This is done in the form of a bulletin board. But the graduate assistant had it set up in the form of a mini network so that everybody had a copy of the message, rather than having it on one bulletin board that everybody can access. All those students once a week generate conversation. So now they don't talk to me anymore, they talk with one another. (Interview, 10/21/92)

Situation 2: "The Disk Group"

Dillon:

In the second session [class], I felt it was important for them to at least know the difference between the Mac and the IBM. So I decided not to show everybody E-mail because it would cost money, but to expose them to an interactive kind of dialogue. So what I decided to do, which is much more elementary, is just request that they submit their weekly journal to me on disk, not on paper. So that I then take the disk and interject my comments into their text which I think is more important. In the traditional written journal I usually put "interesting" at the side, and summary written comment at the bottom. But they never really know what points really struck me when I said that [interesting] because there was no room to really have a conversation on paper. So I requested them to put it on a disk. That way I can save that again under a different title, but at that point, interject my comment... (Interview, 10/21/92)

Situation 3: The "Playschool"

The Playschool was a project option in Professor Dillon's classes. Professor Dillon was part of a team of researchers from across disciplines investigating how children learn science when removed from the ambience of the regular school. As part of 'de-schooling' that the Playschool was meant to represent, there were no teachers. Also, children of all grade levels could come to the center with their siblings and parents. The Playschool was also set up for the study of intergenerational learning.

At the Playschool, children learned science by playing commercial computer games and writing about their experiences to children at the other research sites.

[The Playschool] is an adaptation of the Fifth Dimension. Michael Cole, at the Laboratory of Human Cognition at San Diego, developed this notion of the

Fifth Dimension which is the use of computers for literacy. It is a hypothetical construct of a maze with twenty rooms and each of the rooms have two computer games. And the idea is for children to find their ways through the maze and when they complete that they can go to another room. What we've done is to take that concept and adapted it to our sites. We just changed it a little bit to local needs. So we started with four computers and a roomful of very enthusiastic children. We have sessions from 4:00p.m. to 6:00 p.m., two times a week. ...

Activities are situated around task cards which give children the overview of the games and set some goals at the beginning and set new goals at the expert level. After each task, they have reading response or written response or some kinds of interaction with text. An option may be for the children to use telecommunication to talk to other children at other research sites. (Interview, 10/21/92)

Professor Dillon mentioned that the Playschool project was not about children learning computers. The computer games were only for motivating the children to learn science. However, she felt that the Playschool was an excellent opportunity for her students to experience working with children in a non-school atmosphere. She, therefore, encouraged them to volunteer for the Playschool as a class project option. Those who volunteered went to the Playschool as "Big Brothers" and "Big Sisters." In the process of helping the children with learning tasks, such as filling out task cards and activity sheets, sending and receiving electronic mail messages, these student-teachers were expected to develop professional skills in classroom management, teaching, and technology.

Professor Dillon's Perception of Effectiveness of Computer Use in Her Class

Although there were no dramatic effects of computer use that she could specifically state, Professor Dillon perceived some changes in her classroom. With regards to teaching effectiveness, Dillon could not attribute any effect directly to



computers. However, she mentioned that her own computer skill improved. But she had not had the time to reflect on what technology has done to her practice, to say "teacher educators, how are we changing because of the use of technology in our course?"

Professor Dillon's instructional goals of were to:

- encourage her students to begin to view writing as a dynamic rather than a static process because of computers;
- enhance interaction among students through e-mail communication, whereby students build on one another's ideas;
- encourage students to see technology as an extension of the curriculum, where children can be in control of their own learning path;
- encourage students to learn to apply computers to their own classroom and their lives; and
- observe her as a role model of how computers can be applied in the classroom.

Professor Dillon perceived some of these goals to have been achieved in her classroom. Her students learned some word processing and e-mail skills. In addition, the students who participated in the Playschool project gained a different perspective into computer use. Seeing children at the Playschool play computer games to learn science, the students had "come to see technology as an extension of the curriculum." Students had also grown professionally. For example, the students co-generated ideas for the children log which were used in the Playschool for recording children's progress.

However, Professor Dillon was not certain how much of the learning of the subject matter was influenced by computer use. According to Dillon, computers were just "a vehicle for content... They are pretty tangential to the classroom process."

Professor Dillon noted that most of her students were interested but very anxious about computing. In terms of classroom interaction, Dillon believed e-mail enhanced her students' communication skills. Some of her students who participated in the pilot year of the Playschool had the opportunity to converse with students in another university on e-mail. Knowing that they were communicating with students from a different disciplinary background forced her Teacher Education students to be more precise in their conversations.

It is also healthy that they don't have the same mindset because they can challenge each other, because they know they are not talking the same language, they are likely to be more specific, articulate more their points. (Interview, 10/21/92)

Despite all the advantages that Professor Dillon mentioned, using computers to teach posed a challenge for her. As a new user and learner, how to properly integrate computers into teaching was a problem. She was not clear how to grade the e-mail "conversations" of her students. She worried about how her students' schedule interfered with the kinds of interaction she wanted to promote.

Frankly I don't know exactly how I'm going to grade that, because of the difficulty of the e-mail, with the technical difficulty the students are having. Also the students' schedules have played into this. Some students could only go [to the computer lab] right after class on Wednesday. So those are the first ones always posting something [about class readings] on E-mail and other people respond to them. So it is not as conversational as I hoped. It's not people interacting, it's usually people building on the ideas of the same few who always go and get things started because that's the schedule they have available to do it. There are some pieces in there that I didn't anticipate. I am just going to grade them, just checking my notes for substance of their argument. I purposely have not been a participant in it [students' E-mail conversation] because I did not want -- first because it is a lot of time to read them all, second, I didn't want the dynamic of you and the teacher, "so that we listen to her, whatever she said is probably the right answer" versus them developing it themselves. I didn't mind interjecting my piece in class. But in their E-mail conversation, I try not to do it. (11/23/92)

Students' Perception of Effectiveness of Computer Use in their Classroom

Perceptions of Toni, Judy, Audrey, and Anthony were compared to Professor Dillon's perception of the achievement of instructional goals, the amount and quality of learning, achievement of students' educational goals, and the professor as role model of computer use.

Achievement of Instructional Goals

Except for Audrey, computers were not new to the rest of the students in this case study. Toni, Judy, and Anthony have used computers extensively in their high schools or former universities. They all used this knowledge as a basis for assessing the effectiveness of computer use in this class. Three of the students perceived that computer use in the class was a mismatch with the instructional goals. Audrey, who had little computer experience could not comment on the effectiveness of computer use in the class. She knew she did not like computers and was not sure whether this class contributed to her learning computers better.

It was interesting to note that the views expressed by Anthony, Professor Dillon's past student, were similar to those expressed by her current students. Following were their perceptions on each instructional goal stated by Dillon.

Dynamic information processing.

All the students, except for Audrey, already knew how to use word processors, the use of a word processor to learn information processing skill was not beneficial to them. Moreover, word processing was optional in the class, so students who were new to computers had no incentives to learn about computers. Students like Audrey could decide not to learn computers except if they chose to.



Audrey:

A lot of teachers in the past have asked me to use computers in their courses, but I've always gotten around it. This year I also have the opportunity to get around it, but I decided that since I'm going to be teaching next year, I really should take the opportunity to learn it. Because chances are that eventually in my classroom that I want to be using computer, that I would be teaching my children, if not a lot, at least the basics. So I decided to head on into the computer lab. (Interview, 11/10/92)

Amount and Quality of Learning

With regard to the quality of the students' dialogue journals, Toni, who was in the word-processing group, did not perceive any improvement in their dialogue journals as a result of using word processors. Anthony and Judy did not perceive any special effects of computers either. All of the students mentioned that they did not perceive any clear objectives of using computers and computers were not well matched with the subject matter and class activities.

Anthony:

It [computers] was kind of peripheral. It was more of a tool to use to become accustomed to doing our assignments. But as far as helping to teach us anything about the materials itself, it didn't really play a part. (Interview, 11/23/92)

Judy:

I haven't got much of what she wanted me to get out of this. And I find it hard then-to make the time to go do that [reading articles and posting comment on e-mail], because I see it as a waste. I understand that it is a big part of my grade, but I have a hard time sitting down, reading these articles which I hate. Instead of reading articles and doing e-mail, they should have us spend three hours a week at a place where we can see kids--at a school, at a facility on campus--anything that we could see kids and write about that instead of writing about these articles. These articles are great, but they are the same topics in every class. You read all the same topics over and over and over. And then they want you to sit down and write journals for every class. And now we are doing e-mail and it's just the same topic over and over and over. I don't know how

many complaints people say about "I don't like this". "It is so dumb to sit down and write about these articles". "These articles are so unbeneficial for us as teachers." I mean it's great to see what other teachers that have been teaching twenty years have to say about these things, but after a while you get tired of reading about the same topics. So I find it so very unbeneficial for my use. And the fact that I've had a lot of computer experience, it's boring for me to just sit down. (Interview, 11/12/92)

Classroom Interactions

The effect of computing on classroom interactions received a mixed assessment from the students. As in the case study of Professor Hake, classroom interaction was defined in terms of the amount of time students spent on computers and instructional tasks, pattern of communication between students and their professor, pattern of communication among students, and student and teacher roles supported by computer use in the classroom.

None of the four students reported spending more or less time on instructional tasks as a result of computer use. However, Anthony felt that his use of computers increased because Professor Dillon's class contributed to his using computers for purposes other than word processing. He now used the computer for communication.

Anthony:

I used it once to send the professor a message. It wasn't something class related and I haven't been able to get hold of the professor in her office. She answered my questions and then said, "I'm so excited to see you using this medium to send messages." Later on I would send her messages on class related issues. It was nice when she answered. It can be useful especially when it's hard to get hold of a person. My use of computers does increase, because otherwise, I was just using it for wordprocessing. I still do a lot of that, still more so than e-mail. (Interview, 11/23/92)

Audrey also learned to use e-mail because of the class.

Student-to-student interaction was not enhanced as a result of using computers for word processing. According to Toni:



Only a handful of students are using them [computers], and it's individual. When we have class discussion about the articles, it's the same people who are talking all the time. I don't know if those are the people using computers or if they're not, but the computer really is not playing a role at all in that class. I don't know if computers in this situation are the way to make it happen. There seems to be a problem in that class with involvement and I don't know why. But I don't think it's necessarily anything that the professor is doing or not doing. But maybe it's just because of issues in the class. It's not just a real active class. (Interview, 11/2/92)

Anthony suggested that the interaction perceived in his own group may be due to the group process rather than any effect of computer use in their class.

Anthony:

Our class is maybe an exception, because we are in a special program, we had all of our classes together. So we know one another a lot already. And we work together on other projects. Unlike the standard programs who come from different classes. I wouldn't say that a lot of our interaction could be attributed to our use of e-mail. We would get together and talked about how frustrating it could be, but other than that, I don't think it fostered a lot of interaction. (Interview, 11/23/92)

Student-to-professor interaction was not fostered either. The students were not happy that they were always directed to this "outside person" to handle their computer problems. Audrey said that the only explanation their professor gave for recommending computer use was that submitting journals on a disk was easier for her.

Toni:

I think it would help the student-teacher relationship if the professor could take some time in class to talk about that [computer use]. (11/2/92)

Judy attributed the lack of interaction between them and the professor on computer issues to a lack of knowledge on the professor's part.

Judy:

And my professor isn't knowledgeable about it, so if there is a problem, it's been "Go talk to this outside person, don't come to your professor." So it disrupts being able to go to your professor with complaints about e-mail. "Anything that has to do with e-mail, go see this other person, we don't want to hear about it in class." There is no one if there is something not working right you can go to. But really complaints about the e-mail haven't been [raised in class]. She doesn't really ask if it is beneficial to us and what we thought about it. (Interview, 11/12/92)

In terms of roles that computer use supported, the students perceived no change from the traditional classroom. Students were still students submitting assignments and the professor was still lecturing or listening to students discuss in class. Computers were not perceived as playing any role in the class.

Toni:

It's [computer] not really playing a part at all. Which is surprising to me, because I know the professor uses e-mail and she's introduced computers and wanted us to learn it through the courses. She's really doing a lot but nothing's happening. (Interview, 11/2/92)

Students' Educational Goals

All four students in this study did not feel that they learned from this course how to apply computers in their own classrooms. Using e-mail or word processors are useful skills but how the students could apply them for teaching was not taught.

Anthony:

Something that might have been good would be to just show us some different ways you could use computers in the classroom, use it to present things. I guess e-mail is one activity they [kids] could do, but maybe some other activities as

well, like seeing the different ways you could use a computer if you had one in your classroom. If you got this resource there, the question then would be "how am I going to use it, how am I going to use it to teach?" or Is it just going to be more of a peripheral something rather than something very central. (Interview, 11/23/92)

Judy:

But this class--I haven't taken anything about computers or their importance in schools--I don't think it was beneficial, as far as teachers were concerned. There was not enough emphasis placed on the child aspects of computer use. It's been strictly, "Well this is for dialogues between you and your co-workers to see what they all think." You can do that without sitting at a computer. (Interview, 11/12/92)

Audrey:

You want to learn about people like me that maybe should have been worked on earlier, that should have been coached or encouraged to work on computers. People like me that would go into the work place that don't like computers, that should be thrilled about computers, and why are they teaching? And I understand that. Unfortunately, it's just something that..It would be much more positive if I was like that, but I'm not... I'm going to shy away from any school district that is very computer-based (Interview, 11/10/92).

Effect of the Playschool

The students some positive impacts of the Playschool on their learning. Audrey, through the Playschool, had her first exposure to children, which she found helpful.

Audrey:

We relate with the students. We take two students, and we play computer games and do different skills to help them with science literacy. Actually it is an excellent experience for children because they learn a lot much easier because it is so informal and no "teachers". And it is also good for us because the interaction with the children is really fantastic. (Interview, 11/10/92)

Anthony believed that learning to observe children was one skill he gained from the Playschool.



Anthony:

Maybe I have learned something about observing kids and making judgements about what they are thinking, understanding what they are thinking, which is important in our field, because if a child doesn't understand something, you need to figure out how you are interpreting this so that you can lead them in the right direction. Right now, it's kind of hard to put the pieces together. A lot of the things there are decontextualized. (Interview, 11/23/92)

With regards to learning how to use computers to put the control of learning in their own students' hands, Anthony and Audrey did not perceive the Playschool experience to have been helpful.

Anthony:

I could see using some of those programs as part of a unit in the curriculum, relating them to other things that we are teaching. But taken alone, it's kind of fragmented, there is not much of a context to learn those things. I know it's difficult when they are only coming twice a week, it's very limited exposure, and I know learning takes time, it's a long process. I think those kinds of games can be worked into the curriculum and used to teach different things. As it stands, I don't know how much the kids gain out of it, they may gain a few things here and there, but I think it's something that needs to be integrated. (Interview, 11/23/92)

Students' Perception of Professor Dillon as a Role Model of Computer Use

Professor Dillon's computer use did not appear to inspire her four students to use computers. Toni, Audrey, Judy, and Anthony raised many concerns that may be attributed to lack of experience or skill on the part of their professor. Some of the concerns are summarized in Figure 5.4

- Objectives of using computers in the course were not clearly communicated to the students. Students perceived no connection between computers and the class (Anthony, Toni)
- Students perceived no relevance between the Playschool, class materials, and computer use. (Anthony, Audrey)
- The professor introduced computers into the class as an after thought. In the third week of the semester when computers were introduced, most students have settled into the routine of writing their journals by hand. (Toni)
- Prior computing experience of students were not taken into consideration when computers were introduced. Those who had computer experience were disappointed with the lack of connection between computers and class activities. Those without computer experience became anxious or decided not to use computers at all. (Toni, Audrey)
- The professor never discussed computers in class. All computer training and problems were delegated to the graduate assistant. (Judy)
- Students who participated in the Playschool were never trained. They were left to find out for themselves what to do and to learn to use the computer games with the children. (Anthony, My observation)
- Judy felt that students were isolated by the professor's decision not to participate in the on-line interaction of the E-mail group. To Judy, it was like "sharing ignorance" among themselves.

Figure 5.4
Concerns About Computer Use Expressed by Dillon's Students.

Section Three - Observation

I conducted two types of observations to collect further evidence to build this case study. The first observation was conducted in Professor Dillon's classroom. The purpose was to gain a general impression of the role computers play in regular classroom instruction. The second observation was conducted at the Playschool. The purpose was to have a first-hand experience of the Playschool the way Professor Dillon's students might experience it. Both types of observation were to enable me to gain further understanding of the context of practice and see things from the participants' points of view.

Observation One: Regular Class Session

I visited Dr. Dillon's class a few days after I had interviewed her. I was so impressed with her description of how she uses computers with her students that I decided to include her in the case studies. I asked for permission to visit her class and to interview her students.

My visit was on a Wednesday, the day that Professor Dillon usually sets aside for the 'monitors' of the week to lead the class discussion. The monitors were told to read what everybody wrote on e-mail about that week's article. They were to summarize other people's points and bring questions and comments to class for discussion.

The class discussion on the day of my visit focused mainly on the articles that the students read for the week. The use of e-mail for communication or any computer-related issues were not discussed. One of the things I noticed about the class was that it was not a very active class. I wondered then if it was because it was an evening class and people were tired. Later in the interview with Toni and Judy (whom I met after that class) both students volunteered the information about the "disconnectedness" of e-

mail use with anything else about that class. They seemed very disappointed with the class because both of them had had good computing experienced in their previous colleges.

In the follow-up interview with Professor Dillon a few weeks later, I brought up some of the concerns that students had about the course and the use of e-mail or word processors. She admitted that she herself was still learning. But she was open to better ways of getting students exposed to computers without the additional anxiety.

The good thing to consider is that this is not a course on how to use computers in the classroom, but it is trying to get them to at least get an exposure to it. So it's a little better than none at all...It is a time issue. What we could learn from that is to maybe get smaller groups of people talking to each other on the e-mail versus the whole class. You know I'm learning too. Maybe we could break the groups into four co-groups that read each other and then respond both to me and each other. That way they feel a little bit part connected and not just writing it to everybody, but having a sense of a smaller community that they are accountable to. (Dillon: Interview, 11/23/92)

Observation Two: The Playschool

Even though my enthusiasm had dimmed by the classroom observation and what I heard from students during the interviews, I was still very excited to visit the Playschool. I wanted to be part of the experience of the students who might be visiting the Playschool for the first time. I wanted to see the Playschool through their eyes. Earlier on I had asked Professor Dillon's permission to visit the Playschool. She agreed, on the condition that I went as one of the Big Sisters. I was more than ready to comply. The only way I could see what the undergraduates were getting out of the Playschool was to put myself into their frame of mind.

I visited the Playschool twice. What I saw on the two visits confirmed the impressions that I had from the various interviews. In line with my role as a Big Sister, I did not take notes while I was at the Play School. I, therefore, had to be more attentive to what was going on in order to be able to recall the events at the end of the

day. However, because I also was a participant, my observation could only be focused on one particular situation at a time. So I concentrated on what happened with the group of children that I worked with and relied on the other Big Brothers and Big Sisters to provide information on other groups of children that they worked with. My general impression of the Playschool was later corroborated in the interviews with Anthony and Audrey.

First Visit

My first visit to the Playschool was on November 17, 1992. I arrived at the Playschool center at about 3 p.m. in order to have some time with the regular staff before the children arrived. I met 'Jackson' who was setting up. I introduced myself and told him the purpose of my visit. I asked if I could help set up the room.

We set the eight Apple II computers on four long desks--two computers to a desk--and loaded some of the software. Most of the software was games. Only one was a typing tutor. We placed other games and activity sets which were not necessarily related to the computer games in their baskets, waiting for the children. The tasks for the day were set according to goal levels.

I helped to hook-up the only Mac SE with the modem. The staff were hoping that the system would work so that the children could reply to the e-mail messages they received from children at the other research sites.

While we were waiting for the children to arrive, I seized the opportunity of asking Jackson about the Playschool, how it operated. He told me most of what I had already heard from Professor Dillon--how hard it had been to cope with inadequacy of the facility, the successes despite the problems, the uniqueness of each group of children, the experiences of the Big Brothers and Big Sisters, and about the debriefing sessions which were an essential part of the research project.

While Jackson and I were having our conversation, Anthony came in. Jackson introduced us. Anthony was one of Professor Dillon's students from the previous year. He and two other students continued at the Playschool as regular staff. I later asked Anthony if he would participate in my study.

The children started arriving soon after, and we were all thrown into flurry of activities, matching the children, in pairs, with the games they chose to play in the first session. Jackson already told me to just watch other Big Brothers and Big Sisters interact with the children in the first session. Then in the second session, I could work with a pair of children when they changed activities.

Computer Games

The pervasive use of computers in the Playschool was computer games which the children played in pairs. The Big Brothers and Big Sisters were expected to help out the pair of children they were working with if the children had any difficulties with the games or the task cards. From my observation however, it appeared that the regular children ended-up showing both Big Brothers or Big Sisters working with them and some of the new children how to play the games. This was alright because the Big Brother or Big Sister was not supposed to be the teacher who has all the right answers. Moreover, one Big Sister, 'Monica', told me that Big Sisters and Big Brothers were not trained or provided any orientation on how to use the computer games with the kids. They became familiar with the games as time went on. Anthony also confirmed this later in the interview.

Anthony:

No, they just come just like the kids. It is part of their learning to figure out how the games work. The task cards sort of give some ideas of what the overall goals are, and the computer games have directions, but a lot of time, it is



getting to read the directions. It is part of the instruction we were given, the kids should learn to read the task cards. (Interview, 11/23/92)

I kept thinking to myself about how students who did not have any computer experience and were already anxious about computers felt about the lack of orientation to the Playschool. I made a mental note to ask some of the students in the interviews later.

Electronic Mail

In the second session of the day, Jackson read each child's mail. The children received replies to their earlier mail sent to children at the other research sites. As mentioned earlier in the introduction to this case study, the Playschool was one of many research centers all over the nation investigating children's learning of science. Because it was also a science literacy project, children were expected to write on what they learn about science by playing computer games and working on task cards. They were encouraged to write this in the form of letters to the children at the other research sites.

After Jackson had completed reading each mail, the children were asked to begin writing a reply to their mail. I was curious to know where the e-mail messages came from because they were not through the network system that I had helped set up earlier. Jackson told me that the system had not worked for some time. He has been sending and receiving e-mail messages in behalf of the children from another computer. In essence, neither the children nor the students really did get to use e-mail for anything at the Playschool.

Second Visit

On my second visit, similar pattern of interaction was observed. We followed the usual routine of setting up, after which we waited for the children to arrive. We

went through helping them with the task cards and activity sheets for the day. Throughout the one-and-a-half hours we were there, my attention was divided between being a Big Sister and a researcher, observing the reactions of the undergraduates to the excitement of the Playschool. While I tried to focus on my general impression of the center, I was also looking hard for evidence of real computing taking place between the students and the children at the Playschool.

From my observation, I concluded that there was really not much computer use on the part of the Big Brothers and Big Sisters. We watched the children play computer games. If we observed that one child was dominating the games, we tried to get the other child involved. Most of our efforts were directed at keeping the activities moving, keeping the children interested, and controlling unruly behavior. This impression was later confirmed by the analysis of an audio-tape of the Big Brothers and Sisters' debriefing session.

Debriefing Session

I had asked one of the Big Sisters to tape the debriefing session for me because Professor Dillon requested that I should not participate in the sessions. When the Playschool was over, the other Big Brothers and Big Sisters went to a separate room for their debriefing. I stayed behind to help Jackson clear the room and put materials away.

The debriefing session that I analyzed was taped on my second visit to the Playschool on November 19, 1992. The debriefing session lasted 15 to 20 minutes. From the transcript of the audio-taped session, it became apparent that most of the Big Brothers' and Big Sisters' discussion about the children they worked with centered on issues relating to classroom management and interaction.



Developing Professional Competencies

One of Professor Dillon's instructional goals was that her students learn professional skills through the Playschool. The experience was particularly necessary for her current students who had never been in a classroom, and who would only have one semester of student-teaching before they graduate. Two of the students in this study, Anthony and Audrey who had the opportunity to work at the Playschool, confirmed that it was a useful experience. My observation also confirmed that the students learned some classroom management skills. Analysis of the debriefing session revealed some of the professional skills the students gained.

Anthony mentioned in his interview that he learned from the Playschool how to observe children. The debriefing session revealed that other students also learned to observe and evaluate the children they worked with. The students learned from the previous occasions not to work with too many kids at a time. Whenever they did, the class became rowdy. One of the students mentioned this difference immediately after the debriefing session began. "I felt everything went really smoothly today. It seems like there wasn't any distractions today." One of the regular staff of the project explained that some children who were destructive have been banned for two weeks. Moreover, there were fewer kids to deal with that day because some of the children were at a writing workshop elsewhere. Perhaps that explained the relative change observed by the Big Brothers and Big Sisters rather than any structural changes that were made.

It was interesting to note in this debriefing session that most of the students' discussions were focused on the children's interaction while playing the different games--what they said, what game they played, and how children who said they couldn't get along ended up working well together. The students talked about the issue of cooperation and dominance among kids who worked together on the games. The comments below illustrate the substance of the students' thinking.



I worked with Emilia, who is new, and Terence, and they played "Oregon Trails." They really had a lot of fun. I think she is a bit older than he is. She wanted to push all the buttons, and he was like, "common let me push", and she would let him push. They got along pretty well. ... They got as far as the first ford and the wagon capsized in the river and they lost a bunch of food and they had to start again. (Debriefing session, 11/19/92)

I worked with Layota and she was working on the Master Typing and it teaches you how to type, what different games you can play. She does love it and she got right into it. She worked with Lanishaw. They are both in fifth grade. But you can definitely tell that Layota dominated Lanishaw. (Debriefing session, 11/19/92)

The students also explored what a democratic classroom may look like and the implications for classroom organization in the regular school system. As the students were finding out, when given the opportunity, children may not always be able to make choices in the classroom. This may be because children find it difficult to make up their minds, or they may not know which choices to make. Sometimes children's decisions may be influenced by personal biases which change frequently.

I listened to the tape of the debriefing session over and over for evidence of the students' computer knowledge. I found none to disprove my suspicion that computers did not play any significant role in this multi-level learning environment. There was not much discussion of computers by the students. There was no place in the twenty minutes debriefing where the students mentioned or discussed their own roles in facilitating the computer-assisted learning that was expected to be taking place. There was a brief mention of the limited number of computers in the center, and how that might have affected how children chose the games to play or the skills to work on. This, however, was in relation to classroom management and had nothing to do with whether computers were making a difference in terms of contributing to children's learning or their own effectiveness as teachers.

My Impression

The use of computers in all the three situations set up by Professor Dillon were in line with her view of the role computers should play in the classroom. However, evidence from this study showed that students were not happy with the view that computer use should be peripheral to classroom activities. It was not surprising therefore that Judy, Audrey, and Toni felt "disconnected."

Summary

This case study focused on Professor Dillon who used computers as a motivator for learning her subject matter. In Professor Dillon's class, computers did not play any role in instructional delivery. It was not a subject of the regular classroom discussion. Computer use was limited to students submitting their dialogue journal on a diskette or e-mail comments on class readings. Professor's use was limited to interjecting comments in students' diskettes.

Dillon believed that there were some positive effects of computer use in her class. Her students learned some computer skills, but she could not account for the computer's role in students' learning of the subject matter. Toni, Judy, Audrey, and Anthony did not confirm all of Professor Dillon's view of the effectiveness of computer use in their classes. They believed they learned to use e-mail and learned some classroom management skills at the Playschool. However, Professor Dillon's use of computers did not inspire them to use computers, and the ways computer were used in their classes did not equip them to use computers as teachers of the information society. My observation of events in the classroom and at the Playschool corroborated students' views.

CASE STUDY THREE

Case study three was about Professor Adamson. He was selected for the case study because of his experience in developing and using computer-assisted instruction. I was also interested in the rich computing support that he mentioned, and how that might have influenced his use of computers for teaching. The purpose was to present institutional and personal elements that may enhance or constrain teaching and learning with technology in a particular setting.

To corroborate evidence from Professor Adamson's interviews were interview data of his students, computer support staff at the college of veterinary medicine, and an administrator who supported computing in the college. Seven of Professor Adamson's students were interviewed. "Josephine" was interviewed with Professor Adamson on one occasion and by herself on another occasion. "Rachel" and "Laura" were interviewed together; and "Jackie", "Denise", "Stephanie", and "Debra" were also interviewed together. The computing resource persons interviewed included "Andrew" who worked directly for Professor Adamson, and "Jake" and "Matthew" who worked for the college of veterinary medicine. The administrator interviewed was "Dr. Conway." An analysis of a videotaped classroom instruction constituted my observation of Professor Adamson's teaching with computers. A tour of the computing facilities at the college also provided some corroborative evidence of the interview data.

This case study is presented in three sections. Section one contains the background information about Professor Adamson, his students, the computing support staff, the administrator, and the computing resources at the college of veterinary medicine. Information about computing resources is extracted from the interviews of the administrator and computing support staff. Section two presents Adamson's and his students' perceptions of computer use and its impact on teaching and learning in his



class. Section three contains my observation and impressions about computer use in Professor Adamson's class.

Section One - Background

Professor Adamson

Professor Adamson taught in the college of veterinary medicine. His work included teaching various courses in anesthesiology and pathology to second and third year students. He also supervised students in their clinical year. He had taught for six years at the time of this study and had used computers in teaching for about three years. His main computer use for teaching was through computer-assisted instruction (CAI).

Professor Adamson started three years ago to develop CAI programs to supplement his regular classroom instruction. He started with the "Cardio Pulmonary Resuscitation (CPR)" program on LS/1 InfoWindow authoring system. Adamson later developed the ToolBook version of the "CPR" because LS/1 InfoWindow system was discontinued. Other programs that he developed on the ToolBook authoring system are "Jeopardy" and "Anesthesia Equipment." The programs were developed as regular classroom instructional support and as stand-alone versions. The stand-alone versions are kept in the library for students' use to review topics already covered in class.

Professor Adamson attributed his work with computers to adventure as well as a rich computing environment that provided him with the needed support. This environment was made up of administrative support represented by Dr. K. Conway, a dean in the College of Veterinary Medicine, a two-million dollar computing facilities, a network of resource personnel, and a user-support group made up of colleagues and students. According to Adamson:

I think the timing for me was just perfect. If I was in a department where they didn't have that much investment in computers and I spend much of my time doing computer stuff, I don't think I would be rewarded for doing it.
(Interview, 10/14/92)

Josephine

Josephine was in her clinical year, completing her program in veterinary medicine. She did not take any formal computer course, but she had used computers at work and "sort of taught myself as I go about things." When she began her program four years ago, computers had just been introduced into the college's programs. Full-scale computerized teaching came much later. As a result, she did not have as much exposure to computers for learning as she would have wished. Even then she took advantage of the few computerized, case-based problem-solving exercises available in her second and third year. Josephine felt that computers are a useful way of reviewing topics already taught in lectures.

The first interview with Josephine was conducted at the same time as Professor Adamson's. Professor Adamson had asked if Josephine could join us for his interview. I also interviewed her on other occasions too. Josephine later became my contact with the other students who participated in this study.

Rachel and Laura

Rachel and Laura were interviewed together. They were both third-year students in the college of veterinary medicine. It was necessary to include them in the study because their class was used for the tryout of some of Professor Adamson's programs. I wanted to find out how they perceived computer use in their class and the experience of the tryout.

Both students were not new to computers. Laura had had a BASIC course in high school. She had had another computer course in her undergraduate program. Apart from those two instances, she did not really use computers much until veterinary school. Now she uses word processors to write her papers. There were also the

computer-assisted instruction programs that some of her professors are developing for students' use.

Rachel also had had a BASIC programming course in high school, but she did not use computers at all in her undergraduate program. Now she has to study with the CAI programs that the professors in the college are developing for students' use.

Jackie, Denise, Stephanie, and Debra

Jackie, Denise, Stephanie, and Debra were second-year students in the veterinary school. They were another source of corroborative evidence of the impact of the computing resources in the college of veterinary medicine. Both Professor Adamson and Josephine mentioned that students who began their programs when computerized teaching became popular in the college were less intimidated by computers. I wanted to find out if the second-year students perceived computers for learning in a more positive light.

All four students have had some experience with word processor at work. In addition, Denise had had a BASIC course in high school and a computer-based statistics course in her undergraduate program. Debra had little computer experience before veterinary school.

Andrew

Andrew was a senior about to begin his clinical year in the college of veterinary medicine. He took some courses with Professor Adamson in the previous year. Apart from his veterinary background, Andrew had acquired some computer skills during his undergraduate program. He used desktop publishing software to design a newsletter for his student group. He also worked as part of the editorial team on the national veterinary students' magazine.

Andrew worked for Professor Adamson on his CAI projects. Adamson received one of the internal grants made available to professors in the college to encourage them to develop courseware. With the money, he hired Andrew to help him with the development of his computer-assisted instructional programs. Although he had no formal training in instructional development, Andrew was able to adapt his desktop publishing experience to the visual environment of ToolBook to develop the CAI. According to Adamson:

It was fortunate for me that I was able to get a student to do it who went through the course as opposed to getting a veterinary student who hadn't been through the course. A first-year vet student wouldn't have been as useful to me as Andrew was, who had already been through the course and he knows what issues are confusing and how to clarify them.
... Moreover, he knows he can do a lot of stuff without having to ask me. It's much more efficient having a student than having someone who doesn't have that perspective. (Interview, 11/2/92)

In developing the programs, Professor Adamson provided the content, the structure, and the guidelines for the CAI, and Andrew developed them into presentation formats.

Jake

Jake worked for the college of veterinary medicine as a graduate assistant. He and another graduate assistant were the in-house instructional development consultants to professors in the college. Jake has a background in telecommunication, computer science, and instructional design. Evidence from his interview corroborated the kinds of computing support that professors received in the college.

Matthew

Matthew worked full-time for the college of veterinary medicine as a technical and network expert. He had a background in telecommunication with an emphasis in data communication.

Matthew and his staff supported both academic and administrative uses of computers in the college of veterinary medicine. Their clients included over eighty faculty and staff. They managed the network so that faculty could put their courseware on the file-server for easy access by students and other faculty. In addition to the file-server and the electronic mail system, Matthew and his staff also managed the networks in the centralized lecture hall, the laboratories, and the library.

Dr. Conway

Dr. Conway was a dean in the college of veterinary medicine. He was among the policymakers who supported faculty computing as a means to achieve the missions of the college.

Conway:

Our biggest concern is that we want to prepare our students to be the best students that they can be as they go out to serve society. We want a modern approach to education. We're concerned that students are efficient in the way they deal with the information explosion. There's a lot of information out there and we think that computers will help them deal with that volume more effectively and hopefully more efficiently. We want our educational program to be a dynamic process that is exciting, stimulating, and we really want our students to be lifelong learners. We want them to be able to teach themselves and to leave this university and go out into whatever aspect of the profession they might chose and be able to continue to learn. So those are, I think, the important things we have in mind with respect to why computers are useful to us and why we want to incorporate them in our educational program.
(Interview, 11/2/92)

In line with these goals, the college of veterinary medicine had consistently introduced technology into its programs. According to Dr.



Conway:

We have been using technology in education for a number of years, not computers necessarily, but certainly we've been using the overhead projector, we've been using the blackboard, we've been using carousel projectors, videotapes. So technology is not necessarily new to education, nor to us. We are using computers just as we are using other technologies in helping our teachers to teach and our students to learn.

I included Dr. Conway in this study to be able to get an administrative perspective into computing issues in the college. Dr. Conway's description of the computing resources in the college is presented in section two of this study.

Section Two - Computing Resources in the College of Veterinary Medicine

Computing resources in the college of veterinary included personal computers for each faculty, a lecture hall equipped with 116 personal computers, a computerized laboratory, and a library with 27 computers. Resources also included administrative support, computer support personnel, and a users' support group. All these resources are well-integrated and managed at the college level.

Professor Adamson mentioned that as a professional school, courses and programs were structured differently in the College of Veterinary Medicine. Teaching was not done on one course to one professor basis. Rather, a course could be taught by three or four different professors with their own disciplinary slants. And because the courses were related, it was easy for professors to share teaching materials, especially computer programs. It was also easy for the college administrators to provide integrated computing support for professors. Describing these rich resources, Dr. Conway began with an overview of the sources of funds for computing in the college.

Funds

Funds for computing in the college came from various sources, including the state, the university, and private foundations.

Conway:

We were very fortunate to have available to us some resources as a part of the total renovation and building program that has been going on in the college for the last few years. We had state funds provided for the building per se and in addition, we had a separate budget for equipment. As part of that equipment, we had some monies designated for research; we had monies designated for construction and teaching, monies designated for a variety of categories and needs within the college. So we were indeed fortunate to have some resources that could provide us with a substantial amount of computer technology, not only for the faculty, but for students, the library, the classroom and so on. So we were very grateful for that.

The monies that were part of the building program were basically one-time allocations for the acquisition of equipment and were not continuing support monies. Now we do have monies designated within the total college budget, general funds that are provided for general instructional support and so we used those for expendable supplies, for support personnel in the form of graduate teaching assistants. We have two students who are graduate students in the College of Education that are half-time grad assistants that help our faculty develop programs, to evaluate them, and to learn how to use them and so on, so that's been very helpful to us. But those funds, the money to support those people are ongoing funds that are provided through the university general budget in instructional support dollars. ... We do have some resources through some private foundations that provide us with some monies. There's a limited amount of that, but yes, we do have some ongoing support from that arena as well. (Interview, 11/2/92)

Facilities

A great deal of time and resources went into the planning of the computing facilities for the college. According to Conway:

When we planned the new building, we had a very innovative committee that were interested in improving education. We talked about a lot of different things and we planned two primary facilities focused on computerized learning--one is a lecture hall which has a 116 PCs, one for each student in the class. These are then networked with the instructor's work station that includes a variety of multimedia equipment that can be used in presentations. The instructor's

workstation includes the PC that networked to the students' workstations, a VCR, an interactive video disc player, a slide to video transfer projector that networks the image to all the PCs.

At the same time, we've not abandoned the traditional technology that has served us very well for many years. We have dual carousel projectors in the back of the room, if faculty are more comfortable with that. We retained an overhead transparency projector and the traditional electronic microphone and electronic pointer. So that faculty can then select what form of support media they'd like to have for their lectures.

Now, the second computer instructional unit is what we call a multi-disciplinary laboratory. This is a laboratory designed for basically studying images, particularly in the area of anatomy, histology, and pathology. This laboratory has 27 workstations and the workstations are designed to accommodate two students so we can put 54 students in this laboratory. Again, each station has a PC which is networked to the instructor's station. There's an interactive videodisc player and a double-headed microscope. So again students work in pairs, sharing the images they're looking at and helping one another.

Then at the instructor's workstation, we basically have the same technology that we have in the lecture hall's instructor's workstation. But in addition, we have a microscope for the instructor with a camera mounted on it and the video camera can project images via the network to each PC or to 6 monitors that suspended on the walls on the side of the room. Now this allows an instructor if they want to use multiple modalities, they could for example, ask students to look at a glass slide. The instructor with the video camera could find an area on that glass slide and lead the students through the examination of that slide. So that allows the instructor to basically tutor all 54 students at one time from his instructor's workstation. In addition he could use the interactive videodisc player and then via the network, project additional images related to a given case or a given problem, and if he wanted to go further, he could project slides with dual projection at the back of the room on some additional material that might be related to the same case. So this capability of showing information related to a given concept simultaneously makes a powerful teaching tool for the instructor and a wonderful learning experience for the student.

...We have IBM computers. We're on a DOS platform. We use a Novell operating system, and then we are working with IBM corporation to develop basically a tailored network system that we can use to project high resolution images. We also have what's called a learning comprehension monitoring device, which is a method whereby I, as an instructor, can pose a question to the students and ask them to respond on the basis of that question. For example, do they understand the concept and I could ask them to respond 1) if they understand fully and 5) if they don't understand at all or numbers between those two. This software will allow us then to take the responses, immediately process them and have within a matter of seconds a kind of summary histogram of the student comprehension of that given concept. So we think again, that becomes very powerful in terms of an instructor knowing whether he or she has really

gotten the message across and if not, an opportunity to go back and review it again. (Interview, 11/2/92)

Figure 5.5 is a summary of the computing facilities that Dr. Conway described.

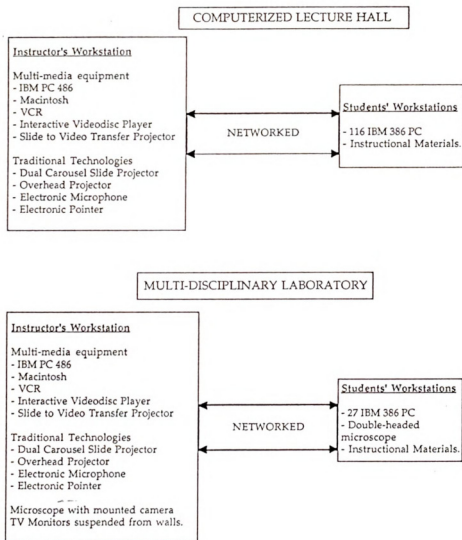


Figure 5.5
Models of Computing Facilities in the College of Veterinary Medicine

Computing Support

Two types of computing support were provided for faculty in the college of veterinary medicine. There was the technical support personnel who helped faculty with both software and hardware problems. They also ran the network. There was the instructional development support personnel. This consisted of two graduate assistants from the college of education who assisted faculty with development of new instructional presentation materials. Instructional materials were kept running on the network by the technical personnel so that students and professors could access them at any time, either in the lecture hall, the laboratories, or the library. "So it's not people working independently, but a cooperative effort to help faculty be successful with the technology (Conway: Interview, 11/2/92).

Matthew, the technical and network person in the college, described what his work entailed.

Matthew:

We're responsible for the hardware, make sure it works. We're responsible for the software, make sure it's on there, make sure it's hooked up to network so people can access it across the network and send electronic mail and files to each other and communicate with other information resources. We don't really create the ToolBooks. I created some programs that allow us to control the videodisc players and some of the other educational instruments like video tape player and slide to video transfer. But the actual educational program is done by graduate students with educational design experience.

... We use ToolBook for the educational software. So we have ToolBook located in a central location. That way when a faculty updates a ToolBook [CAI], we just put it there and all students can access it. In fact we have it set up so some faculty can update the ToolBook [CAI] from their offices and all the students have access to that almost instantaneously. (Matthew: Interview, 11/19/92)

Jake, one of the two graduate assistants who provided professors with instructional development assistance, described what his work entailed.



As far as what I do here, I work with professors as their contact persons. What I do is I try to extract what it is that they want to teach with computers, and why they want to go to computers and try to focus their objectives. And then basically bounce ideas off them, and they bounce ideas off me as we try to figure out how we can go about creating a ToolBook [CAI] that would get these objectives across in some exciting way. And then I will talk about resources, how much money they have for the project and what did they want to get out of it as far as software. Also if they want to learn ToolBook, I show them the basics, give them ideas and show them how to do that. If they want to do just one stand alone ToolBook and walk away from it and not touch the computer again, then I'd do it for them. If they don't have the time to develop it on their own, but if they have the money, we hire a student and I train the student to do it for them. (Jake: Interview, 11/19/92)

Working for a college where computer use for teaching was taken seriously by both faculty and the administration could be very demanding. According to Matthew, it could also be "a very exciting experience too."

It's hard keeping up with all the requests. Faculty are very diverse and interested in a whole variety of endeavors. We're scrambling to provide a lot of the new information services that are popping up, like Gopher, an information database. We're providing CD-ROM capabilities so there are a host of things available on CD-ROM. There is a mammals CD-ROM and there's a Physician's Desk Reference on CD-ROM and a Veterinarian's Manual on CD-ROM. We're working on providing MEDLINE and reference update program to track references to current journals. It's just a lot to do just for faculty.

And then there's the students. We have to provide all the ToolBooks [CAI] that the faculty create. We're providing word processing programs and spreadsheet programs for the students and electronic mail. We have to make sure all the networks keep working.

We provide all the standard programs for the administrative staff too. We support administrative staff within the departments. They need word processing and spreadsheets. We also provide enrollment for the students. So there's a lot to do. We have one other full-time person and two students on the staff, yet there's a lot that keeps us busy. (Matthew: Interview, 11/19/92)

In Jake's case, one of the most difficult aspects of working with professors on instructional development projects was clarifying their objectives. So Jake would do extensive needs assessments with the professors.

Most of the time, the professor comes with an idea, probably from what they've seen from other professors' software. It is a difficult process because you don't want to insult them as instructors by saying that they should try and get their objectives. You don't want to say that they don't know exactly what they want. On the other hand, they don't know what they want. So I have to keep the balance between asking professors to state their objectives and having to help them define or clarify these objectives. Also, I have to admit sometimes that I don't have all the answers.

Basically we talk about what they will want to see in their finished project, if they could pull off their dream packet, what would they want to see in it. And I would tell them what they can do and what they can't do, using some of their ideas. I like to find out how the course was taught before--if it was stand-alone with fliers and scripts or stand-up instruction--try to find out what we could do better with computers. (Interview, 11/19/92)

Another difficult part was to get some faculty to start using computers or creating programs for their courses. While some faculty were quite advanced, some had not started taking advantage of the computing resources in the college.

Dr. Conway mentioned that internal grants were made available by the college to faculty on a competitive basis. Professors who won the grants were free to hire personal assistants for instructional development projects. Professor Adamson received one of the grants and used the money to hire Andrew to work with him on his computer-assisted instruction programs.

Andrew worked on Professor Adamson's three CAI projects--the "CPR," "Anesthesia Equipment," and "Jeopardy"--in collaboration with Jake, the instructional development expert in the college. However, Andrew provided a "student perspective" for the programs which would not have been possible if they had been developed by Jake and Adamson alone.

Andrew:

When I first started on it, I approached it from the student's perspective, this is what I think would have helped me the semester when I had the class. I inserted

things that I remember were confusing to me that I would like to have demonstrated better. Some of the things included in the program are just things that I thought would be more helpful because I'm a student and I know some of the things that would be confusing to me. By the time I'm done working on something though, I usually become a little bit more familiar with them and I can evaluate the finished product from the students' perspective as well. (Interview, 10/23/92)

Being able to teach from a student's perspective was one advantage of computer-based instruction, according to Andrew.

I think it is important to approach this from a student's perspective more than a faculty perspective. Sometimes they [faculty] can approach their subject from a student's perspective, but sometimes they are so comfortable and familiar with their topic that they assume things and students may get lost. And I don't think this would work if we assume things. We should start at the basic level, actually below what students should already know, because review never hurts. Like the ECG tracings, I had a class where I had to look at all that stuff. I understood it while I was in the class, but as I sat down and try to review the ECG tracings, it took me a long time to sit there and think through it enough to know what to do with it. (Andrew: Interview, 10/23/92)

Andrew believed that while developing CAI could be fun, it could also be very challenging. A CAI developer faces the question of how to create a visually realistic program as well as present information in a concise, complete, and logical manner. According to Andrew, a lot of creativity and some artistic ability is required to create visually realistic programs. CAI development also requires a lot of time commitment too. Andrew approximated that 200 hours of development time may be required for a first program. He added that a person new to CAI development should be aware of the limitations and potentials of the authoring systems used. He or she would need to spend time to learn the program, and should not hesitate to switch programs if their development programs do not satisfy the needs. A developer should also be aware that some programs are updated regularly, and the later version might be able to do what the earlier version could not do.



A faculty contemplating CAI development may find it necessary to employ a knowledgeable resource person.

Administrative Support

According to Dr. Conway, the goal of computing in the college was not to replace the faculty in the classroom. "We want it to be another means of faculty being successful teachers." To ensure faculty success in using computers to teach, the college set up an ad hoc committee called educational advisory committee.

This is made up of students and faculty who are interested in education, who are interested in improving the educational experience. Now it's a committee that somewhat parallels the curriculum committee. But as an ad hoc group they would be unencumbered by some of the routine logistical responsibilities that the curriculum committee has. They're basically a think tank group who can advise, dream if you will, about things that could or should be done to improve the educational experience and they don't have to worry about routine matters. Interestingly enough, there are some committee members that are also members of the standing curriculum committee of the college. So there's a lot of overlap and I think that's important.

This group has been instrumental in setting up some regular monthly seminars focused on education, what we can do. We've invited speakers from across campus to make presentations, people from the College of Education, including Dr. Yelon. People from the Office of Medical Education and Research--Dr. Anderson and Dr. Bridgham--have both made presentations. So we think that's been helpful in giving some new ideas to faculty on approaches that are being used elsewhere on this campus.

With that, then we've also done some internal kind of updating of faculty, asking faculty within the college who have developed programs to make presentations about what they've done; problems they've encountered, successes and failures, and so on. So it's a sharing within the college of things we've tried that have worked or things we've tried that have not worked. We think that's been very useful. We've had faculty who are interested in problem-based learning; invite and include students to do a demonstration of what problem-based learning is all about. And we're going to repeat that. So those are approaches we've taken in terms of giving a new approach to education some visibility. It's attracted some attention. We have good faculty attendance at the seminars and we think it's worthwhile. (Interview, 11/2/92)



Dr. Conway felt that faculty should be adequately recognized and rewarded for computing as much as they are rewarded for research.

I feel pretty strongly about that. I think that developing innovative, dynamic educational experiences is truly a scholarly endeavor. In my opinion, that needs to be rewarded for faculty effort just as acquiring a grant or doing a bench research experiment or whatever. I've basically committed to our faculty that I will help them in any way I can to do things well, to be scholarly in the way they approach them and provide resources for doing that. Then I encourage their department chairs to consider their efforts in part of promotion and tenure decisions. In fact, if I may add, we set up a mini-grant program within the college which I shared with all the department chairs and asked if they would consider rewarding those faculty who received grants for their efforts. They agreed on the basis that the applications be reviewed and that we include some external consultation in making the decisions as to whose grants would be funded and whose would not. We did that--the department chairs were strongly supportive so I think we've got a solid base for a reward system for scholarly and creative instruction within our college. (Interview, 11/2/92)

Section Three

Computer Use in Professor Adamson's Class

Professor Adamson stated that his goals were that his students become better veterinarians and become comfortable with using computers as a professional tool. As veterinarians, students should develop the ability to think on their feet and make quick decisions. Quick decisions are necessary if they are to save the lives of animals in their care. Adamson saw the computer as a tool to achieve these and other instructional goals.

Adamson:

The overall goal is to make learning more fun, to make the students want to learn. And that doing this type of things would stimulate them more than just listening to videotapes or lecture or reading them out of books. Specifically, in case of the CPR for instance, I want them to be able to think quickly on their feet and make decisions in certain time frame. That type of computer simulation gives us ways to allow them to think in small time frame, to make quick decision and to save the dog. For that situation, time is critical in our



profession. When you die, you only have a few seconds for someone to bring you back to life again. The only way to practice that is to do it artificially [through the computer]. Well you could practice that by killing a dog, but that is wasteful. (Interview, 10/16/92)

The dominant instructional use of the computer in the college was computer-assisted instruction. ToolBook, the platform on which most of the programs were developed, was a powerful tool with animation and graphics capabilities. These enabled professors to present information in forms that aid visualization of concepts. In addition, the CAI format allowed professors to package their instructional materials to allow students multiple interaction opportunities.

At the time of this study, Professor Adamson had developed three computer assisted instruction programs--"CPR," "Gas Anesthesia," and "Jeopardy." He described the three programs as follows:

"CPR"

I started the dog CPR thing in about 1989, so three years ago. I always used computers for word processing but I never really used it much for teaching. And again because I thought the computer will be a good way to simulate all the different ways an animal could die and then how to save it. Then from there I thought it will be useful to demonstrate some concepts that are difficult to explain by just using chalk in your hands to a group of students. I thought using a computer would be a useful way to simulate some of those concepts. (Adamson: Interview, 10/14/92 & 10/16/92)

"Gas Anesthesia"

And in another program that I have developed, I have some simulations that allow me to show some concepts such as factors that influence the level of anesthetic in the blood. You can start with the anesthesia machine and certain changes you make on the anesthesia machine would affect how much anesthetic gets to the patient. And the example of the dog hooked up to the anesthesia machine where you control the thing on the computer that shows the change ... that would show how you can alter the amount of anesthetic that gets

to the patient. Once it gets to the patient, then it has to go to the blood, and the factors that influenced how much gets to the blood - two big factors are how much they are breathing and how fast the blood is going through the lung. And the train example was used to demonstrate how to teach those concepts.

In the first part of the train analogy, we demonstrated how changing the blood flow to the lung would influence the way the animal handles the anesthesia. If the blood flow is very high and that would be in the case when the animal is very excited or when the animal is not well sedated, then when you go to the next task, it is difficult to anesthetize it. Because the blood is flying by the lung so fast, when the animal breathes in the anesthetic, the blood goes through the lung without getting a very high concentration of anesthetic in it.

I have explained that to the students and they don't yet understand it. So what I did on the computer program was that I had train cars moving along on the computer screen. And I said, think of a train going underneath a grain elevator and it drops down grains into the train cars. And when a car fills up, the train moves a little bit forward and the grain elevator drops grain into the next train car. So I have on the computer program a train going underneath this grain elevator. I said the train is analogous to the blood going by the lungs. And if it's going very fast and the grain is falling through the elevator at the same rate, the level of grains in each train car will be very low. If it is going slowly, then each train car would have a very high level of grain in the cars. And the level of the grain in the car is analogous to the concentration of anesthetic in the blood.

If the blood is going very slowly, you can fill up the level of anesthetic in the blood very rapidly. On this simulation, I have a train going by and there is a control for the students to slow down or speed up the train's speed so that they can demonstrate how the level of the grain in the cars gets changed.

One other issue is that the way the animal breathes will affect the anesthetic. If they don't breathe at all, they are not going to get any anesthetic to the lung. Going back to the train analogy, in the second example, I had the train going at the same speed this time. But the students, by moving the control on the computer, they can alter the rate at which the grain is falling from the grain elevator, which is analogous to the breathing of anesthetic into the blood. If you breathe in rapidly in deep breathes, that would be analogous to the grain falling fast and which means you get a lot of anesthetic in the blood.

In another example, I have a dog on the anesthetic machine and showing how changing the oxygen flow rate affects the anesthetic concentration in various parts of the machine. I have a control on the screen in such a way that when the students move the mouse, they can just change the actual flow rate and it visually displays the concentration that would result in each part of the machine when they do that. (Adamson: Interview, 10/16/92)

"Jeopardy"

Jeopardy was a little different from the other two programs. It was developed in the form of a game to help students review concepts that have been taught in Professor Adamson's courses. It also reviewed facts from courses taught by other professors. Sometimes the categories were not related to courses taught in the college. They may be general knowledge topics. The Jeopardy idea was borrowed from the popular TV show by that name.

The Jeopardy is another way of teaching them some facts, and it also helps students become comfortable with using the computer. (Adamson: Interview, 10/16/92)

Apart from putting a version of Jeopardy in the library for students to review on their own time, Adamson also had the version he used in class. Those were usually on the topic covered in class for that day.

I never make my lecture 50 minutes. I always stops the watch at about 40 minutes or 45 minutes. And for the last five or ten minutes, I review the most important concepts of the lecture in the format that I copied from the game show "Jeopardy." And I either randomly select three students to play or I divide the class into thirds. Sometimes I divide the class in halves. Last week I divided the class in half and half. The Michigan football fans were one team and the University of Michigan football fans the other team and they play each other. And it was a lot of fun. And again the categories are topics that I talked about in the lecture that I think are the most important parts. And then after they answered the question, I would then expand a little bit on it to say well, you got that right and everyone would realize that this is why that is right. (Adamson: Interview, 10/16/92)

Professor Adamson's Perception of Impact of Computer
Use in his Class

Professor Adamson's perceptions of the impact of computer use on his teaching were mostly positive. He perceived himself to have achieved his teaching goals. These included being able to bring reality to the classroom and expand the concept of education beyond the subject matter through his computer-assisted instruction programs. Professor Adamson mentioned that he was able to do things that were impossible for him to do before computers. He was able to create both the class and the stand-alone versions of all his CAI programs. He was able to make a more realistic Jeopardy program with computers.

Adamson:

About five years ago when I started using Jeopardy in class, there were no computer versions then. What I would do is write on the blackboard the names of the categories and I had the \$ amount written under them. When the students said the correct response, I would just crossed the \$ amount off with a piece of chalk. And then I would take the question from underneath a paper and put that on an overhead projector. So you can't do it realistically without the computer. I didn't have the timing and the automatic scoring then. In addition, the computer gives you color graphics, it gives you instant jump to the Jeopardy answers. And now with the class that now have computers on every desk, I can send this to them on the network. (Interview, 10/16/92).

However, not all Professor Adamson's computer experiences were pleasant. An "experiment" in which he tested a program developed as an alternative to lecture on the same topic flopped.

The "Experiment"

Professor Adamson helped a colleague to develop a CAI program on how anesthesia equipment works. Over the years, students had complained about the course.



The equipment they were supposed to see in the course was too small and many students found it difficult to understand how the equipment works from listening to lectures. When the CAI program on the course was completed, Professor Adamson and his colleague conducted a try-out to determine its effectiveness as an alternative learning medium.

In the process of the try-out, Professor Adamson split the students into two groups. One group listened to the lecture of the professor who normally taught the course. The second group worked in pairs on the CAI program. When the lecture ended an hour later, Professor Adamson also stopped the CAI group. Both groups were asked to complete a test based on the topic. The CAI group was also asked to rate the computer program as a medium of instruction.

Students' reactions to this "experiment" were not very pleasant. Adamson read aloud some of the students' comments.

Adamson:

Listen to this comment. "Computer classes were not a prerequisite for us being accepted into this program. Therefore I feel it is very," and very is underlined, "inappropriate of the instructors to assume we have computer knowledge and rely on it for lectures. We have paid for lecture classes not computer games. So that is what we should get. This is not a brave new world," and that's underlined too, "and some of us at least don't want it to be and cannot learn in such environment. If you do not want to lecture don't be a professor." Can you believe that? (Interview, 10/16/92)

Adamson himself later critiqued the approach that he used in the "experiment."

Adamson:

Well, in retrospect I think it would have been better to have his lecture and also have them go through the computer program as a refresher or to help them with concept they could not understand during the lecture. I don't think its the best idea to go through and get rid of that lecture. (Interview, 10/16/92)

Also making the computer group stop at the same time the lecture stopped was not a good idea, according to Adamson.

... because some students wanted to go through the computer program more slowly and read about, think about it, so I questioned how I set it up. I don't think I set it up very well. I should let them go through it at their own time but I wanted them to take the test right away because I didn't want them to talk to the people that had a lecture and they might detect why they are doing the test. But anyway, they both took the test, the lecture students and the computer students and the students that went to the lecture did significantly better than the student who had the computer program. The pre-test score was not any different but post test scores, although I think statistically they might not be different because I have a large variation. (Interview, 10/14/92)

Even though Professor Adamson admitted that the way he set the "experiment" up was not right, he also tried to prepare students for it. Not only did he explain to them the purpose of developing and trying-out the program, he made another opportunity available for them to review the lecture which he video taped. But none of the computer group ever went back to review the tape. Some of the students had made up their minds not to learn from the program even before they saw it.

Adamson:

Some of the students went into the computer program angry because they thought that they were being used as the guinea pig. Maybe they were, I don't know. But, let me tell you this much, I video taped the lecture too and I said, "Hey, you can go watch the video taped lecture if you want, but first I want you to do the computer program, then take this test. Then after that you can watch the video or the lecture." And well, they complained, hey we are getting cheated out of lecture. You know how many came to watch the video tape of the lecture? Zero. Nobody wants to do that much. They complained that they didn't get to see it, and then they didn't bother to look at it...I did explain to them, I said, "you know, students had trouble with this lecture, so we are trying to improve it." And I said, "this scores on this test I am giving you, I'm not even asking your names, I don't care who you are. I just want to see what is the best way to teach." And I thought that would warm me to them and like wow, here is a teacher who really wants to help us, but students... (Interview, 10/16/92)

Despite the unpleasantness of the "experiment," Adamson believed that there have been positive impacts of computer use on his students' learning. Many students came back to tell him that the programs helped them review the courses. Computers also fostered interaction between students and their professor. Students sent him e-mail messages when they had difficulties with aspects of the course. Some students have helped him modified his program by volunteering information on what aspects of the program were not clear. According to Adamson, students found it less intimidating to tell him what was missing in the program rather than his lecture.

Overall, Adamson felt that students' reactions to computers have been very positive. The students who reacted negatively to the experiment were those without computer knowledge. Andrew, Jake, and Dr. Conway confirmed this view.

Students' Perceptions of Impact of Computer Use in Adamson's Class

It was not easy to separate students' views about computer use generally in the college from computer use in Professor Adamson's class. Part of the reason may be because of the ways courses and teaching were structured in the college. As mentioned earlier, professors share the teaching of a course and they also shared teaching materials. So students talked about computer use in the college generally rather than in Professor Adamson's class in particular.

Students' reactions to computer use reflected the general reaction in the college. This is how Dr. Conway described it.

Conway:

It's been a spectrum of reactions from fear, intimidation, caution, moderate enthusiasm, to just dynamic excitement and a thrill to have the technology and the opportunity to work with it. I think that's reflected not only in the faculty

but in the students as well. Those who are experienced with computers and have used them are very excited. Those who are not familiar, who are not comfortable with computers, are obviously much more cautious. (Interview, 11/2/92)

The computer resource personnel--Jake, Andrew, and Matthew--also confirmed this view.

The reactions of the students in this study, just like the rest of the college, were mixed. Josephine's reaction was mostly positive. She found the case-based problem-solving exercises to be especially helpful in reviewing courses and preparing for her board exam.

Josephine:

There is a simulation program upstairs in the library for cases studies. Some of them are like, you go up to the farm and a horse is sick, what are you going to do? And you have a bunch of things to choose from and you are timed and you are graded on whether you make a good choice or bad choice. You may kill the horse or you may save it... Anesthesia program [developed by Adamson] is like that too. Where you get a patient that you are going to anesthetize and the program keeps prompting you about the decisions you want to make to get the patient anesthetized correctly. You have to use the right procedure. You can get your patient anesthetized well or the patient gets off the table. Or a patient dies. But it is nice because it makes you think the same kind of thought process that you are going to need when you are actually with the patient. And then you are timed, because you can run out of time, you can't sit there the whole day either. Time is crucial in a lot of things that we do too. For me when I do those cases on the computer, it helps me format a routine so that I don't leave anything out. (Interview: 10/14/92)

Having the case studies also enabled her to test her hypotheses about her patients using the computer "patients."

Josephine:

What I found myself doing is that I go on to do stuff that otherwise I wouldn't do [on a real patient] when I'm on the computer, so that I can find out what would happen. Or like a drug that I don't know about really, I mean I probably have learned about it sometime, but I don't really know about, which on a real

patient I wouldn't use. But on the computer patient I would try it and then I would see, oh so that's what that does. I think the computer broadens my horizon on stuff. And then I can kind of try it on the patient later. Or if I get something on the computer that I don't know about, I would go and look it up somewhere in one of my textbooks. (Interview: 10/14/92)

Both Laura and Rachel agreed that they had learned from the case-based computer programs. The case-based problem-solving exercises enabled them to practice clinical decisionmaking, which is very important in their field. Laura suggested, however, that it might be better if the programs have more of the questions "that challenged us to think rather than reading the text off of the screen."

Jackie, Denise, Stephanie, and Debra, the four second-year students, agreed that the case studies helped them in studying for tests. Computers made it easy for them to study the cases which they would otherwise have read up on in their textbook. They preferred the computer program to the textbook, however, because textbooks only present bits and pieces of a case at a time. With the computer, "you will get the answer right away. The program asks you questions about the case and then would explain why your answer is right and why this answer is wrong."

The students' reactions about computer use for classroom instruction were mixed. While Rachel felt that she learned better when professors use computers to illustrate topics during lecture, Laura felt that the computer and the professor were not a good combination during lectures.

Laura:

I found the computer more of a distraction than a help. I would prefer to have the professor teaching the lecture instead of relying on the computer to teach us. (Interview, 11/19/92)

Rachel:

Some professors used it basically as an outline for presenting their lecture. (Interview, 11/19/92)

Laura:

And I think that's alright too, because they gave you the big topic and they can talk about that, but everything wasn't right there on the computer. So you still have to listen to them. With the Anesthesia professors, they had everything right on the computer, so you could either tune them off or tune off the computer. (Interview, 11/19/92)

Jackie, Denise, Stephanie, and Debra, the four second-year students agreed that computers might be more helpful in the lab situation than in the class, "until professors are able to figure out how to use them in class." The students did not think that the computer by itself, as an instructional delivery medium, was a good idea. They believed that computer programs may be good in conjunction with the regular lecture. The students also mentioned that they like the CAI programs as a review after the class lecture.

As a review program, Laura and Rachel preferred that the case-based problem-solving aspect of the auto-tutorial be presented first. Then students should be given the option of accessing the concept screens if they need to. All the students agreed that playing Jeopardy at the end of the lecture was fun.

Among the concerns that students expressed were the way Professor Adamson set up the experiment with the anesthesia equipment program. Laura, one of the third-year students on whose class the experiment was performed, confirmed that they did not have enough time to go through the whole program before they were stopped. However, Laura perceived that most of the professors have not mastered the techniques of using computers in teaching.

Laura:

I think another thing that might help--we have some computers with interactive cases in our labs, and the professors have no idea how to work the programs or how to get the programs up on the computers. If they were taught before they

even try to use it in our labs, it would be a lot more helpful, and it would save our time, because we sat there maybe for fifteen minutes trying to get it up on our computers. If they knew how to work the equipment, it would help a lot, because I think that was the major problem when we first started using computers. (Interview: 11/19/92)

Rachel, one of the third-year students, mentioned that the workshop organized for students to help them learn about using technology for learning was very limited. It assumed that the students already know the basics of computing. Moreover, most of the programs developed were not easy to navigate. Frequently, the developers did not provide information about how users can exit the program.

Rachel:

They need to have easy entry and exit into the programs. And also within the program to page, because it is not easy to know where in the program are you. You can't just get there, you have to go through everything else and backtrack or go way forward and it takes a lot of time. (Interview: 11/19/92)

Section Four - Observation of Computer Use for Teaching

Another source of corroborative evidence for this case study was an observation of computer use that I conducted of Professor Adamson's class. Because Adamson was not teaching a class during the semester of this study, I obtained and analyzed a videotape of his lecture in which he used computers as a presentation tool. The next segment of this report contains Adamson's and my descriptions of his computer use for teaching.

The tape-recorded lecture that I analyzed took place in the large lecture hall with 116 computers for students' use. There was also the instructor's workstation. Professor Adamson was using mainly the computer program to illustrate concepts of



the lecture, punctuated by his narration. Through the slide to video transfer, the same materials he was using were transmitted to each screen at the students' workstations. He used the mouse to point at important topics, which the students could see because of the slide to video transfer projection.

The topic of the lecture was "Gas Anesthesia," which Professor Adamson already described above. Most of my observations corroborated evidence from the interviews of Adamson and his students. When the presentation began, the professors had an outline on the screen. This was to the students' screens.

OUTLINE

A. Advantages and Disadvantages of Inhalation Anesthesia

1. Economics of Anesthesia
2. Equipment
3. Supplemental Oxygen.
4. Control of Anesthetic Depth
5. Occupational Hazard

B. Important Terminologies

My first thought about this outline was that it did not separate advantages from disadvantages. It may be confusing to the students. This thought was confirmed later when a student asked if supplemental oxygen is an advantage or a disadvantage. Under "Economics of Anesthesia", the professor briefly described the costs of anesthesia gases. The cost anesthetic depends on the type of gas used for the patient. Under item A.2.: "Equipment" the professors clicked on the screens that displayed the anesthesia equipment, and he followed this with a brief explanation of how the equipment works. Item A.3: Supplemental Oxygen", Professor Adamson explained that it was "

used to vaporize the anesthetic. This mixture also provides supplemental oxygen to the patient." The explanation he provided on items A.4 ("Control of Anesthetic Depth") and A.5 ("Occupational Hazard") were not clear to me.

Most of the focus of the lesson was item B., ("Important Terminologies") in gas anesthesia. Important terminologies explained included MAC, MAC Values, important factors in MAC Values (solubility, partial pressure, and alveolar concentration)

MAC

Narration: "What do you think about when you see the word MAC?"

This was followed by three illustrations of the connotations of the letters MAC to students. a) MAC--a place to shop--illustrated by a picture of MAC on Grand River Avenue {only MSU students may know that MAC is a place}; b) MAC, a computer--illustrated by a picture of a Macintosh computer; c) MAC-- illustrated by a drawing of a McDonald burger. The program then zoomed back to the question that the professor asked initially, "What do you think about when you see the word MAC"? This was followed by the definition of MAC in Anesthesia, i.e., Minimal Alveolar Concentration which is a measure of minimal inhalation potency.

MAC values.

Narration: "MAC values range from low to high potency."

The professor clicked the buttons to display examples and equations relating to MAC values.

Examples and equation: Methorylorane has a MAC value 0.2 and highest potency
 Nitrous Oxide has > 100% with low potency.

Important factors in MAC values.

Solubility was the most difficult concepts among the important MAC factors.

The professor spent a lot of time explaining it with a lot of different illustrations and analogies. Solubility affects the anesthetic level and partial pressure.

Narration: "Therefore, agents with low solubility will build up faster and cause more rapid changes in the anesthetic levels. This is the most desirable."

Partial Pressure

Narration: "Agents with high solubility will take longer time to reach a given partial pressure than agents with low solubility."

Three analogies were used to illustrate this point. 1) A drawing of an airplane--very fast {high solubility}, 2) drawing of a car--fast {high solubility, but not as high as an airplane}, 3) drawing of a person with an anesthesia equipment--slow {low solubility}.

Alveolar Concentration

Narration: "There has to be a balance in the gas concentration in the brain. So less gas in the alveolar means less in the brain."

This was illustrated with a drawing of a lever on an oxygen tank. The professor demonstrated how students could use the mouse to pick up and move the lever up or down to increase or decrease the amount of gas going into the lung of the patient. Effect of the decrease or increase of gas on alveolar concentration could be observed immediately.

The professor's presentation ended at exactly 50 minutes according to the time panel on the computer program, just as he had earlier mentioned. The last ten minutes of the class was spent on the "Jeopardy," to review the lecture. The class was divided into three groups and Jeopardy categories were based on the three major topics covered. The professor read out the answer and the students responded with the appropriate question.



Example:

Answer: "The term that describes the potency of inhalation anesthetics."

Question: "What is MAC - Minimal Alveolar Concentration?"

There was also a final Jeopardy category that was based on a current event--Hurricane Andrew. Adding the general knowledge category was consistent with Professor Adamson's stated goals of adding fun to learning and extending learning beyond the classroom (Observation, 11/13/92).

My Comments and Impressions

I felt that the analogies on MAC were far-fetched. I wondered if the picture of a burger could help students make a connection with Minimal Alveolar Concentration?. I wondered if I missed the definition of partial pressure and its role in anesthetizing a patient or if the professor did not define it. It was not clear to me what agents do the analogies of the plane, car, and a person represent. I felt that Dr. Adamson made good use of animation in the presentation program. For example, the animation of a dog's head gradually expanding and then busting open because too much pressure was applied as a result of using nitrous oxide as a solubility agent, seemed to illustrate that point well. The analogy of the train going under a grain elevator was an illustration of the effect of circulation, one of the three factors that affect gas build-up in the system of the animal being anesthetized. Animation, color, and graphics were used effectively to illustrate those concepts. For example, the color blue was used to denote empty train cars, and red showed full or half-full train cars as they are being filled with grains from the grain elevator. Red was also an association with blood circulation which was what the train analogy was about. The drawings and their animation added lots of fun to the program just as Professor Adamson intended.

My impression was that computer programs were yet to be properly integrated into classroom events. The presentation was more like the professor reading the lecture off the computer screen. The professor did all of the "page-turning," while the students watched it on their screens. Except for the animation and graphics used to illustrate concepts, the presentation did not depart too much from the traditional lecture. The class seemed to come alive when the Jeopardy game was played. The students obviously learned some of the concepts as they were able to respond correctly to the Jeopardy based on them.

Summary

This case study focused on Professor Adamson who used computers for computer-assisted instruction. Computers were a major instructional tool in Professor Adamson's class. The computer-assisted instruction programs that Adamson developed were used to supplement his class presentation. Students also used the programs for review of topics already covered in lectures. The experiment in which he explored computers as an alternate to teacher instruction did not work. Adamson believed that the effect of computer use on his teaching had been mostly positive. He had been able to add dimensions to his teaching which were impossible prior to computers. He perceived his students to have learned through his use of computers.

Students' reactions to computer use for learning were mixed. While they perceived computers as a useful learning tool, they did not want computers to replace the interaction with the professors. My observation of classroom use of computers confirmed Professor Adamson's views of computer use in his class. The observation also revealed that computer integration was still an evolving process in the college.



SUMMARY OF THE CASE STUDIES

The first case study examined Professor Hake's computer use and the effects of his being an experienced computer teacher on his students' learning. Hake perceived positive effects of computer use on his students' learning. His students' reports and my observations confirmed Hake's perception of effectiveness of computer use.

The second case study was about Professor Dillon, a beginning computer user, who believed that computers should not dominate the subject matter. She perceived computer use to have been partially successful in her class. Her students' report did not confirm Dillon's perception of effectiveness. As prospective teachers, they preferred to learn computers as a tool for teaching rather than a communication tool.

The third case study looked at Professor Adamson who had a rich computing environment and used computer assisted instruction to support class presentations. Full-scale computing was relatively new in the college, and computerized teaching was still in the evolving phase. Adamson and his colleagues used mostly computer-assisted instruction for teaching. Adamson perceived computer use in his class to be effective. Some of his students reports confirmed this view, while some did not. Students warned that computers should not take over instruction from the professors.

CHAPTER SIX

SUMMARY, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

More research about technology in higher education is needed because college graduates are going into the work force ill-equipped to use technological tools, and because there is inadequate knowledge about how technology functions in higher education classrooms. One of the criticisms of computing research has been its focus almost exclusively on learners' interaction with the technology. How teachers, especially professors in higher education, view computers as a tool of work has not received much attention from the research community. There is a need to know how faculty use computers in their daily lives to help redefine educational goals that reflect the needs of the information society.

This study investigated how a group of professors perceive computer use in their teaching. There were four purposes for conducting the study. The first purpose was to answer questions about the different ways in which professors use computers and the kind of impact computer use has on their teaching. The second purpose was to increase understanding about how the technology can best be used in education, and what factors contribute to its effective use. The third purpose of the study was to provide faculty who are either non-users or beginning users of computers with information on which to make decisions about computer use in teaching. The fourth purpose was to provide administrators with a basis for making informed decisions about future technology plans and implementation.



Summary of the Study

Twelve professors were interviewed thoroughly about their perceptions of computer use and its impact on their teaching and students' learning. To consider the context in which professors use computers for teaching, three of the professors were selected for case studies. I obtained additional data via student interview to build the case studies. I also interviewed computer resource personnel and an administrator in a college where one of the case studies was conducted. I needed corroborative evidence from the students' interviews, classroom observations, and documents were necessary to check the trustworthiness of the evidence gathered from professors' interviews.

Among the findings of this study are that professors used computers for different teaching purposes including enhancing their own efficiency and effectiveness in the classroom, providing computer experience for their students, and automating repetitive teaching tasks. Teaching activities for which professors used computers included classroom instruction, instructional planning, management, communication, information storage and retrieval, testing, and grading. Impacts of computer use on teaching perceived by professors included the opportunity to expand the range of teaching strategies, efficiency in managing teaching tasks, and more control of teaching. Impacts of computer use on learning perceived by professors included increase in students' class participation, increase in quality and quantity of learning, positive attitude toward learning, and marketability. Among the impacts on classroom interactions were new modes of communication, increase in cooperative learning, and new roles in the classroom.

Some of the conclusions of this study are that computer use among the professors studied is idiosyncratic, influenced by personal and institutional factors. I speculate that positive changes taking place as a result of computer use indicate that

computers may offer education the opportunity to redefine educational goals that reflect the needs of the information society. However, the changes are likely to be gradual and slow. Computers are not likely to replace teachers in the classroom, and full integration of computers into the classroom process is still far from being achieved. The revolution that computers may bring to education may be because they fit better into the existing structure in the school than prior technologies.

Section One - Computer Use for Teaching

Research Question One

Research question one focused on the ways in which professors use computers in their teaching. Specific questions based on it are as follow:

- A. For what teaching purposes do professors use computers?
- B. For what teaching activities do professors use computers?
- C. What are the processes of computer use for teaching among professors?

Finding 1: Teaching Purposes for which Professors Use Computers

Professors in this study used computers for two major teaching purposes. These included serving educational goals and overcoming some teaching barriers. The professors distinguished between teaching goals they set for themselves and learning goals they set for their students. Alleviating teaching constraints such as a large class and limited office hours, is another teaching purpose for which computers were used.

Relation to the Literature

This finding confirms the findings of a number of studies that addressed educational goals of computing in schools. Sheingold, Kane, Endreweit, and Billings



(1981) found that school systems used microcomputers in ways that are consistent with their own goals, needs, and ways of operating. Among the broad educational goals mentioned in the study of Plomp and Pelgrum (1992) are: preparation of students for the future, keeping the curriculum up-to-date, and making school more interesting. Similarly, Betza's (1986) study identified educational objectives that computers were used to serve at Washington State University to include learning, skill performance, and job preparation.

In addition to the general educational goals identified in the above studies, Walker (1983) found that there were seven instructional objectives that microcomputers can be used to promote in the classroom. According to Walker, microcomputers can be used to promote: 1) more active learning, 2) more varied sensory and conceptual modes, 3) less mental drudgery, 4) learning nearer the speed of thought, 5) learning better tailored to individuals, 6) more independent learning, and 7) better aids to abstraction.

Similar goals and objectives were mentioned by the professors in the current study. However, the professors differentiated between teaching goals that they set for themselves and the learning goals set for their students. This is a departure from the studies reviewed. None of the studies distinguished between teachers' and students' goals of using computers. This may still be a carry-over of the view of the computer as a tool for learning rather than a teaching tool.

The idea of teachers' goals distinct from students' goals first came up in the exploratory study (see Appendix A). Further review of the literature on teaching revealed that educational goals can be defined at the levels of students, teachers, classrooms, and institutions. For example, constituting teaching goals, are students' learning and developmental goals; curriculum goals, extracurricular, academic, and personal goals; , and subject-matter principles. Teachers' goals relate to teachers'



autonomy and authority in the classroom, that is, the degree of control over the curriculum (H. Munby, 1983).

In the current study, most of the goals that the professors set for themselves are administrative in nature and are productivity related. The professors used computers to increase the effectiveness of their teaching strategies and efficiency of teaching task performance. They also used computers to model professionalism to their students.

Most of the instructional goals that professors set for their students were cognitive in nature. They were mostly goals of instruction prior to computers. These included understanding, application of knowledge, thinking and problem solving. In addition, new goals set included computer and information processing skills, including the ability to visualize 3-dimensional objects and explore and predict scientific phenomena. Some of the information processing skills included acquisition of knowledge using a holistic perspective and developing the ability to look at large-scale information and how its parts interconnect. Also included was the research skills of students, that is, the ability to gather useful information from various sources. Computers were used to enable students to learn these skills faster and better.

The second aspect of this finding dealt with how professors used computers to alleviate constraints of teaching. Clark and Peterson (1986) suggested that teachers operate within constraints and opportunities in their work environment. The constraints may be the physical setting of the classroom, the school, or it may be the curriculum.

The constraints which the professors were concerned with included the limitations of previous teaching tools and strategies, students' learning problems, the university timetable, large classes, and limited office hours.



Conclusions and Implications

The professors perceived computers as tools for extending both their own and their students' capabilities. The goals they set for themselves and their students reflected this expectation. The goals that professors set may be an indication of where they think computers fit best in their classroom.

The fact that professors differentiated between their own and students' goals in their use of computers was an indication that professors view computers as tools for teaching, not just another tool for affecting students' learning. This may increase its acceptance among new and non-users of the technology.

The professors stressed a lot of cognitive goals. Only one interpersonal goal was mentioned, namely, students' ability to work in teams. No affective or motor skills were mentioned. This, however, may be due to the composition of the professors studied. Further study may be needed to determine the affective and motor skills goals that professors set. It is interesting that apart from computer literacy and information processing skills, professors are not setting additional new cognitive goals for students.

In the course of the study, only a few of the professors were able to clearly demonstrate the linkage between stated goals and the classroom activities designed to achieve those goals.

Questions for Further Study

1. What are the new educational goals being set for computers by professors?
2. How are professors using computers to teach affective and motor skills?
3. What are the ways in which educational goals set by professors inform institutional missions and vice versa?
4. Are professors adequately linking educational objectives with the classroom activities designed to achieve those goals?



Finding 2: *Teaching Activities for which Professors Use Computers.*

Professors in this study used computers for seven main teaching activities. Classroom instruction, which was the most prominent teaching activity, was defined variously by the professors. Most professors used computers for more than one teaching activity while a few used computers for only one teaching activity. To some professors, computers are the subject of instruction and to others, they are teaching aids.

Relation to the Literature

This finding is consistent with the findings in the literature of academic computing. According to a Johns Hopkins University study reviewed by Lillie, Hannum, and Stuck (1989), computers can be effectively used in direct instruction, management of information about instruction, assessment, diagnosis, and instructional planning. Computers were perceived as an extension of teachers' instructional and instructional management capabilities among the teachers in that study. Significant use of computers for curriculum management and evaluation was reported by the teachers. CBI as a substitute for instruction was not used nearly as much as CBI as a supplement to instruction. CBI was most effective when aimed at increasing knowledge and comprehension.

In the present study, teaching activities for which professors use computers included classroom instruction, instructional planning, instructional management, testing, grading, electronic communication, and information storage and retrieval. The most popular use was classroom instruction. Professors defined computer use for classroom instruction to include taking computers directly to the classroom to aid class presentation, or using computer products like slides, transparencies, and computer-generated materials transferred to video tapes in class presentations. Also considered as

computer use for instruction were the computer-assisted instruction programs used to illustrate concepts during lecture or kept in the laboratory or library for students to review topics already taught in class was also considered computer use for instruction.

Instructional planning involved using computers to create the structure and content of the syllabus and lecture notes. It also included using computers to develop overhead transparencies, slides, and handouts. Computer use for instructional management consisted of keeping databases of students' attendance records, grades and reports, and student advisement.

Computer use for testing included administering multiple-choice tests, on-line competency tests, keeping a test bank, and keeping practice tests on a file-server for students' use. Using computers for grading involved professors manually scoring the test. However, computers were used to compute the weighted averages and final grades and to draw the grade curves.

Computer use for communication included sending and receiving messages from students about class assignments, students receiving and submitting assignments through e-mail, students discussing class readings among themselves on e-mail, and posting of information to the electronic bulletin board.

In terms of the mode of computer use, the finding in the present study also confirmed those in the literature reviewed. Computer use in Plomp and Pelgrum's (1992) study ranged from playing games to computer-assisted instruction. Plomp and Pelgrum also found computer use for demonstrations in front of class, introductory courses about computers as tools, and remedial and enrichment CAI. Dalton (1987) confirmed the findings of Plomp and Pelgrum's study. Dalton found that teachers perceived computers more as an instructional tool or a supplement to their own instructional programs.

In the current study, the mode of computer use for teaching activities varied among the professors. Most of the professors used computers for multiple teaching

activities, while a few used computers for only one teaching activity. There were professors whose usage involved regular classroom instruction while some took computers to class for occasional demonstrations. Computers were either taught to students as subject matter or used by both professors and their students as tools of teaching and learning. Professors whose subject matter was computers taught students a wider variety of applications, ranging from basic productivity tools such as spreadsheets, word processing, to advanced application such as CD-ROM, QuickTime, and Hypermedia. Professors who used the computer as a presentation aid in classroom instruction used a limited number of applications. Some professors' instructional uses of computers were peripheral, such as asking students to use computers to complete their assignments.

Conclusions and Implications

The small number of professors in this study preclude making claims of having exhausted possible ranges of teaching activities for which professors use computers. It is more likely that other teaching activities for which professors use computers exist but were not mentioned by the professors studied. Further studies are recommended to identify other teaching activities for which professors use computers.

As a result of the variation in teaching activities and the different definitions of what constitutes instructional uses of computers among professors, it may not be easy to recommend "one best way" of using computers for teaching. Administrators should, therefore, provide facilities flexible enough to accommodate a range of possible uses.

Questions for Further Study

1. What are the factors influencing the choice of teaching activities that professors use computers to support?
2. For what other teaching activities do professors use computers?

Finding 3: Processes of Computer Use in Teaching

The findings about the process of computer use among the professors studied are presented in terms of: a) the procedures of computer use and b) the computing resources used for teaching.

Finding 3a: Procedure for Computer Use in Teaching

Procedures for performing each teaching activity with computers differed from professor to professor. Professors emphasized different aspects of their teaching in the procedures they used. In carrying out the procedures, computers served as the professors' tool rather than the task performer.

Relations to the Literature

The literature of academic computing is silent over procedure of computer use for teaching. Except for those studies that described the strategies used in the design of computer-assisted instruction programs, most of the available studies of teachers' computer uses are surveys which did not take into account the details of the context in which computer use occurred. Cox (1992) found that computer-assisted learning (CAL) programs developed for instruction (as opposed to those developed for review) contained elements that could be termed as procedure of use, such as, 1) presenting

students with a description of the topic, 2) posing questions, 3) checking the validity of the answers, and 4) providing feedback to reinforce learning.

The literature on teaching provided further insight into teaching procedures, especially procedure for instructional planning. At the planning phase, teachers set the class goals, curriculum objectives, and strategies; specified content; selected method of assessment; and developed class materials. This could be done as yearly, term, weekly, or daily planning. Teacher's planning was greatly influenced by teachers' beliefs and is drawn from many knowledge bases. These included knowledge of subject matter, discipline requirements, students' learning, students' prior knowledge, school timetable, and resources available (J. Herman, 1988; R.J. Yinger, 1979).

In the current study, there are indications that professors may plan differently from elementary and high school teachers on which most of the studies in *Research on Teachers' Thinking* were based. Professors' planning did not appear to be as elaborate as those of elementary and high school teachers. Professors in this study appeared to emphasize the structure of their syllabi which were based on a semester's course. They also emphasized their lecture notes which were based on daily plans. Professors appeared to stress subject matter content more than learning objectives or strategies. However, because the focus of this study was not professors' instructional planning, these are hypotheses for further study.

Professors in this study defined their procedures for using computers differently based on the teaching activity and their personal style. In instructional planning, professors used computers to create the graphics (slides) of lecture notes and made them into overhead transparencies. He also reproduced the slides and bound into note-taking booklets for students. Students used the notes as "an advance organizer" to help them prepare for class. Students also used the booklet as a note-taking guide during class. The notes also served as a repetition opportunity for students.

Another instructional planning procedure emphasized steps for structuring the course content into a syllabus. The procedure began an organizing topic which were broken down into parts historically or functionally, further broken into meaningful units, and organized into a structure and elaborated. The end product was an outline of topics and sub-topics that was given to students as the syllabus. The computer was used for composing and organizing the structure of the course and lesson plan. The professor composed the plan on the computer and used "cut and paste" functions to rearrange the component parts.

In line with findings from the *Research on Teachers' Thinking*, professors appeared to draw on certain knowledge bases and a set of belief systems in their instructional planning. These included knowledge of their profession, professors' intuitive knowledge of what they believe is important, and their experience. Knowledge of the context of teaching, such as the university's calendar, also appeared to influence professors' planning.

The computer's role was more central in the procedures for classroom instruction. It was used as an essential part of instructional delivery. Professors appeared to emphasize different aspects of their procedures for computer use for instruction. While some professors emphasized the interactivity in their classrooms, some emphasized the function of the CAI they used in instruction. Steps in a procedure for classroom discussion, for example, consisted of the professor 1) asking students to do research on a certain topic, 2) "throw up skeletal ideas as seeds," 2) ask for class discussion of the topic, 3) summarize and type the points raised in the discussion into a word processor, 4) edit and review the points as the class reaches a consensus, and 5) store and print out class notes for next class.

Procedures for testing and grading still resembled what it was prior to computers. The difference was that computers aided the efficiency of administering and grading the tests. In administering multiple-choice tests, the computer presented the

question and answer options. Students selected the letter corresponding to their response. For essay or competency tests, the major use of computers was to store "practice tests" on the file-server. Students practiced with those before taking the actual test. In some cases, word processors were used to personalize essay tests for students. Many of the tests, especially essays, were scored by the professors. They used computers to create a "boiler-plate" of important feedback that professors wish to convey to students on their papers. In grading, the professors created databases of quizzes and exams, entered formulas to compute averages, sums, and produced the final grades, including the curve of students' performances.

Conclusion and Implications

It is interesting to note that most of the procedures described by professors are what they normally did prior to computer use. However, with computers, the process has become easier and richer. Rather than revolutionize the education process, the computer's contribution may be that it fits better into the structure of the school than its technological predecessors.

There was no one particular teaching activity for which computers were most suitable. Administrators of higher education institutions may need to provide computing resources to cater to the variety of styles and needs of their faculty. Other professors contemplating computer use in their teaching may find it easier because they have examples of alternative approaches from which to choose.

Most of the procedures described gave no indication of what proportion of teaching activities were carried out with the computer. Measures of the proportion of computer usage may indicate the level of computer integration into teaching activities.

Questions for Further Study

1. Do professors plan similarly or differently from elementary and high school teachers?
2. What proportion of teaching is being done with computers?

Finding 3b: Resources for Computer Use in Teaching

The professors studied used four categories of computing resources: 1) software and hardware, 2) technical and administrative support, 3) training, and 4) funding. Computing resources for faculty came from four major sources: 1) professors themselves, 2) their departments or colleges, 3) the university, and 4) sources external to the university. Most faculty found the available resources adequate for their current usage. Needs for additional resources were expressed by some professors.

Relation to the Literature

This finding is consistent with findings of other studies on academic computing. Part of the conclusions of a review of various studies conducted by the Office of Technological Assessment (OTA) (1988) were that powerful hardware and software, increase access to computers, training for teachers, administrative support of experimentation and innovation, and time to learn and practice are essential to successful implementation of computers in schools.

Plomp and Pelgrum (1992) found that general purpose software such as word processors, spreadsheets, and database programs were broadly available in the schools they studied. However, educational software was not widely available. In Austin's (1988) study, faculty had access to both Apple and DOS computers and used computers as both personal productivity tools and as instructional media.

These findings were confirmed in the current study. The professors studied used 14 groups of software applications consisting of 42 brands of off-the-shelf commercial

software, and 8 locally-developed courseware programs in their teaching. Most of the software packages were generic applications, while a few were discipline specific. These included productivity software such as word processing, databases, spreadsheets, e-mail, graphics, statistical packages; presentation and authoring systems; multi-media tools, such as, interactive video, CD-ROM, and Quicktime. Tables 3.7 and 3.8 present the categories of applications used by the professors.

Word processors and presentation software were used more frequently in instructional planning, while spreadsheet programs are used more for grading. ToolBook and HyperCard were the most popular platforms used in developing CAI programs.

Professors chose these software packages for different reasons. Some applications were chosen because of their characteristics, such as ease of use and learning, suitability for teaching tasks, and user-friendliness. Some applications were chosen for professional consideration, that is, they were the applications students were likely to use in the field as professionals. Some professors used certain applications just because there were no better alternatives.

Macintosh, IBM, and IBM compatibles were the most common types of computers used by the professors. NeXT and UNIX computers were used mostly by the professors in computer and natural sciences. Most of the professors used e-mail through the MSU IBM mainframes. Peripherals used included Proxima LCD display panel for projection, CD-ROM and interactive videodisc players, scanners for transmitting images to students' workstations, and VCRs. Hardware characteristics that the professors considered included memory, graphics, and color capability.

In terms of facilities, some of the professors whose computer use directly involved their students used public computer laboratories for their classes or lab work. These facilities were managed by the MSU Computer Laboratory. More professors used computing facilities housed within their departments or colleges. Some professors

used the services of the Instructional Media Center for equipment loans for classroom instruction.

Betza (1986) found that sources of funding and resource support varied among faculty. Sources of computing support mentioned by the faculty in Betza's study included grants from companies, government sources, and the university itself. Some professors mentioned that they had no support.

Similarly, in the current study professors' sources of support included themselves, their departments or colleges, the university, and sources external to the university. The professors had at least one personal computer for their own use provided either by their department or college. Professors purchased their software through teaching funds from their departments or on their own. Technical support was usually provided by the college or department through full-time technical experts or student assistants who were knowledgeable in computers. In a few instances, the university-wide technical resources were used. More experienced professors seemed to rely mostly on themselves for technical support.

Administrative support was less-mentioned among professors. Only the professors in the colleges where there were heavy investments in computing and where full-scale computerized teaching was done (colleges of veterinary medicine and human medicine) mentioned that administrative support was essential to their successful computing.

Funding was the most utilized university-wide computing resources. More than half of the participants in this study were selected because of the funding they received from the university to develop technology-based instructional materials. The grants, which were in form of money, programming, and studio time, were helpful to the professors. However, some of the professors who did not receive the grants were using computers as much as those who did. Professors also found funds for computing from



government agencies, such as the U.S. Department of Education, corporations such as Apple Computers, Zenith Computers, and Autodesk.

Training was the least-utilized computing resource available to the professors. All the professors stated that they trained themselves to use computers. With the exception of a few professors who had learned about computers in graduate schools, all the rest of the faculty did not have any pre-service training in computer use. Only a few professors had taken advantage of the training provided by the university.

Among the needs expressed by the professors were more funding for further development of CAI projects, computer laboratory facilities for departments that have no in-house facilities, easy access to projection equipment, and technical experts to keep abreast of computer technology on behalf of professors.

Conclusions and Implications

A review of the literature on computing resources at Michigan State University revealed that there were training programs specifically geared toward helping faculty integrate computers into their teaching. It was, however, surprising that only a few of the professors studied had taken advantage of the training resources provided by the university. It was equally surprising that fewer still expressed interest in further training.

Most colleges on campus seemed to have computing systems customized to their own special needs. Even though more of the professors mentioned that they used resources from their own college or department than they do the university computing resources, there are some university resources that professors used. Both centralized and distributed computing services may be beneficial to professors than either one alone.



Questions for Further Study

1. Is the lack of interest in computer training general among MSU professors? What are the factors responsible for faculty's lack of interest in computer training provided? Under what conditions are faculty likely to utilize the training resources?
2. What forms of administrative support for computing are available to faculty in their departments or colleges? Do professors perceive any influence of administrative support on their successful implementation of computers in the classroom?
3. Under what conditions are distributed computing resources beneficial for faculty computing versus centralized computing, and vice versa?

Section Two - Impact of Computer Use on Teaching, Learning, and Classroom Interaction

The findings about the impact of computer use are presented as Finding 4a through 4c. Finding 4a deals with professors' perceptions of the impacts of computer use on professors' teaching, 4b focuses on the professors' perceptions of the impacts of computer use on students' learning, and 4c deals with the professors' perceptions of the impacts of computer use on classroom interactions.

Finding 4a :Impacts of Computer Use on Teaching

Professors perceived mostly positive impacts of computer use on their teaching. Computers extended their capabilities, enabling them to use creative and innovative strategies in teaching. Computers increased their efficiency and control over teaching. Their knowledge of computers increased.



Relation to the Literature

This finding supports similar findings of computer impacts on teaching. According to an OTA (1988) report, teachers perceived that technology had impacts on their teaching. Teachers are changing their teaching style from presenters of ready-made information to facilitators of students' learning. The range of opportunities and strategies through which teachers can reach their students has increased. Similarly, the teachers in Sheingold and Hardley's (1990) study believed that computer use had changed their teaching. Because they can present more complex materials and in greater detail, teachers' expectations of their students has increased. Computers also presented the teachers with the opportunity to individualize instruction and the learning environment for students.

The opportunity for increased collaborative learning was the major change attributed to computer use by teachers in a 1985 Johns Hopkins University study reviewed by Lillie, Hannum, and Stuck, (1989). The majority of the teachers studied, however, indicated that classroom organization and routines have not changed as a result of using computers.

Similarly, in the current study professors perceived impacts of computer use on their teaching. Computer use increased the opportunity for professors' creativity and innovation in instructional strategies. The professors believed they have been able to shape students' learning by using computers to bring into the classroom a variety of information, real-life and simulated data that enriched the learning situations. The professors have been able to create multiple opportunities for students to learn through computer-assisted instruction programs, sharing of lecture notes, class demonstrations, and to increase students' participation by switching from lecture to discussion and hands-on methods. Through CAI, professors have been able to individualize instruction by holding the instructional context constant while varying time for individual students.

At the same time, professors reported an increase in the group assignments involving computers that they are giving to their students.

In terms of productivity, computers allowed the professors to increase the efficiency of teaching task performance by automating repetitive tasks and cutting down on preparation time. The freed time was used to increase interaction with students and provided more regular evaluation of learning. Professors were able to manage students' records, teaching records, and save office space by keeping teaching notes on diskettes.

More control of teaching and increased computer knowledge were the personal gains of computing that the professors reported. Computers provided professors with the flexibility of updating or developing new teaching materials. Professors were less reliant on outside sources for their syllabus preparation. Computers allowed them to make last-minute changes in their lecture notes which sometimes enriched the class materials.

Conclusions and Implications

From the literature and this study, there is evidence that computers are impacting the classroom process. There are gradual changes in the classroom that may be indicators of what is feasible and what educators consider important. It is interesting to note that while there were changes in teaching strategies, activities of teaching and content of instruction did not seem to have increased in the additive sense. Professors appeared to be teaching similar course content, but in different ways. Perhaps the gains of computers in education may be that it enables teachers do better what they already know how to do. Creating new knowledge for traditional courses may not be one of the immediate gains of computers. However, this hypothesis is subject to further testing.

There were professors who believed that computer use contributed nothing to their teaching. Computers were just "something nice" to show students.

Questions for Further Study

1. Do computers offer professors the possibility of creating new courses or new knowledge bases for traditional courses? What are the reasons for faculty conservatism regarding computer use?
2. What are the real and professed reasons for computer use among professors?

Finding 4b: Impacts of Computer Use on Students' Learning

Professors perceived mostly positive impacts of computer use on their students' learning. Students learned better and have developed positive attitude to learning. Computers contributed to the achievement of students' educational goals in terms of marketability, competencies, and motivation to learn.

Relation to the Literature

This finding confirms similar studies of impacts of computer use on students' learning. According to Betza's (1986) study, students learn more concepts and skills, and can do so at their own pace and time. Top on the list of evidence that the faculty in Betza's study presented about the benefit of computer use to their students was jobs. This was followed by student's motivation and learning. According to the professors, students need computer skills to get good jobs. Evidence of students who have started their own computer-based businesses was also cited.

Betza also cited an improved attitude toward learning and high motivation due to computer use. Students rated computer homework highly. Learning, and improvement in performance, were also mentioned by faculty. According to the faculty, students are more capable and more competitive, citing evidence of students

who have won awards, published articles, or presented papers on projects originating from computer-related courses.

In the current study, some of the perceived impacts of computer use on students' learning included active participation, increased learning, computer skills, meeting national standards, and marketability. The professors believed that computer use for class discussion, computer assignments, and group projects increased students' active participation in the learning process. Moreover, students learned more and better and were able to demonstrate more knowledge of the course and of computers. They also demonstrated the ability to apply that knowledge. Students' attitude toward learning also improved. This was demonstrated in students' desire to learn more about computers and in their enjoyment of the course and working with computers.

Students' competence also increased. In addition to subject matter knowledge, they learned skills associated with computing, for example, word processing or data processing and computer literacy. In some instances, students' verbal skills were also shown to have increased. As a result, both students and their professors perceived students to be more marketable because they had learned the required skills of the information society.

Not all the perceived effects of computers on students were positive. Some students were so impatient to begin using computers that they sometimes miss out on necessary learning steps. Many students still had anxieties about using computers. They found it difficult to be comfortable around computers and this prevented them from seeing computers as another medium of learning. In some cases, there were no perceived impacts of computer use on students' learning.

Conclusions and Implications

Evidence from this study and the literature supports the idea that when computers are well used in teaching, students learn more, and have a positive attitude towards learning. They see the computer as a tool of work and learning. The majority of the professors were still struggling with how to use computers to teach in order to effect students' learning. The connection between perceived students' achievement and computer use was still missing in most cases, as many of the professors did not evaluate computer aspects of their teaching. Professors may need training in how to integrate computer into courses and how to evaluate such courses.

I recommend that computer anxiety and students' acceptance should be taken into consideration by faculty introducing computers into their courses. Just as there are differences in professors in terms of their computing skills or their affinity for computers, similar differences are found in students. Professors should plan for these differences.

Recommendation for Further Study

A longitudinal study of how professors link students' achievement with computer use may be needed.

Finding 4c: Impacts of Computer Use on Classroom Interactions

Professors perceived that the impact of computer use on the classroom processes was a change in the mode of interaction, the communication pattern, and the roles in the classroom.

Relation to the Literature

McMeen (1986) predicted that because of computers, the role of teachers will clearly change. Teachers will spend less time giving routine lectures or grading multiple-choice exams. Instead, they will be able to spend more time designing challenging assignments, serving as consultants, providing inspiration, and rewarding success.

Evidence from the literature and the current study suggests that McMeen's prediction may be coming true. Plomp and Pelgrum (1992) found that many teachers have started to change their classroom management using computers. By applying different forms of grouping and student-to-student interaction during lessons with computers, teachers change their roles. Computers thus challenge teachers' existing instructional routines by requiring them to shift roles from the image of the all-knowing teacher to that of a guide and a learning partner (J. Olson, 1992; R. Kozma and J. Johnston, 1991). This however, is posing a challenge for teachers as many teachers find the shift to mentoring uncomfortable, and many do not know how to make the transition.

W.P. Dickson and M.A. Varen (1983) found that grouping students for CAI instruction yielded consistently superior performance across both gender and ability. The group size and the requirement to rotate the role as communicator forced higher and more sustained levels of engagement than was possible with traditional one-learner-to-one machine role in CAI interactions. The students received perspectives from their partners that enabled them to confirm, correct, or clarify their comprehension of the lesson's concepts.

Similar results were found in the current study. The professors believed that computer use made a difference in the interactional processes in their classrooms. It increased student-to-student interaction, student-to-professor interaction, and the amount of time students spent on computer-based class assignments. Computers

allowed different modes of classroom interaction and allowed professors to share their role and authority while maintaining their influence.

The professors perceived that computers offered them opportunities for individualization of instruction and cooperative learning. Computer use provided them the opportunity for making learning more relevant to the needs of individual students and allowed students to work at their own pace. It occupied other students' time while the professor was attending to individual students' needs during instruction. Group projects were also seen as promoting learning, especially when the group dynamics works. However, group interaction appeared to hamper learning where group dynamics did not work.

There appeared to be an evolving pattern of communication between professors and their students. Some professors and students perceived the gap between students and professors to have been reduced because of the availability of e-mail as a communication medium. Rather than waiting for professors to initiate communication, students appeared to be taking more initiative in getting a dialogue going between them and their professors. There has been an increase in the amount of messages and feedback between professors and their students regarding class assignments and non-class matters.

E-mail has also increased access to professors. Students did not have to wait until office hours to talk to professor outside of class. They did not have to "hunt" down a professor before getting the help they needed.

Opportunity for students to provide their professors with feedback about their teaching was one perceived advantage of e-mail communication. Professors have used the feedback from their students to revise their CAI programs and reteach certain concepts in the classroom. Moreover, professors perceived changes in the roles of students and the professor in their classroom. Professors' expectations of their students have increased. This was evident in their willingness to let students lead class



discussions and in allowing knowledgeable students to introduce new computer applications into the classroom and mentor other students. Professors also perceived students to be more willing to take on their new roles.

Conclusion and Implications

The change in the role of professors from that of a teacher to that of a mentor may take longer than anticipated. Most professors are still trying to find out how to be mentors rather than teachers. Learning to learn from computer sources as well as from the professor is gradually taking hold among students, but many students still perceive professors as their main source of information. Computers are likely to be more like a text book, something adjunct to the professors for a long time, because of the orientation that students have that there should always be "someone" lecturing.

It may be in the area of communication networks that computers can make the most dramatic impact on how students relate to their professors. Because some networks are set up so that students can ask question or give suggestions to their professors anonymously, students tend to be less inhibited by the authority figure of the professors. It appeared that the more adventurous among the professors welcomed any form of feedback from students, whether pleasant or unpleasant. According to the professors, by hiding behind the "anonymity" of the e-mail to challenge professors' assumptions without fear of persecution, students can help make the instructional process better.

More professors believed they are also learning from students. Some students are more competent in computers or have computer knowledge which professors are willing to let them share. As a result, students are beginning to feel comfortable with the role of information providers. This has implications for possible changes in traditional views of teaching in which only professors teach and only students learn.



The interaction with computers in the college classroom is still at its infancy. Professors are still trying to find the best way to group students for class assignments, resolve conflicts that may arise when grouping does not work, giving students exposure to the limited number of computers available, and managing the volumes of E-mail messages that came from students daily.

Questions for Further Research

1. What patterns of communication between students and professors are made possible as a result of computer use for teaching?
2. In what ways can e-mail communication from students influence professors' teaching?
3. Under what conditions would students benefit from professors' "mentoring" and "lecturing" roles?
4. Does the computer offer the potential for shifting the balance of who teaches and who learns in the classroom?

Section Three - Case Study Findings

The purpose of the case studies was to explore further the impact of computer use on teaching and learning and the conditions under which the perceived impacts can occur. Findings in this section are discussed as Finding 5a through 5c.

Finding 5a: Case Study One

Students' perceptions of computer use and its effectiveness confirmed those of the professor's. Computer use and the professor's strategies were perceived to have increased students' learning. Students demonstrated knowledge and application of computers.

Discussion

In the first case study, the goals of the professor were to promote understanding, application of technology, and a positive attitude toward learning in his students. Both the professor and his students confirmed that computer use was effective in promoting learning in that class. Increased knowledge and competency, positive attitude toward course and computer use were some of the effects perceived. The students demonstrated a knowledge of computers by listing and describing uses for the different computer applications they were taught in the class. This was important considering the fact that computers were the subject matter of the course. The students also listed computer capabilities and weaknesses, and what they could do as professionals to take advantage of the capabilities and overcome the weaknesses.

They also perceived Professor Hake as a good role model of computer use. His students saw him as knowledgeable about the computer and how to teach it. His understanding of problems of learning a technical subject, such as computers, was also noted by his students. He worked to relieve the computer anxiety of his students. He motivated them to learn to use the computer as a tool by showing students its relevance to their lives, their prior computer experience, and by the way he himself used computers. As a result, students were more confident about their abilities, and when computer problems arose, they thought of solutions rather than abandoning the projects.

Experience in teaching and in computer use may have contributed to the professors' success in the classroom. It appeared that he made few teaching mistakes, and he integrated computers much more closely with the course content. He had a working routine which he had tested on many occasions. He used the knowledge of what worked in other situations to gauge success in the current situations. So he tried-out his materials before every class and spent considerable time preparing for class.

Conclusions and Implications

It is interesting to note that both the professor and his students recognized that computers have weaknesses and will not solve all their problems, in spite of the degree of success they have achieved in that class. It is also interesting that they did not attribute computer problems to their own lack of skill, but to the hardware and software used.

Evidence from this study shows that computers have potential to enhance students' learning when certain conditions are met. Computers may enhance students' learning when: a) students perceive computers to be relevant to their work and life, b) they perceive their professors to be effective role models of computer use, c) students perceive professors to be knowledgeable about computers, d) professors work at relieving the computer anxiety of students, and e) professors prepare adequately for computer use.

Finding 5b: Case Study Two

Students perceived no effect of computer use on their learning the course or learning about computers. The goals or intentions of the professor did not meet students' expectations. Students did not perceive the professor's strategy for computer use in the courses as effective.

Discussion

In case study two, the professor introduced students to computers as an information processing and communication tool. The goals were that students acquire computer literacy skills and be able to use technology to enhance the curriculum in their own classrooms. While the professor perceived herself to have succeeded in

achieving these goals, her students did not perceive any effect of computer use on their learning. From the students' point of view, the objectives and implementation of computers in the class did not match.

The professor also seemed to have misdiagnosed students' computing needs. Students did not consider word processing a priority computer skill for them to learn as prospective teachers. Most of them already knew word processing. Educational software for the K-12 school system in which students expressed interest were not taught or used in a computer class for teachers. Even though students believed that the course exposed them to E-mail use for communication, they were not taught or shown how E-mail could become a teaching tool.

The strategy used by the professor also was a concern to the students. Making computers "peripheral" to the course sent mixed messages to the students about the professor's computer interest. Computer skills were taught to students by "an outside person." Computer problems were never discussed in the regular class. When there were problems, students were directed to the professor's assistant. Students' perceptions were that computers were not important to the professor, even though she claimed that they were. They attributed this to lack of computer knowledge or skills on the part of their professor.

Conclusions and Implications

Case study two illustrated some of the pitfalls that professors contemplating computer use for teaching may want to avoid. Making computers peripheral to the course may not be the best way to go. Professors should not assume computer literacy in their students. Coming from a variety of backgrounds, students are likely to be at different levels in terms of their computer skills. Care should be taken to match students' needs with the course requirements.

Things that professors may need to pay attention to when introducing computers into their courses include: a) knowing the ability range in terms of computer skills of their students, b) preparing students' minds for computer use and providing incentives for its use by stressing its relevance to things of interest to students, c) providing multiple opportunities for students to learn to use computers, d) using themselves as role models of computer use, showing students by example that computers are important, e) taking time to address concerns that students may have regarding computer use, and f) encouraging students to use computers by awarding grades for the computer aspects of the course.

Given that the professor in this study was a beginning teacher and beginning computer user, these results and perceptions from the students may be expected. It was interesting, however, that the professor attributed the problems perceived in the class to lack of time and too much work load rather than lack of interest on her part to explore further the possibilities of computers for teaching.

Finding 5c: Case Study Three

Perceptions of the impact of computer use were mixed. While CAI was perceived to have enabled some students to learn better, some students perceived that computers hindered their learning. The consensus was that computers should not be allowed to replace the professor. Administrative support for computing was high and resources for computing were well integrated.

Discussion

The professor in the third case study was part of a large-scale computerized teaching effort in his college. Well-coordinated computing resources were at the

disposal of professors for both large classes and small group instruction. The perspectives of the administrator and personnel in charge of these computing resources indicated that computer use required a coordinated team effort. Administrative support in terms of provision of resources, support of professors' efforts, and reward for computing were part of this team effort.

Computer-assisted instruction, the main instructional use of computers in the college, drew mixed reactions from students and professors alike. Some students perceived a positive impact of computer use on their learning. The case simulations helped them to learn about making quick decisions which was essential in their discipline. Some students found the CAI programs useful in preparing for their board exams.

Evidence provided by the professor, other students, and computer resource personnel indicated that most of the negative impact perceived came from students who had no computer experience. Because full-scale computerized teaching was still at its infancy in the college, there were many false starts. Initially, students' lack of computer experience was not taken into consideration before they were introduced to computers for learning. Also, there was a backlash from early experiments by professors to see if certain aspects of their lectures could be replaced with computers. These conditions, with students' impatience and lack of acceptance, appeared to have shaped later computer use for teaching in the college. As professors matured in their computing efforts, and with the continued support from the administration, they became better at developing computer-assisted instruction programs and better at teaching with computers. While they still used CAI programs as a presentation aid in their lectures, professors used the programs more as tutorials that reviewed topics already covered in lectures. Case-based problem-solving exercises appeared to be a preferred mode of using CAI to help students apply concepts learned from other sources.

Conclusion and Implications

While students in this case study complained that they had no computer skills, efforts to get them to learn to use computers through training did not yield much result. Attempts to get them to view a video-taped lecture versions of the computer class about which they complained did not meet with much success either. Part of their complaint was that as medical students, there was too much material to cover and too many exams to pass. These may be genuine concerns that speak to restructuring programs of study in medical colleges across institutions or within the institution in order to encourage students to take advantage of computers for learning. On the other hand, with time, computers may help students process the volume of information better.

Full-scale computerized teaching as operative in this case study may be the best way to implement computers in education. However, institutions should be aware of the investment in time, money, personnel, and the cost of experimenting, that such an approach may involve.

Questions for Further Study

1. Does problem attribution affect students' perception of computers as a tool of learning?
2. What conditions enhance the chance of successful use of computers in the classroom?
3. What are the characteristics of students' attitudes that may shape instructional use of computers in the classroom?
4. How do students' make connections between computer simulations and the real life experiences that those simulations represent?

Section Four - Themes

This section presents some of the themes that emerged from the study. They include the problems associated with computer use for teaching, challenges that computer use for teaching pose for professors, the affective aspects of computing, and influences on professors' computing choices. Findings in this section are presented as Finding 6a through 6d.

Finding 6a: Problems of Computer Use for Teaching

Some problems that professors perceived in their computer use for teaching included hardware and software, lack of skill, limited access to computing facilities, lack of computer integration into the programs of study, and computer anxiety in students.

Relation to the Literature

This finding confirms similar studies of problems of academic computing. Sheingold and Hardley (1990) found that inadequate hardware and time to plan and implement computer-based lessons were some of the barriers that teachers perceived in their teaching. Similar findings were reported in Betza's (1986) study.

The study by Kozma and Johnston (1991) attributed the inability of teachers to use computers extensively in their teaching to lack of knowledge or computer competencies, inadequate hardware and software, lack of computing support, and organizational structure of the school system. van den Akker, Keursten, and Plomp (1992) also believe that lack of technical skills in using computers created uncertainties on the part of the teacher. A consequence of this may be that educational computing will be restricted to the limited level of expertise of the teacher. According to Drew (1989), professors face the problem of aptitude to incorporate creative new applications that may be ahead of their time.

Lack of institutional support for pre-service training may be a problem. Naron and Estes (1986) found that the pre-service teacher training in the departments of education in the universities they studied did not adequately prepare teachers to use computers. Most of their computer courses were geared toward providing technology literacy, and unless a student-teacher is specializing in instructional technology, his or her exposure to technology is limited.

In the current study, some of the problems are similar to those in the literature reviewed. Hardware and software problems that the professors faced range from bad disk drives to poor resolution of projectors, network failures, inadequate storage memory, obsolete computer systems, virus-infected software, software that is not user-friendly, bugs in software, and inadequate documentation. Prohibitive cost of obtaining site licenses for copyrighted software/courseware limited access to certain computing facilities.

Some of the professors lacked the computer knowledge and skills needed to make computing an essential part of their courses and needed to evaluate the courseware they developed. Limited access to computing facilities, such as in-house laboratories that would meet specific needs of their discipline and good projection systems for whole-class instruction, impeded full integration of computers into teaching. Some professors struggled with computer "phobia" in their students. While lack of structural integration of computers within their colleges or the university were perceived to be problems.

Conclusion and Implications

Computers problems are an integral part of computer use which professors are going to continue to experience. Some of the problems may be overcome with time and

training. Hardware and software problems are likely to continue, even with advancement in the technology.

Professors' lack of knowledge about computers is likely to continue into the near future. This may occur because of the lack of willingness among some professors, especially those who are limited computer users, to explore computers beyond their current usage. When asked if they would like to learn more about how to integrate computers into their teaching, many of such professors complained about a lack of time.

Finding 6b: Challenges of Computer Use for Teaching

Challenges that professors perceived in their computer use for teaching included keeping technology in perspective, the university reward system, and time.

According to Drew (1989), some of the challenges that professors faced in the use of computers included university politics and how to keep technology in perspective. People have the tendency to forget that computer applications are developed by fallible human beings. Drew cautioned that while technologies can enhance work in higher education, they must be applied judiciously and with a healthy skepticism.

The preference in higher education for research as the basis for faculty recognition and reward was a concern for professors in the current study as it was for faculty in Drew's study. Professors worried that computerized teaching took as much or more time to prepare for as research. Yet the university did not reward teaching as much. Many professors, especially those who are not yet tenured, considered it a risk to spend much time to develop computer-based teaching materials. For some of the professors who had administrative support of computing either from their departments

or colleges, an important consideration was that the departments' timing coincided with their need to innovate.

van den Akker, et al. (1992) concluded that computer use demands from teachers many time-consuming management and organizational activities. Time to plan for computing was reported to be a major barrier for teachers in Sheingold and Hardley's (1990) study. Teachers devote a lot of time and effort to using computers in the classroom, as well as spending their own time to learn about technology. Concern for their students and the personal gratification of learning a new skill were key motivators for the teachers in using computers. Extensive support was crucial in the teachers' use of computers, and time to master computer-based teaching strategies was also an issue. It takes five to six years of teaching with computers before teachers can achieve a current comfort level with computers. McMeen (1986) and Plomp and Pelgrum (1992) supported these findings. According to the authors, schools need time to build up enough expertise, knowledge, and experience among teachers before any impact might be expected.

In the current study, time was also a challenge for most of the professors. Among the extensive computer users, especially those who developed computer-assisted instruction programs for themselves, initial development time required a heavy time investment. The professors approximated time for first program developed to be over two hundred hours of design, development and programming time. Time demand may decrease with additional programs developed because the model was already in place. Other extensive computer users among faculty also confirmed heavy time investment, especially in preparing for computer-aided teaching. These professors felt that computers did not actually save teachers' time. However, computers allowed them to space their time better and spread the task over a longer time span because they were no longer location-bound.

Except for the professors who used computers on a limited basis, most of the professors considered the additional time spent on developing computer-based teaching materials as well-spent.

Conclusion and Implications

Expectation of reward or recognition did not seem to be a major concern for the professors, except that recognition connoted institutional support. Professors needed the institution to show that computing is something worthwhile to do, rather than saying it just on paper. Many of the professors in this study mentioned that they received adequate rewards and recognition from their departments, colleges, or the university, through teaching awards and grants, for their efforts at integrating computers into their teaching. Internal satisfaction of doing something to improve their students' learning was enough reward for some professors. To encourage the use of computers in teaching, administrators may need to address professors' need for administrative support, and adjust the university reward system to put teaching on equal footing with research.

Finding 6c: Affective Aspects of Computing

Professors in this study felt that computers contributed to their satisfaction with their teaching and gave them more control over their work.

Relation to the Literature

McMeen (1988) suggested that teachers are likely to readily accept computers as a tool of teaching if they can feel, to a large extent, in control of the consequences of the technology in the classroom. Teachers' morale is high when they perceive



themselves to be in control of their work. Any tool that puts them more in control is likely to be actively sought while those they perceive as taking control away from them will be rejected. On the other hand, computers can give professors as much control as they are willing to explore. According to R. Kozma (1991), the limits will be set only by the individual's imagination.

Perception of the amount of control of teaching that computers afforded them was a strong factor in computer use among the professors in the current study. There was no consensus among professors over whether computers gave them more or less control over teaching. The majority of the extensive computer users among professors believed that they gained more control. Some professors perceived that being able to use computers to do their syllabus made them less dependent on the secretary's time. They were able to control the content of their courses, and do so at their own time. The satisfaction of producing professional-looking class materials was one of the advantages that the professors perceived.

On the other hand, the fear of losing the control of teaching to computers was very real among some professors. Such professors felt that people could get carried away and allowed computers to take over teaching.

The fear of losing control of teaching and learning to computers seemed to be real among the students in the case studies too. Most of the students expressed the view that they would not want the computer to take over the classroom. Even those who have a positive attitude toward computers felt that there should be a limit as to how much a computer is allowed to do in the teaching and learning processes.



Conclusions and Implications

The amount of control that professors perceived that they have may influence how much they want to commit to computer use for teaching. Those in charge of faculty training should present computers to professors as something that can empower them, rather than displace them.

Finding 6d: Influences on Professors Computing Choices

Personal and professional factors influenced professors' computing choices.

Personal Factors

Personal factors that influenced professors' computing choices included self-initiative, beliefs about computers, prior innovation experience, experience in computer use, and perceptions of subject-matter requirements.

Institutional/Professional Factors

Professors' subject matter, academic discipline and the department or college, the university calendar, and class size seemed to influence computer use for teaching.

Relation to the Literature

These findings confirmed the findings of studies about computer use in schools. Novak and Knowles (1991) in their review of studies of teachers' computing influences, found that there were external and internal factors influencing teachers' use of computers. External factors included students' characteristics such as grade levels and ability levels. For example, where there are students with low ability levels, teachers may choose to use drill-and-practice computer programs to reinforce basic academic skills. Internal factors include teachers' knowledge and understanding of

computers and their personal beliefs about the computer. For example, teachers who believe that the computer can enhance the process of teaching and learning are more likely to include computers in their instruction.

Sheingold and Hardley (1990) found that some of the factors that contributed to teachers' achievement with computer use were teachers' own motivation and commitment, administrative support and support from colleagues, and access to sufficient technology. In J.S. Stark et al's (1989) study, faculty believed that the strongest influence on the way they organized their courses was their own beliefs and experiences concerning their fields. Similarly, D. Kagan (1992) found that as a teacher's classroom experience grows, his or her professional knowledge grows richer and more coherent, forming a highly personalized pedagogy.

The findings in the current study confirmed some of the findings in these studies. The professors' personal drive seemed to be most influential. Professors' reasons for choosing computing included personal desire to try something new in teaching, the need to fulfill requirements of their discipline, and their perception of societal goals. They sought out and learned computing skills from different sources including colleagues and professional sources.

Professors' beliefs about the computer appeared to be a factor in their implementation of computers in teaching. Some professors believed that computers were more or less a threatening instrument. It appeared that professors who perceived computers as threatening considered computers as necessary "add-ons" to their already crowded teaching loads. Computers are something "nice" for students to know, but professors should not be expected to teach it to students. Most of the professors, however, perceived computers as a tool for gaining more control over their work.

While experience in teaching may be important in professors' "formatting" an efficient teaching routine, it did not seem to influence their decisions to use computers for teaching. Older professors were as likely as younger professors to adopt computers

for teaching. However, experience in computer use seemed to determine professors' effectiveness at integrating computers into the classroom. In the classrooms of experienced computer users, computer use appeared to be properly matched with instructional objectives and events in the classroom.

Professors' subject matter seemed to influence the aspect of computers to which they expose their students. Those who taught technology as a subject matter exposed students to a variety of computer applications. Those who used computers as vehicles for other subjects chose one or two applications they perceived as most suited to their students' needs.

Among the external factors found to influence professors' computing choices were their students. Students were a powerful influence in shaping teachers' instructional decisions and behaviors in areas such as the type of teaching materials and methods selected and used (W. Doyle, 1979).

Another factor was professors' disciplines. Betza (1986) found that some computer uses were more prominent in certain disciplines than in others. Approximately 50 percent of the CAI at the University of Washington was used in education and English classes to familiarize students with K-12 software. The computer as tutor was more prominent in mathematics, engineering, business, and science courses. Similarly, Carson (1986) found that computing means different things in different academic areas. For example, in engineering, computing means using high level programming languages, whereas in the humanities and social sciences, there is a tendency to rely totally on off-the-shelf programs.

In the current study, academic disciplines of professors seemed to affect the aspects of computers they adopted. Although Carson and Betza ascribed computer-assisted instruction, tutorials, and simulations to schools of education, the same did not seem to hold in the current study. This, however, may be due to the small sample of participants in the study. Those who used CAI more were the professors in the medical

sciences and science education. The CAI allowed them to include simulations and case-based problem-solving exercises that enabled students to explore scientific concepts. Professors in other disciplines such as arts, education, and humanities, on the other hand, used more of off-the-shelf commercial software.

Professors' departments or colleges appeared to indirectly influence their computing choices. The hardware in most of the cases was provided by the departments without prior consultation with faculty on their preferences. Although professors expressed satisfaction with their equipment, a few professors who had options preferred Macintosh computers to DOS PCs.

Conclusions and Implications

It is important that those in charge of faculty's training understand the personal aspects of computing in planning and implementing training programs for professors. Not all professors are comfortable with computers. Understanding professors' beliefs about computers may help in planning programs that enhance professors' beliefs in positive direction.

Administrators may need to match professors' preferences with vendor options when planning future computing platforms for professors. Professors' preferences may be an indicator of the satisfaction they derive from their equipment.

Some of the future uses of computers perceived by faculty in this study included proper integration of the existing technology. Newer technologies such as CD-ROM, Hypermedia, DV-I, interactive video, e-mail, and Integrated Services Digital Network (ISDN) are likely to play prominent roles in future uses of computers among professors.



Section Five - Relating Findings to Theory

Two theoretical frameworks were adopted to serve as the backdrop and explain the findings of this study. They include symbolic interactionism and change theories. Symbolic interactionism was adopted as a backdrop for understanding computer use from the professors' perspectives, and the meaning computer use had for professors as a tool of work. Understanding professors' meaning may shed further light on why they interact with computers the way they do in their teaching, and actions that policymakers may take to enhance computer integration among current users and encourage adoption among non-users of computers among faculty.

The change theory was employed to provide an explanation of professors' reactions to the change that computer use represented and the kinds of changes that may be taking place in education as a result of computing. Administrators may find the explanation useful in understanding how to plan future implementation of computing.

Symbolic Interaction

The goal of any research in the symbolic interactionism tradition is to contribute to the understanding of society through exploration and explanation. Such research is usually focused on presenting the participants' points of view. In this study, my focus was on some of the values and meanings that computers have for professors and how that may have influenced their computer use in the classroom.

Professors' Meanings

Meaning is defined by symbolic interactionists to include the verbal productions of participants that define and direct their actions. Meaning is a more personal reaction to a phenomenon, an interpretation of the interactions of elements in the context of



practice and the personal characteristics of the practitioner. Meaning may be a more important factor in explaining the success or failure of computers in education than, for example, the lack of hardware and software.

To get at the meanings that professors attached to computer use in this study, I analyzed the terms that they used in designating their own actions involving computer use. I also made a note of beliefs about computer use in teaching as expressed by the professors.

Sense of Self

Individual professor's sense of self, work, and the computer, and the way professors came to feel like good users of technology were eloquently expressed in the terms professors used to define themselves as users. Among the professors in this study, Kandel saw himself as a "versatile" user of technology. While Forester thought his computer use was not "profound, but simple." Johnson also saw himself as a computer user whose usage was "basic."

The sense of self was also evident in the personal elements to which professors attributed their computer use. Adamson perceived himself to be "adventurous," while Englebar perceived himself to be a "persistent learner." It appeared that professors who perceived themselves as adventurous, were not easily discouraged by obstacles they may have perceived in the context of using computers. They were willing to learn new applications and are more likely to be extensive computer users.

The terms that the professors used to designate computers also revealed their attitude towards it as a tool of work. The symbolic interactionist believes that an object has a physical and symbolic meaning for humans. As a physical tool, professors referred to computers as "a tool of work;" (Hake, Boss, Englebar) "a problem-solving tool;" (Boss) "a tool to speed-up the process of education;" (Cain) "a tool for bringing reality to the classroom;" (Adamson, Mattsen) "a tool for bringing learning close to

students;" (Smith) "a tool for losing control of teaching;" (Johnson) and "a tool to accommodate different learning needs of students." (Landon)

Symbolic Computer Use

Although the symbolic meaning that professors attached to computer use were not categorically stated, it could be inferred from their statements and attitudes toward computer use in their classrooms. According to Olson (1992), expressive teaching acts convey messages about how the teacher wishes to be seen by his or her students. Without understanding these expressive aspects of teaching we cannot make sense of what teachers do. Using a computer in a classroom is more than just helping students to learn--it is a way of saying something about the kind of a teacher one is.

The same may be true of some of the professors in the current study. Symbolic computer use refers to a situation whereby professors maintain the image of computer users when in fact they are not deeply committed to computer use. Symbolic computer users in this study were found to lack some or all of the attributes of true computer users which include: a) willingness to take risks about their jobs, b) curiosity to learn more about computers, c) finding time to learn to use computers; d) willingness to accept initial failure, d) tendency to persist, and consciously integrating computers into the curriculum. Symbolic users' true reasons for using computers may range from meeting certain conditions, such as, satisfying an expectation ("at least students get exposure to it" [Dillon]), or to something fun to do [Johnson]).

In line with the symbolic interactionist' view, the meaning that professors attach to computing may change as new understandings of computers become available. For example, in the earlier days of computer-assisted instruction, it was seen as tool for drill-and-practice. With the advancement in technology, CAI is now perceived as a problem-solving tool, using a case-based approach.



Computers as a Socialization Tool

Symbolic Interactionism also embraced the concept of socialization, a process by which a person acquires the symbol systems of the social organization by gradually taking on the role of others. Socialization view may be necessary for understanding of the meaning that professors attach to the interaction with their students as a result of computer use.

Professors, in their teaching, were communicating the symbols of their professions to their students. Students on the other hand, were learning to take on the role of professionals in their chosen fields. Most of the professors in this study mentioned modeling of professional roles to their students as one of their teaching objectives. Their ultimate goal was for students to be successful as professionals in their chosen fields. Professors acted on this goal by communicating what was important in their field through teaching. Some of the professional skills that the professors believed were important included 1) the ability to learn from others, 2) ability to work with people to achieve a goal, 3) ability to learn the content of a subject matter, and 4) computer skills. Strategies used by the professors to socialize their students into professional roles included 1) role playing (asking students to assume the role of the professor), 2) assigning responsibilities, and 3) using themselves as role models.

Modeling Professional Skills

The models of computing that professors present to their students may influence how students come to view themselves as computer users. Faculty whose students perceived them as competent and confident computer users are likely to have students who are confident computer users. Evidence from the case studies indicated that students in the classrooms where computers were perceived to be well-implemented believed that computers are "empowering" (Connie, April, and Rosa). Such students perceived computers as "tools" of work and learning, and perceived themselves to be

"comfortable" with computers. In the classes where computers were perceived to be poorly implemented, students believed that computers were "frustrating" and of limited use to their learning.

Conclusions and Implications

Full integration of computers into teaching may hinge on the meanings that computers have for professors. Many adopters of computers among professors have not made a full commitment to using computers because of their perception of it as an object of losing control over their teaching. Perceptions that they were "limited," "basic," or "simple" computer users may indicate lack of knowledge, lack of will to learn more about computers, false humility, or satisfaction with their current knowledge. Those who advocate faculty computing should determine what is applicable in an individual professors' cases.

It is important that trainers and administrators recognize and understand the characteristics of symbolic computer use. Some of the root causes of symbolic usage may be personal and institutional. Administrative measures may be taken to remove perceived risks that professors believe they will be taking if they use computers. Released time to learn to use computers may be an additional administrative measure. Willingness to accept initial failure and persistence can be encouraged through training and administrative support.

Understanding Change

A change theory was adopted to explain professors' reactions to computer use as a change process, and to provide an explanation of possible changes taking place in education as a result of computer use.

Reactions to Change

Many of the existing change theories address the pre-adoptive phase of a change process focusing on factors that enhance or prevent the adoption of an innovation. A theory explaining a change in progress was the change matrix developed by Fossum (1989). According to Fossum, there are four levels and four stages at which change takes place. Change takes place at the individual, group, institution, and environment levels. At each level of change, individuals, groups, and organizations go through four major stages of change. These include denial, resistance, adaptation, and involvement stages.

At the denial stage, individuals or groups within an organization may deny that any change is taking place. Resistance usually follows denial. Resistance can take various forms ranging from a negative attitude to outright opposition to change. Issues that may surface at the resistance stage include control, power, helplessness, loss or grief, risk--a feeling that the change brings danger--and anger or conflict. The adaptation stage is when the change begins to become accepted or even welcomed. People learn to implement the change for themselves and others. Involvement is the final stage of change. At this stage, people actively participate in the change, make contributions and suggestions, initiate work on their own and come to see the change as it is.

Similar reactions corresponding to Fossum's stages may be found among the professors in this study. But, faculty appeared to be at different stages of reactions to computers for teaching. While all seemed to be at the adaptation stage, some have totally committed to computer use, but some are still at what Plomp and Pelgrum (1992) termed the "stage of easiest response" to computer use.

Professors' reactions may also be described by the proposed model derived from Dr. Conway, the administrator in Case Study Three. According to Dr. Conway,

both professors and students in his college went through a spectrum of reactions that range from fear to intimidation to caution to moderate enthusiasm and to dynamic excitement.

At the fear stage, even though people had accepted the change as a fact of life, they still had some fear of the computer technology. They were uncomfortable with the computer, and they avoided it as much as possible.

At the intimidation stage, people felt encumbered with the technology. Some people, especially students felt that computers obstructed their learning.

The caution stage was when people still had some reservations about the technology even when they perceived its usefulness. They did not trust the machine to perform all the time, and they knew it was limited compared to the human mind. A lot of faculty and students seemed to be at this phase. They used computers for a variety of activities knowing that it could fail them at any time.

Moderate enthusiasm and dynamic excitement have a lot in common. People at these stages are more excited about computers, they felt pride of ownership, and volunteered time to help develop computer programs. Such people may remain at the dynamic excitement stage for a long time. They are likely to explore more innovative approaches to using computers.

People progress through the stages at different rates and in different combinations. Sometimes the stages fade into one another such that the progression through them may not be noticeable. Some people jump stages to move straight from fear to dynamic enthusiasm. Some people may pass through these stages quickly. However, many people seemed to linger at the caution stage. Those who remained longer at the intimidation stage were people who were likely to become straddlers. Such people realized the importance of computers, but are investing as little effort as possible in exploring and learning more about computers as a tool. They invested just enough time and energy into it to make it appear that they are users of the technology.

In this study, Professors Dillon and Johnson may be at any of the stages ranging from fear to intimidation to caution, while Professors Hake, Adamson, Englebar, and Mattsen may be at the stages of moderate enthusiasm to dynamic excitement.

Conclusions and Implications

Administrators in charge of computing at any level within the institution should recognize that these stages exist and plan on helping faculty overcome them. They should also recognize that individuals progress through these stages at different rates. Individual differences should be planned into computing initiatives for faculty. On-going technical and administrative support may be a way to help professors move through those stages quickly.

Kinds of Change

According to Sheingold, Kane, Endreweit, and Billings, (1981), the computer does not have a simple "impact" on an organization or the people in it. Its implementation and use are embedded in a complex system of social and political relationships. Computers interact with the social system in which they are implemented, and this interaction changes over time as computing activities influence the social system, and the social system shapes the influence of the technology.

What kinds of changes are professors making in their classrooms? According to Plomp and Pelgrum (1992), expected structural changes in schools as a result of computer use include new teaching strategies, different classroom and school organization, different roles and tasks for teachers, new relationships between students and teachers, new courses, and a new emphasis on existing courses. The results of the current study seem to point in the direction that Plomp and Pelgrum described.

New Teaching

There are new emphases on existing courses as professors add information processing and computer skills as part of instructional objectives. However, professors still teach a content similar to what they would have taught without computers. Computers did not replace the lecture in the classrooms of even the most proficient computer users among the faculty studied. Rather, computers were used as presentation aids, to illustrate concepts that professors could not easily explain, to graphically present information, or to take notes of class discussions.

Professors who use computers in classroom instruction used the discussion method frequently. Professors seem to get more student participation through the discussion method. Computer elements that encouraged this method included the ability to type notes of the points raised by both students and professors into a word processor, and the ability to display these notes through the overhead projector and LCD panel. Seeing their notes going up on the screen seemed to act as an incentive for students to contribute more to the discussion. Being able to rethink their points, change what they do not feel comfortable with, and reach a consensus before they print out the product of their joint efforts was very exhilarating for the students and their professors.

Most of the professors in the sciences stressed the importance of promoting visualization in their students. This is one strategy they were now better able to promote with computers.

New Communication Mode

Among the professors that used e-mail as part of their teaching, there appeared to be increase in the rate of one-on-one communication between them and their students. Many students found it easier to ask for help on their assignments through e-mail than physically tracking down professors or their assistants.

New Roles

Professors are beginning to see themselves as mentors rather than just the information source for their students.

Conclusion and Implications

The computer revolution may not be radically changing the classroom process. Maybe professors are finally discovering a tool that can fit into the system of education, and with which they can make good instructional decisions.

Limitations of the Study

The scope of this study was limited to one campus--Michigan State University, partly because of the nature of the study and partly because of my limited funds. As a qualitative research project, the study required that I stay close to my sources of information. I needed frequent access to professors and their students in order to collect and check multiple sources of evidence. My limited budget could not support such a requirement at multiple sites. Other institutions who may want to use this report should take into consideration the characteristics of the institution involved.

Moreover, only 12 out of about 3,000 MSU professors were asked to participate in this study. The small number was necessary in order to adequately manage the volumes of information that can be generated from in-depth interviews, documents, and observations; the three research methods used in this study. The views of the twelve may not be representative of the views of MSU professors as a whole. However, I recognize the fact that a qualitative study is not about getting representative views, but about presenting examples of views among a group of people.

This study was also limited by the nature of the methods used.

1) Interview, the major technique used, has its own inherent limitations.

According to Jones (1985), interviews are verbal reports that come to the researcher as a second-hand information, hence, subject to interviewee's interpretation. The bias introduced into the data from such a source may affect the validity of the result of the study. I have taken the necessary precautions to insure the quality of the study by getting evidence from multiple sources, and by gathering evidence from the same respondents on several occasions. However, I do recognize that it is not possible to achieve one "objective truth" in a qualitative research. This report, is therefore, a presentation of some out of many possible "truths" about the situation studied. The users of this report should bear this in mind.

2) Because of the short duration of the classroom observations conducted, I could not verify certain leads or patterns of behavior in the classrooms studied. Establishing long term patterns of behavior in the classroom might have led to different conclusions than those proposed in this study.

Also, utterances of individual participants during class events were not recorded or analyzed to maintain confidentiality. Moreover, I relied a great deal on verbal reports of other participants for evidence to support my observation of classroom interaction. As mentioned above, verbal reports are subjective views of the participants which may introduce bias.

In case study three, I could not locate any of the students in the videotaped lecture of Professor Adamson. Issues that arose from my observation could not be verified directly by any of the students involved. However, on different occasions, I indirectly obtained corroborative evidence from Dr. Adamson, Josephine (one of the students in this study), and Andrew, the student who was assisting Professor Adamson in the development of the CAI.

Summary of Major Implications

- Teaching activities, goals, and procedures may vary among professors and may be influenced by their personal styles and experiences.
- A combination of centralized and distributed computing services may benefit professors in integrating computers into teaching. Computing resources located in the colleges or departments of professors have the advantage of being customized to the specific needs of the disciplines. However, cost may make some centralized services a more viable alternative.
- The advantage of computers in education may be that it enables teachers to do better what they already know how to do, rather than helping teachers to create new knowledge for traditional courses. Rather than revolutionize the education process, the computer's contribution may be that it fits well into the structure of the school.
- The advantages of computers may not be equally perceived by all professors. Policymakers and gatekeepers should make allowance for the reality that not all professors are likely to use computers. Even when they do, they may be using computers for symbolic purposes.
- The majority of the professors may still be struggling with how to use computers to teach. Some may lack the knowledge and skill of how to make computers an integral part of the course and evaluate computer-aided courses. Lack of interest in computer training among some professors may hamper full-scale computer use for teaching.
- Computers are likely to be perceived as an adjunct to the professors in the near future, until students can be gradually persuaded to look at computers as another source of learning. Many students may still have the orientation that there should always be "someone" lecturing.

- Communication networks may dramatically impact students and professors' interaction. Ability to hide behind the anonymity of some networks to provide professors with feedback without fear of persecution may help professors shape their teaching.
- The traditional view of teaching in which only professors teach and only students learn may change as more knowledgeable students are allowed to tutor other students and in some cases their professors in computer skills.
- Computer use may contribute to learning only when professors are committed to it. They should be knowledgeable about it, be willing to spend time, and be able to consciously motivate students to learn to use it as a tool.
- Computerized teaching may require heavy investment of time and resources. Time to learn, time to install computing, time for computers to begin to have an effect may be part of the cost of computing.
- Students' acceptance of computers as a tool for learning may be one area to address. Professors' willingness to commit time to computers must also be addressed.
- Computers may remain at the periphery of teaching for a long time if the initiative to learn to use computers or integrate them into teaching is left to professors alone, if further incentives to use computers for teaching are not provided for professors, and if professors are not allowed time to integrate computers into their teaching.
- Computers may not likely replace professors in the classroom in the near future. Students' needs for human contact and the role models of their profession that professors represent make replacing professors with computers not only undesirable, but also impossible. The issue to face would be how to help other professors to explore the advantages and avoid or minimize the disadvantages of computing expressed by the users.

- The computer may likely make a difference to students' learning when it is well-integrated into the students program of study and into the course structure, so that students can see its relevance, and professors can work to relieve the anxiety that students associate with computing, and when professors model computer use adequately.
- Professors may still be trying to find out how best to use computers for teaching and how to be mentors rather than teachers, just as students may still be learning to learn from other sources as well as the teachers.

Recommendations of the Study

Recommendations for Professors

1. Have a well-defined purpose for using computers. The purpose helps determine what aspects of computers would be suitable.
2. Begin computing with simple applications and gradually progress to more advanced applications with time and training.
3. Do not expect miracles. Computers cannot solve all teaching and learning problems. While they may provide an opportunity for creativity in teaching, they may not yield spectacular results such as helping professors create new courses. Realize that computers cannot be used for all educational tasks, some tasks are best performed by humans.
4. Use available resources for teaching. Take advantage of training resources on campus and at professional meetings. Seek help from knowledgeable colleagues. Do not overlook students as a resource. Extend the search for funding beyond the

department, college, or university sources, to external sources. Use available examples to guide computing choices and usage.

5. Take students' computer anxiety and acceptance of computer into consideration when introducing computers into courses. Students have different abilities and affinities for computers.
6. Take students' computer experience into consideration when planning computer integration into courses. Some students are knowledgeable in some computer applications and some are not. Take time to find out what students' needs are and match those with class activities.
7. Provide incentives for students to learn to use computers by showing their relevance to students' work and life.
8. Be a positive role model. Show students that computers are important by using them, and by the way they are used for certain purposes.
9. Address students' computer concerns as part of class events, and communicate to students that computers are an important part of the course by awarding grades for computer aspects in the course.
10. Plan on committing a considerable time to computer integration into courses.

Recommendations for Administrators

1. Provide computing resources to cater to the variety of styles and needs of faculty.
2. Provide training on how to integrate computers into courses and how to evaluate computer-aided courses. Provide the kind of training that professors can perceive as empowering.
3. Allow professors time to learn and the institution to innovate.
4. Provide visible administrative support for computing. Reward innovation involving computer use. Adjust the university reward system to put teaching on an equal footing with research.

Recommendation for Trainers

1. Design training programs on how to integrate computers into specific courses, and how to evaluate such courses.
2. Design programs that enhance professors' perceptions of self-empowerment.

APPENDICES

APPENDIX A

APPENDIX A

Exploratory Study

The purpose of the exploratory study was to help narrow the research questions and focus the design of the study. The broad research question and specific questions that were based on it addressed the issue of how faculty use computers in their teaching. The initial review of the literature revealed that how faculty use computers in their teaching was an issue that had not been thoroughly explored in research.

I began a detailed review of the literature by looking for studies on computing which address the way or manner of computer use, the process of computer use, and the implications of computer use for education. Relevant topics that emerged from the review of the literature reveal that:

- Teachers use a variety of computer-based technologies like, electronic mail communication, videodiscs, electronic bulletin boards, simulations, text processors, and graphics for their teaching (Sheingold and Hardley, 1992; Austin, 1988).
- Teachers use computer-based technologies for teaching activities like instructional planning, instructional delivery, testing, grading, management of instruction, and students' records (Sheingold and Hardley, 1992; Austin, 1988).
- The curricula goals that teachers use computers to serve include, teaching difficult concepts, remediation and enrichment of instruction, and application of concepts through problem-solving exercises (Dalton, 1987; Quigley, 1986)
- Teachers believe that their teaching has changed as a result of computer use. They could teach more complex concepts and provide a variety of examples

using the computer (Sheingold and Hardley, 1992; Kozma and Johnston, 1991).

- Teachers express needs for computer resources such as more and better hardware and software, technical and financial support, and training (Sheingold and Hardley, 1992; Naron and Estes, 1986; Peel, 1984; Kozma and Johnston, 1991).

With these topics in mind, I developed an interview guide for the exploratory study. The interview guide contained three broad questions: 1) Why do professors use computers in their teaching?, 2) How do professors use computers in their teaching? and 3) What are the effects of computer use on professors' teaching?

STUDY ONE

The first trial study consisted of an in-depth interview with Professor D., a professor in the College of Education at MSU (Interview, 11/21/91). Using the open-ended questions in the interview guide, I asked the professor to describe his use of the computer for teaching and his motivations for using computers.

I obtained Professor D's permission to tape the interview because it would help me in my analysis later. Since the purpose of the study was to discover relevant topics, I left the direction of the conversation to Professor D. In few instances, I interjected comments or questions to clarify some issues raised by the professor.

There were three major findings of this first trial study that were an important departure from the literature. I found that:

- 1) Professors may have teaching goals that they use computers to serve and that are different from learning goals that they set for their students.

- 2) Faculty would use computers for things that are important to them.
- 3) The personal aspect of computing may be as important as the professional aspect.

Professor's Goals and Goals Set for His Students

In the following excerpts taken from the interview, Professor D explained the differences between the two goals of teaching. His own goal of using computers for teaching was to create or enhance discourse in the classroom. His other goal of modeling "good teaching" to his students was interwoven with the goal of becoming effective teachers that he set for his students.

Three weeks ago, I used a LCD panel with this little Mac SE in a class I am teaching downstairs to 24 juniors [undergraduates in their junior year]. I came into class and set the LCD panel on an overhead projector, and I typed "I can't talk." I had asked them, as an assignment, to go out and do a field observation. And then I just typed at the top of the screen "What did you see" and just gestured. Well, I didn't say a word for 60 minutes, for the whole period until it was over. And a wonderful discussion occurred. I was typing their comments as they described what they did and saw. I was able, by using an LCD without saying a word, to withdraw myself as a professor, quit talking myself, let the students talk and argue and debate. And then when it was over it was one of the most interesting discussions, because by pretending that I could not talk, I forced myself to listen yet collecting ideas. The students would look up at the screen occasionally and kept the conversation on the task. When it was over, I saved it as a text file. I put it on the server downstairs so the students could go through and read the notes. And then I printed off a set of notes and handed them out at the next class so the students could refer to them and think about what was said. The topics that came up in that discussion were topics I might have otherwise made available by lecture, but they arose out of the students' own dialogue.

Now as I struggle how to teach differently and how to create students' discourse, that was a very satisfying experience. I consider it one of the most interesting classes I have taught. And I was also modeling for this group of juniors that will become teachers that it is possible to not do all the talking and to let the children talk (Interview, 11/21/91).

From this discourse, I began to realize that the distinction between professors' teaching goals and learning goals that they set for their students may be a question to consider for the main study.

Importance of Computers to Faculty

Professor D also mentioned in the interview that faculty would use computers only for things that are important to them. Sometimes, what professors perceived to be important to them may be influenced by what is considered to be important in their disciplines. According to Professor D, professors in the sciences may use computers differently from those in the Humanities.

If one looks at Physical Sciences, you will find many of them using technology far more advanced than what I have on my desk. They are doing genetic analysis and running experiments and gathering data from the super computer. If you ask them to spend time teaching undergraduates to write, they would be frustrated in the extreme because they would find those systems unfamiliar to them and hard to work with. And so those people like most, use it for something that is important to them and rewarding. The reason most of the faculty in most places in this building are using it to write on a word processor is because that is where they get their rewards and their satisfactions. Some percentage of the professors in this college is now using electronic mail and that has become something that is intellectually rewarding. It makes you feel like you are part of the intellectual discussion in the building (Interview, 11/21/91).

From this second finding I began to formulate a second hypothesis about the influence of faculty's discipline on the way they use computers. This hypothesis was strengthened by the fact that Professor D works with other professors on how to integrate computers into their teaching. So he was in a good position to know the types of computer usage in the different disciplines on campus.

Personal Aspect of Computing

A third possible hypothesis that the interview with Professor D made me think of was that there may be personal as well as professional consideration in professors' decisions to use computers in their teaching. In the interview, Professor D mentioned that some people enjoy working or playing with computers while some do not. Such people derive their reward from just having a computer as a tool. Also, people who enjoy working with computers somehow seem to find time for computing. Whereas people who do not like computers may find it difficult to find time to learn to use them.

These three findings were in addition to other findings regarding the goals of computing, teaching activities, computing resources used, and the impact of computer use on Professor D's teaching which were all similar to the findings in the literature of academic computing reviewed. I made a note to explore further the new threads, namely, faculty's and students' goals, the importance of computers to faculty, and the influence of faculty's disciplines on how they use computers in the next two mini-studies.

STUDY TWO

Professor B, who I interviewed for the second mini-study taught courses in the humanities. His name was mentioned to me by an administrator at the Office of Academic Computing and Technology with whom I had an informal interview.

The interview with Professor B was very illuminating. For about 90 minutes, we covered different issues about computer use in teaching and learning. A sizeable amount of the interview time was devoted to the description of a computer-assisted instruction program that Professor B was developing for a survey course in the humanities.

Professor B had a philosophy that guided his teaching and seemed to permeate the design of the CAI. He believed in "leveling out the playing field" between slow and fast learners so that students can achieve similar instructional objectives at their own pace. Professor B said computers allowed him the opportunity to do just that within the constraints of the university time table and his usually large classes, with little or no additional cost. This excerpt from Professor B's interview illustrates his points:

Students learn at different rates, and they learn in different ways. Programs such as these allow the student to pace themselves. The student who is having more difficulty can go back for repeated exposure. You can even take this structure, this model, and design it for remedial, developmental, review, whatever euphemism you want to use. We can create programs that allow the slower learner to supplement the regular program without additional costly personnel and remedial mechanisms in place. The same computer laboratory would serve several other purposes. So if you have the initial investment in a lab where you have a number of computer terminals for students to come in, they can learn a variety of different things. Plus, let us suppose, a room with 30 terminals, and have 30 students an hour going through a program, assuming each student takes an hour, each one of those students can be somewhere else in the program. They don't all have to be on the same subject at the same time as they have to be in the lecture hall. And if one student can get through 14 programs in the first 2 weeks, that student has an advantage. That student has completed his work in this particular course area, and it has freed that person's time to devote to other courses. On the other hand, not all students can work that way and some students don't understand easily so they will take all 14 weeks of the term to complete the program. But they have the opportunity to do so. Whereas in the conventional system in the lecture hall, the student keeps up or gets run over (Interview with Professor B, 12/12/91).

The computer thus became an important tool for Professor B to remove the constraints of the context of learning for his students. Among those constraints were students' learning deficiencies, a large volume of information to be covered within a short time frame, and a large class which limits students' access to their professor.

Although, from the conversation with Professor B, there was no indication that his disciplines directly influenced his choice of computer-assisted instruction as a computing option. However, the large volume of information and the fact that many freshmen classes are required to take his survey courses (which results in large classes) may be an effect attributed to his discipline. Professor B also distinguished between his goal of using computers to increase the efficiency of his lecture preparation and grading, from the goal of getting his students to learn to read. According to Professor B, beginning college students do not know how to read, absorb, and use relevant information. Apart from holding the instructional situations constant for slow learners, a major purpose of his CAI program therefore was to teach students how to do critical reading and critical analysis of information.

Apart from confirming some of the findings of the first mini-study, this second study also raised issues of the constraints in the teaching context (e.g. students' learning problems, university time table, large classes) which the professor tried to alleviate with computers. These issues were noted for further exploration in the third mini-study.

STUDY THREE

For the third trial study, I interviewed and observed Professor Y. I decided to include observation in this study to test out the technique as a viable data collection tool. The literature on the qualitative study approach supports the idea that the procedure of computer use by professors may become more visible if an observation technique is used (Wood, 1992; Yin, 1989; Lincoln and Guba, 1986; Clark and Peterson, 1986).

Professor Y's approach to computer use was a little different from Professors D and B above. Professor D used computers in direct classroom instruction with his

students. Professor B combined computer use for his own instructional planning with a computer-assisted instruction program that he was developing for his students. In the case of Professor Y in the present study, he used the computer mainly for his course and lesson plans. However, he gave regular assignments to his students in which they elected to use computers. My decision to interview Professor Y was based on my definition of teaching which includes instructional planning. *Research on Teachers' Thinking* supports the view that teaching begins with the planning that the teacher does prior to classroom instruction, and that teaching continues in the form of evaluation long after classroom interaction (Clark and Peterson, 1986).

The findings of the third mini-study were similar to those of the first two, even though computer uses were different.

Professors' and Students' Goals

Setting teaching goals for themselves and learning goals for students was an important approach in all three professors' teaching. Most of the time, the goals set were about students' performance when they leave college. According to Professor Y: There is an external reality, and there are jobs competencies and tasks. There are people out in the real world who will judge the students as to whether or not they can do certain things. And I want my students to be able to show me they can do those things. And I want them to show me in a certain way, not in any other way. If they decide to show me in their own way that might not be the way that the people at Arthur Anderson who may hire them or at EDS want to see it. There are certain ways of doing things. It is like getting a student to show me if they can use a parachute by drawing pictures. No, no, no. I want them to use the parachute... To me, that is one of the key things in my planning (Interview, 4/24/92).

Importance of Computers to Professors

In terms of the importance of computers to professors, how the computer enables professors to change the nature of a task to be performed or their own teaching

style seemed to be another important factor, apart from professors' discipline.

Instructional planning was a task that Professor Y normally performed. But with the aid of the computer, his creativity improved. He was able to create a more elaborate course structure with much more flexibility than previously. The excerpt below illustrates the flexibility that the computer afforded Professor Y in his instructional planning process:

... Then I started, of course I put this organized content on the computer. And as I gathered information I started to change this and fiddle with it. Then I started to plug into a general format I have on the computer some of the content. For example, I realized, under needs assessment, after I looked at a couple of books, I started seeing that they were saying the same thing--there was a very specific way to do it. Again, I am doing a task description on how to do a needs assessment. And I started to see some major segments and I put them down in the computer. As I got the pieces together and got the ideas, I could see them forming on the computer. I took out redundancies and added new ideas. I took the content and showed it to some students. I then put the content in order and gave it a nice structure. Now I am in the process of figuring exactly what those specific test items would be. How would I actually evaluate what the student knew of this content? What would he have to do? And what would the project be? Which is most important because that is like the real world performance. That would give me my objectives.... Then I will create practice test items to do during class and for homework, and two forms of a test... I have to create at least four items for every single test. I will then make sure this is well integrated into my materials (Interview, 4/24/92).

The procedure described in this excerpt was confirmed by an observation session that I conducted with Professor Y.

Conclusions and Implications for the Main Study

These mini-studies explored the subject of how professors use computers in their teaching. Using in-depth interviews with open-ended questions, in which I had not imposed any structure, allowed important topics regarding professors' computer use for teaching to emerge from professors' perspectives.



Some of the topics that emerged from the exploratory study confirmed findings from the literature on academic computing, namely, that professors:

1. use a variety of computer technologies in teaching;
2. use computers for a variety of teaching activities;
3. use computers for teaching goals;
4. use a variety of resources in their teaching; and
5. believe computers have changed their teaching.

In addition, topics discovered from this exploratory study included:

1. the distinction between teachers' and students' goals,
2. teachers' philosophy of computer use;
3. the procedure of teaching with the computer;
4. possible influence of the discipline to which professors belong or the nature of the subject matter;
5. the constraints of teaching context;
6. personal aspects of computing;
7. the kinds of reward that professors expect or get for computing.

These topics were used to develop the research questions and the interview guide.

In addition, the trial studies provided me with an opportunity to implement detailed interview and observation as data collection techniques. The exploratory study also added strength to the idea that it is legitimate to ask how faculty use computers in teaching.



APPENDIX B

APPENDIX B**UCRIHS Approval Letters**

MICHIGAN STATE UNIVERSITY

OFFICE OF VICE PRESIDENT FOR RESEARCH
AND DEAN OF THE GRADUATE SCHOOL

EAST LANSING • MICHIGAN • 48824-1046

October 27, 1992

TO: Bosede Oluremi Aworuwa
1420B Spartan Village
East Lansing, MI 48823RE: IRB #: 92-489
TITLE: COLLEGE TEACHERS' USE OF COMPUTERS TO SUPPORT TEACHING: A
CASE STUDY
CATEGORY: 1-A, 1-C, 1-D
REVISION REQUESTED: N/A
APPROVAL DATE: October 22, 1992

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete. I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the UCRIHS approved this project including any revision listed above.

UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Investigators planning to continue a project beyond one year must seek updated certification. Request for renewed approval must be accompanied by all four of the following mandatory assurances.

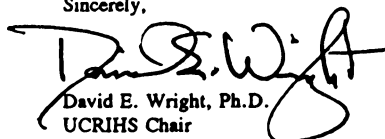
1. The human subjects protocol is the same as in previous studies.
2. There have been no ill effects suffered by the subjects due to their participation in the study.
3. There have been no complaints by the subjects or their representatives related to their participation in the study.
4. There has not been a change in the research environment nor new information which would indicate greater risk to human subjects than that assumed when the protocol was initially reviewed and approved.

There is a maximum of four such expedited renewals possible. Investigators wishing to continue a project beyond that time need to submit it again for complete review.

UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. Investigators must notify UCRIHS promptly of any problems (unexpected side effects, complaints, etc.) involving human subjects during the course of the work.

If we can be of any future help, please do not hesitate to contact us at (517) 355-2180 or FAX (517) 336-1171.

Sincerely,



David E. Wright, Ph.D.
UCRIHS Chair

DEW:pjm

cc: Dr. Stephen Yelon

APPENDIX C



APPENDIX C**Research Instruments**

This appendix contains the research instruments for this study. The instruments are presented in three categories.

Category One: Interview guides for the professors, students, computer resource personnel, and the administrator interviews.

Category Two: Observation Guide.

Category Three: Samples of Fieldnotes.

Category One: Interview Guides

Faculty's Interview Guide

Title of study: College Professors' Use of Computers for Teaching

Letter of Introduction

Dear Dr.....

I am doing a descriptive study for my doctoral dissertation about how college teachers use computers in their teaching at Michigan State University.

I will like to interview you on the ways you use computers in your teaching, either for lecture preparation, classroom instruction, or for managing your teaching, such as record keeping. Based on the outcome of the interview, I may include an observation of computer use in your classroom. I may also collect some of your teaching materials for analysis as part of a case study. If I decide to include you in the case studies, I may need your permission to interview some of your students about their perceptions of computer use in the classroom.

Here are the estimated times for each activity of the study:

- a) First in-depth interview - 1 1/2 hours or less.
- b) Two observation sessions - 1 hour each or less.
- c) Follow-up interview - 1 hour

The interviews will involve asking you to describe in detail your teaching practices, your computer use, students' learning, subject matter, and classroom events. During the observation sessions, I would like to observe and take some notes about the events in the classroom. I may follow this up with a few questions after class or during the follow-up interviews. I will be audio-taping all of the interview and observation sessions.

You may decline to answer or discuss any question or points during any of the sessions. You may decide to withdraw your participation at any time during this study without any penalty.

I intend to protect the confidentiality of the information you provide by labeling audio-taped interviews with code names. All audio-tapes, consent forms, code names, and transcripts will be stored in a secure location. In my analysis, I may include lengthy excerpts from the interview transcripts in presenting the report of this study. I will use pseudonyms and disguise any personal identifiers when writing the report and



in any presentations or publications. However contextual information about your practice may enable someone familiar with your department to guess your identity despite the use of pseudonyms and codes.

I will make the transcripts of the sessions and a draft of the report available to you. You may delete any quotes that you do not wish to be included from the report.

Attached is a copy of the questions that will guide the discussion during the first interview. Feel free to call me if you need additional information about the study. Kindly complete and sign the attached consent form and mail in the self-addressed stamped envelope provided.

Thank you in advance for your time.

Consent Form

I, Dr./Mr./Ms. -----

(Name)

have read and understood the attached letter informing me of the requirements of the study and of my rights if I choose to participate.

I ----- to participate in the
(volunteer/decline)
study.

(signature)

(Date)

Interview Guide

Background

1. How long have you been using computers for teaching?
2. How did you get interested in using computers for teaching?

Ways of Using Computers in Teaching

1. What kind of teaching activities do you use computers to support?
2. What teaching goals do you use the computer to fulfill?
3. What teaching problems do you use the computer to solve?
4. What type and brand of computer do you use and why?
5. What software do you use for the teaching activities described above and why?
6. Describe a typical use of the computer for the teaching activities you mentioned.
7. What are the problems of using the computers the way you describe it for your teaching?
8. What are the challenges of using the computer the way you describe it for your teaching?
9. What kind of technical, training, and other support are required to be able to use computers the way you describe here. What are the sources of such support?

Perceptions of Impact of Computer Uses on Teaching, Learning, and Class Interactions

10. Briefly describe the ways your use of computers for teaching has made a difference in:
 1. your teaching
 2. your students learning
 3. the kinds of interaction and roles in your class.



Students' Interview Guide

Title of study: College Professors' Use of Computers for Teaching

Letter of Introduction

Dear Mr.....

I am doing a study for my doctoral dissertation about how professors at Michigan State University use computers in their teaching.

I will like to interview you about your perception of the ways computers are being used for in the course of Professor. I would also like to know your opinion about the impact of computer use on your learning the course, and what it contributes to your overall educational goals.

Here are the required time schedule:

- a) One in-depth interview - 1 hour or less.
- b) A follow-up interview about 20 - 30 minutes to clarify points raised during the first interview and during observation sessions.
- c) Informal conversations by phone if needed.

I need your permission to audio-tape and take note during the interviews. The interviews will involve asking you to describe in detail how your professor's use of computers has influenced your learning and your educational goals. I may also ask you questions after each observation session that will be conducted in your class for the purpose of a case study. However, the observation is not about you personally and will not directly involve your behavior or responses. The observation will focus mainly on the whole class and specifically on events that involve computer use in your class.

I intend to protect the confidentiality of information you provide by labeling audio-taped interviews with code names. I will not use your real name in any conversation, analysis, and reports of the study. All audio-tapes, consent forms, code names, and the transcripts will be stored in a secure location. You may decline to answer or discuss any question or points during any of the sessions. You may decide to withdraw your participation at any time during this study.

In my analysis, I may include lengthy excerpts from your interview transcripts in presenting the report of this study. As I mentioned earlier, I will not use your real name, and I will disguise any personal identifiers when writing the report and in any presentations or publications. I intend to make the transcripts of the sessions and draft of the report available to you. You may delete any quotes that you do not wish to be included from the report.

Attached is a copy of the questions that will guide the discussion during the first interview. Feel free to call me if you need additional information about the study.



Kindly complete and sign the attached consent form and mail in the self-addressed stamped envelopes provided.

Thank you in advance for your time.

Consent Form

I, Mr./Ms. -----

(Name)

have read and understood the attached letter informing me of the requirements of the study and of my rights if I choose to participate.

I ----- to participate in the study.

(volunteer/decline)

(signature)

(date)



Interview Guide

Background

1. How long have you been using computers?
2. How did you get interested in using computers?

Perceptions of Professor's Use of computers

3. Would you describe some of the ways your professor uses computers to support the teaching of this course?
4. What more do you wish you could have done in this course with the aid of computers?
5. What do you wish was not done with computers in this course?

Perceptions of Impact of Computer Use on Learning and Classroom Interactions.

6. In what ways have your professor's use of computers to support teaching activities influenced your learning of the course?
7. In what ways have your professor's use of computers influenced the achievement of your educational goals?
8. In what ways have your professor's use of computers influenced your working with:
 - a. your professor?
 - b. other students?
 - c. the computer?
 - d. subject matter?



Administrator's Interview Guide

Title of study: College Professors' Use of Computers for Teaching

Letter of Introduction

Dear Dr.....:

I am doing a study about how professors at Michigan State University use computers in their teaching for my doctoral dissertation. As part of the study, I will also do case studies of selected colleges, faculty, students, and computer resources personnel. As an administrator in charge of computing for your college, I would like to interview you about faculty computing and available resources for computing in your college. I would also like your perceptions about the impact of computers on teaching and learning in your college.

Below are some questions that I hope may guide our discussion. I am asking for your permission to audio-tape and take notes during the interview. You may decline to answer or discuss any question or points raised. You may decide to withdraw your participation at any time during this study.

In my analysis, I may include lengthy excerpts from your interview transcripts in presenting the report of this study. I will use pseudonyms and disguise any personal identifiers when writing the report and in any presentations or publications. However, because the information required involves description of computing in your particular college, persons familiar with the college may guess your identity.

I will make the transcripts of the sessions and a draft of the report available to you. You may delete any quotes that you do not wish to be included in the report. Kindly sign the consent form attached to this letter and return in the addressed envelope enclosed.

Thank you in advance for your time.



Consent Form

I, Dr. -----

(Name)

have read and understood the attached letter informing me of the requirements of the study and of my rights if I choose to participate.

I ----- to participate in the study.

(volunteer/decline)

(signature)

(Date)

Interview Guide

Background

1. What were the early attempts at computer integration in the college like?
2. What have been the most difficult and the easiest parts of computer integration?

Purpose

3. Why is it important to you that faculty in your college use computers in their teaching?

Computing Resources

4. What kinds of computing resources (e.g., hardware/software, facilities, training, users' support and technical staff) are available to faculty?
5. How are those computing resources organized for easy access by faculty?
6. What has been or is the source of funding for computing in your college?
7. How much of the university-wide computer resources do your college use?

Impacts of Computing

8. What have been the impacts of these resources on professors' teaching and students' learning?

Vision of Computing

9. What is your vision of academic computing in your college and the university as a whole?
10. What do you want your graduates to get from all these efforts?

Computer Resource Personnel Interview Guide

Title of study: College Professors' Use of Computers for Teaching

Letter of Introduction

Dear Mr.....

I am doing a study of how professors at Michigan State University use computers in their teaching for my doctoral dissertation. As part of the study, I am doing case studies of selected colleges, faculty, students, and computer resources personnel. As a computer resource person for your college, I would like to interview you about what your job entails. I would also like your opinion on computer use in the college generally, and the impacts of computer use on teaching and learning

Here is the required time schedule for each of the activities:

- a) Interview - 1 hour or less.
- b) Follow-up interview about 20 - 30 minutes to clarify points raised during the first interview or/and during observation sessions.
- c) Informal telephone conversation if needed.

I am asking for your permission to audio-tape the interviews. I intend to protect the confidentiality of the information you provide by labeling audio-taped interviews with codes rather than your name. All audio-tapes, consent forms, code names, and the transcripts will be stored in a secure location. You may decline to answer or discuss any question or points during any of the sessions. You may decide to withdraw your participation at any time during this study without any penalty.

In my analysis, I intend to include lengthy excerpts from your interview transcripts in the report of this study. I will not use your real name and I will disguise any personal identifiers when writing the report and in any presentations or publications. However, because the information required involves description of computing in a particular college/department, and your role as a resource person, persons familiar with the college/department may guess your identity. I will make the transcripts of the sessions and a draft of the report available to you. You may delete any quotes that you do not wish to be included in the report.

Attached is a copy of the questions that will guide the discussion during the first interview. Feel free to call me if you need additional information about the study. Kindly complete and sign the attached consent form and mail in the self-addressed stamped envelope provided.

Thank you in advance for your time.



Consent Form

I, Mr./Ms. -----
(Name)

have read and understood the attached letter informing me of the requirements of the study and of my rights if I choose to participate.

I ----- to participate in the study.
(volunteer/decline)

(signature) (date)



Interview Guide

Background

1. How long have you been using computers?
2. How did you get interested in using computers?
3. How long have you been a computer resource person for the professor/department/college?
4. What is your background?

Job Description

5. What specifically does your job involve?
6. What is it like to be a resource person for both students and professors?
7. What is your experience with developing computer-based instructional program?
8. What is the most difficult thing about being a computer resource person for students and professors?
9. What resources are available to you and what more do you wish you could have to do your work better?

Impact of Computing

10. What do you see as the biggest impact of the way computers are being used in this college/department on students learning and faculty's teaching?



Category Two: Observation Guide

Title of study: College Professors' Use of Computers for Teaching

Checklist for Classroom Observation

Professor's Code number:

Course code:

Date:

1. Classroom setting -

composition of students - grad: __ undergrad: __ No __

number of computers

number of students per computer

2. Classroom interactions

- individualized learning	Yes	No
---------------------------	-----	----

- group/cooperative work	Yes	No
--------------------------	-----	----

- other (describe)

3. Activities

a. mode of instruction

- lecture	Yes	No
-----------	-----	----

- computer-based instruction	Yes	No
------------------------------	-----	----

- student presentation	Yes	No
------------------------	-----	----

b. media

- audio	Yes	No
---------	-----	----

- visuals	Yes	No
-----------	-----	----

- texts	Yes	No
---------	-----	----

- hardware

- mainframe	Yes	No
-------------	-----	----

- microcomputer	Yes	No
-----------------	-----	----

- IBM & compatible	Yes	No
--------------------	-----	----

- Macintosh	Yes	No
-------------	-----	----

- UNIX	Yes	No
--------	-----	----

- other	Yes	No
---------	-----	----

- software

- general purpose

word processor	Yes	No
----------------	-----	----

spreadsheet	Yes	No
-------------	-----	----



database	Yes	No
statistical pack.	Yes	No
others (describe)		

- courseware/special purpose usage

CBI/CAI	Yes	No
Microworlds	Yes	No
Games	Yes	No
Simulation	Yes	No
Tutorial packages	Yes	No
Interactive video	Yes	No
Others (describe)		

- other equipment/materials (describe)

c. subject matter goals

- adjunct instruction	Yes	No
- enrichment	Yes	No
- whole instruction	Yes	No
- instructional tool (describe)		

d. instructional objectives

- cognitive (list and describe)
- affective (list and describe)

e. content of course/program

- content topics covered (list and describe)

- teacher control (amount and how)

- computer control (amount and how)

- student control (amount and how)

- amount of feedback opportunities (describe)

- amount of practice opportunities (describe)

- length of students' interaction with instructional material

- tests and evaluation procedures

- other (describe)

5. Problems

- technical (describe)
- usage (describe)

6. Solutions to problems

- amount and sources of technical support (describe)
- amount and sources of user support (describe)
- teacher-invented solution (describe)

7. Other unanticipated events.

Category Three - Samples of Field notes

The research required taking fieldnotes. The notes contained mostly short descriptions or summaries of events, the places in which the events took place, and the people involved. While taking or reviewing the notes, I usually noted interpretations that occurred to me in the course of an interview or observation. I carefully kept those interpretations in block brackets. The interpretations or hunches sometimes served as starting points for further exploration or analysis later in the study.

In my search for supporting and contrary evidence, I kept an "audit trail" of events and the situation of their occurrence. My fieldnotes and tapes carried the date and place of the interview in addition to the code number of the participant that I interviewed or observed. They were my lifeline for identifying who did or said what when the data started piling up.

The samples presented below are illustrations of 1) the general notes or memos that I kept about each or all of the activities of the study, 2) the search for corroborating or contrary evidence, 3) maintaining an audit trail, and 4) thoughts about the interviews generally.

General Notes

**Audrey (Dr. Dillon's student),
11/12/92.**

Source: Interview and tape of interview

Thoughts: She is very bitter about this class and about computer--any other reason beside lack of knowledge about computers?

Comments:

Even though the student said she does not really want to learn to use the computer, she recognized how important computers could be in her career as a teacher-



-computers might prove to be crucial in her effectiveness/efficiency as a teacher in the information age.

Audrey perceived the Playschool to be an opportunity for them [students] to use the computer with children. Ask Audrey, did she achieve that goal?

Other questions to ask Audrey:

1. What do you mean when you said the interaction with the children at the Playschool is "fantastic"?
2. What do you mean when you said that the Playschool was "right in the middle"?
3. What skills did you learn at the Playschool that you think you might want to use in your own class when you become a teacher?
4. Do you think the way computers were used in your class and at the Playschool helped you in learning that course or in learning to use computers for your own teaching?

11/19/92

Matthew (A computer resource person for veterinary medicine college).

Source: Interview

Job description: In charge of network in the college, makes sure everything runs smoothly for professors and students since most courseware is on the network. Images are also broadcast through the network, using M-motion card, which works with Windows platform.

Responsibility - technical

- work with professors to see that their courseware runs smoothly all the time, that they do not have glitches in class
- work with students to see that they get the courseware or tutorial to use at the time they need it, helps with technical problem (e.g. equipment breakdown)
- work with administrators to see that professors' wishes are communicated and administrators' wishes are communicated to professors.

Matthew suggested that I talk to somebody who works on instructional development with professors (Jake) [will come in at 1pm]



Connie (Professor Hake's student)

Source: Interview

Date: 12/16/92

Ask Connie:

1. Example of goals set by her group "based on organized findings from the schools" as it relates to their project.
2. You mentioned that there are politics in the school system that you might have to deal with when you finally go out to work - do you have an example you would like to share?
3. What really happened in your group? You said the interaction did not work.

Comments:

Group interaction in Connie's group did not work out because of many personal differences. According to Connie, the professor did not catch this until very late into the semester. Connie suggests that maybe the professor should interact more with groups as he does with the whole class to prevent what happened in their group. She was not willing to share the details of the problem, just said it is personal differences, they could not get together because they could not find suitable time for everybody. Five in that group. This reminds me of what Professor Smith said about four being the optimum number for group projects. Something to think about.

Other groups in Connie's class were able to work together without much problem. So there is really no fault-proof formula for selecting people into groups, because the personality of the students is also involved. This may have implications for cooperative learning.

Professor Smith

Source: Interview

Date: 10/28/92

Thoughts:

- Seemed disappointed about many things. Talked about colleagues not wanting to do cooperative teaching using systems science as a base. (Perceived advantage of system perspective: it would have provided a multi-disciplinary approach to teaching and a holistic perspective that he wants so much to promote in his students). Also talked about students' attitudes toward learning. Seemed happy about this interview--that someone is appreciating his using computers enough to want him to talk about it. He was very supportive, provided me with more information than I asked for. But it was helpful. Treated me as a colleague. I felt very comfortable with him.



Topics I picked up from him worth exploring for analysis:

- Concept of optimal number of students in a class. When students are more than four for group project, interpersonal conflicts arise. When students are less than four in a group, they do not bring enough backgrounds into understanding the project completely. (System perspective).
- There must be a philosophy of using computers for teaching. Computers should not be used just because it is available, it must be used with a purpose in mind.
- Technology must be kept in perspective. It does not do everything in teaching. It has weaknesses too.

Search for Corroborating or Disproving Evidence

From Interviews with Professor Dillon (Code: I004.Ed1)
10/21/92.

Things to do:

1. Visit the 'Playschool' [Location?]
2. Get students from both Dr. Dillion's classes.
 - 2 from those who submit journals on disks [class meets on Mondays 4-6pm]
 - 2 from those that e-mail [class meets Monday, Wednesday 3-4pm]
 - 2 from those that go to the Playschool [Tuesday/Thursday]
3. Listen in on their debriefing session after the Playschool is over.
4. Talk to the graduate assistant to Dr. Dillon
[computer support person]
5. Ask Dr. Dillon for:
 - a copy of fieldnote format [used for research project at the Playschool]
 - a copy of teacher's journal
 - a copy of the format of students' dialogue journal
 - the consent letter.

10/14/92

Today I had my first interview with Professor Adamson. It was very interesting. He is a nice person. He treated me like a professional colleague. Did I use the right approach by asking him just to talk about his work with computers? Maybe I should ask more direct questions. I had a feeling that he seemed to be waiting for me to lead the direction of the talk.



Things from today's interview that I need to clarify in the next interview with Professor Adamson:

Probe Questions:

1. So you see computers as a means of solving some educational problems, like saving some animals lives? Are there any other teaching problems that computers allow you to solve?
2. What role do you see these computer programs that you have developed playing in your teaching? What goals/objectives do you see yourself and your students achieving with the programs?
3. Tape 086: "... Also that it [computer] would be useful to demonstrate some concepts that would be difficult to explain..."
Examples of such concepts?
4. Reward structure: What is your idea of how a computer program developed for teaching by professors should be rewarded?
5. How much time on average did you spend developing the computer-assisted instructional review programs?
6. So you think the right environment has to be in place for professors to develop computer programs for teaching -what exactly do you mean by that?
7. Tape 090: "...Simulation allows me to show concepts.." What are the concepts?
8. Note: Ask for a videotape of class presentation.

Thoughts:

Professor Adamson's story about his first attempt to introduce his students to computers as a learning tool is very interesting. Makes me wonder: Do students know that all those efforts are for their own benefit? It appears that Professor Adamson has not totally got over the episode. He seems to shy away from asking students to learn anything directly from the computer. Is that why he made all his computer-assisted instruction review programs? Ask him about this.

Analysis Point:

Teachers are looking for ways to teach with technology. Professor Adamson believes it would enhance his teaching, even though he, like many other professors, is still struggling with how best to integrate it into his teaching.

Students' attitude as a modifying factor on professor's computer use for teaching may be worth pursuing.

Ask Josephine (Professor Adamson's clinical year student):

1. Can you explain more about your statement that computer is the thing of the future?

10/16/92.

I had the second interview with Professor Adamson today. I was able to ask him more specific questions, but the conversation was not as free flowing as the previous interview.

His computer background - Experience of prior use of word processing and spreadsheet encouraged computer use for instruction.

Questions for next time:

1. Has the Anesthesia Equipment program totally replaced the physical learning of anesthesia? How often does the live demonstration takes place now that there is a computer program to supplement instruction?
2. Ask Adamson: You said the overall goal of developing the CPR program was to make learning more fun for your students, and that the program is to teach students to be able to think on their feet and make on-the-spot decisions. What other objectives or goals do you have for developing the program and the other two programs?

Josephine took me on a tour of the computer laboratories in the college and the 116-computer lecture hall today. Josephine seemed to be very proud of their computing facilities. Ask other students what they think about the lecture hall.

Maintaining an Audit Trail

Date: 10/25/92

Source: From all interviews : Things to clarify. Issues not adequately addressed by professors in the interviews.

Ask Dr. Adamson:

1. What do you think of the student's perspective that Andrew brings into the development of the computer-assisted instruction programs that he assists you with?



2. You said "Jeopardy" allows students to review courses including those that were not taught by you? How are courses structured in your college, and how do other professors take it when they know that your computer programs review their courses also?
3. About the lecture hall - how do you use the equipment at the teacher's station?
 - Extron - what used for?
 - Genie scan converter?
 - Why IBM 386, 486 and a Mac Quadra 700 at the teacher's station?
4. You mentioned that students have 24 hour access to the computer labs/lecture hall. Do all students have that access or is it limited to a particular level or year?

Ask All Professors:

- 1) What were the early experiences with computers like? What would you have done differently (from what you now know about computers)? Any particular frustrating/unique experiences you would like to share?
- 2) What roles do you see your students playing in learning now that we have computers around?
- 3) Why do you choose particular brand of computers? Would you have preferred other brands? What brands?
- 4) What does it mean to you to have computers in your work life? What are the implications of computers for you, your work, and the education process?

Thoughts on Professors' Responses to Interview Questions

1. There appears to be an element of selectivity in the way professors respond to questions about computing. There is something idiosyncratic in the way they perceived their computer use and the way they responded to the interview guides. Selectivity may also be influenced by maturity-the more experienced with computers, the better informed, the more refined in making choices about aspects of computing they select.

[Selectivity - could this be my theory?]

2. Evolution of computing described by professors in terms of college or department's history of computing. See Professor Boss' description.



Evolution of computing described in terms of individual progression to the present computing level, See Hake, Landon, and Kandel's descriptions.

3. Interaction of personal and environmental elements evident in the way each person described their computer usage.

My Feelings about the Interviews

1. Interview with students

What does it feel like with each group of students?

With Hake's students, I felt elated. Seeing the professor through his students' eyes gave me a new respect for him as a teacher.

With Adamson students, I almost felt pity because of the time and effort he invested on the CAI development and the students' lack of appreciation of his efforts. I felt a little better when Josephine and the four second-year students mentioned that they liked and used the programs. Part of the problem may have been the way Adamson introduced that anesthesia equipment program to the students. There seemed to be a reluctance in the college now about letting computers introduce new concepts to students. So it is likely computers would be used as a review program for a long time, except if Prof. could "sneak" new concepts into known ones.

With Professor Dillon's students, I felt like I was being made into a mouthpiece for things students felt were wrong with the way computers were being used in their class and in their program of study generally. I felt compelled to do something. My sympathy seemed more with the students rather than with the professor (because I'm a student?) I almost forgot that I was studying a professor who was also a learner.

2. How does it feel to interview professors?

With the professors, I felt good and respected. They were very enthusiastic in telling the story of what they do with computers (probably the first time anybody feels professors' work deserve so much attention). In a sense computer use is symbolic to all the professors, because it is something they are doing that probably 40 percent of their colleagues are not doing. So I have confidence in the information they provided. Also they were professionals so knew the importance of giving accurate and truthful information.



APPENDIX D



APPENDIX D

Coding Procedures

Coding of the interview data was done on two levels. First level coding was done to reduce the data by separating relevant information from the transcripts. Categories used for this initial data reduction were based on the interview questions. Responses that directly addressed each interview question were separated from those that did not address any particular question. Some of the responses that did not address any particular question were either kept for thematic analysis or in a separate file. All the data addressing each interview question were classified under the categories they addressed. These categories were later reclassified under the broad and specific research question that they addressed.

The second level of coding was done to generate categories and themes inductively from the data. Data fell into multiple, rather than mutually exclusive, categories. At the second level coding, cognitive mapping was used to get at the meaning that participants attached to their actions.

Coding Procedures

First level coding involved reading the transcript to demarcate meaningful units. Meaningful units were participants' statements that addressed a topic of interest. The statement may consist of one or more sentences, paragraphs, or passages. A meaningful unit for example, may contain a description of the procedure of computer use in a professor's classroom or computer resources used for teaching.

The first step was to generate codes that would be used to demarcate the meaningful units. The codes were derived from the interview questions and are listed as follow:

TG =	Teaching goals
TGp =	Professors' goals of using computers
TGs =	Goals that professors set for their students or instructional goals and objectives.
TA =	Teaching activities
TP =	Teaching processes
TPp =	Teaching processes (procedure)
TPr =	Teaching processes (resources)
IPT =	Impact of computer use on professor's teaching
ISL =	Impact of computer use on students' learning
ICI =	Impact of computer use on classroom interaction
I =	Interesting or important. This was used to designate statements that could not be classified into any of the above categories but which may be of interest later. Some of those interesting pieces later formed the thematic categories discussed in chapter six.

The second step was to devise a set of instructions for recognizing designated categories in the transcripts. Each category was defined with examples that will be acceptable as equivalents. Below are the coding instructions used.



Coding Instructions

Coding instructions were generated according to the categories of the interview questions.

Background Information

Year of Teaching and Year of Teaching with Computers

Number of years that professor has been teaching versus number of years of computer use for teaching.

Example:

"For about four years. Started out using a few of the units that were available here and as more topics were developed, those were incorporated into the class, so it's been four years.

Influences on Computer Use

The process by which professor developed interest in computer use for teaching. Who and what influenced professors' use of computers for teaching.

Example:

"The project I've worked on to develop HyperCard stacks started about 4 years ago. Before that, I developed an interest in the use of computers in teaching. I'd used computers quite a bit just because I'd had a fair amount of background in the use of computers."

Computer Use for Teaching

Purpose of Computer Use: Goals

What professors and students wish to achieve as a result of using computers for teaching.

Example - Goals set for students:

"To improve instruction in their classes, so that they can see that computers can become an integral part of instruction. It can help them manage instruction, it can help them make better instructional moves."

Example - Professor's goals:

"I want them to begin to see that these tools are very powerful tools that make my work easy or easier and could make their work easier..."



Purpose of Computer Use: Teaching Constraints

A pre-existing situation that has made teaching tasks unproductive, which the use of computers has helped professors to remove or alleviate. The situation may be cited as the reason professors began using computers.

Example:

"The primary use in instructional activity is the use of the computer to enhance the student's ability to read a text and listen to a lecture. One of the basic problems that students have is their ability to read critically and listen."

Teaching Activities

Any action relating to teaching that is of major duration, spanning weeks or months. Examples include, instructional planning, instructional management, and instructional delivery.

Example:

"I use a lot of word processing for all of my handouts, my notes, etc. I use spreadsheets a lot for all my grading. I use databases for keeping track of my students' records and giving them status reports."

Type and Brand of Computers

Microcomputers and/or mainframe, Macintosh, DOS or Windows-based personal computers, UNIX, NeXT, and other brands.

Example:

"So we developed the first HyperCard (Macintosh-based) stack together. Then I also looked at the possibility of using IBM computers when the university got InfoWindow computers and people in academic computing were available then to help with programming in LS/1 language. So I did the pilots in both of those hardware systems."

Software

The types of applications/programs (name and kind) used for teaching activities.

Example:

"Part of it is just doing applications of common computer software such as writing papers on WordPerfect, doing spreadsheet calculations, because we do some financial analysis in one of the classes."



Training

The kinds of training that professors had in order to use computers for teaching.

Example:

"I didn't have any training. But I think I have a fair understanding of computers because of my physics and electronics background. I read lots and lots of books, but the fact is there was nobody around giving training when we first started out."

Funding

Sources of funding for professors' computing.

Example:

"It's been mostly some department money and some college money... The college has provided some money to hire graduate assistants to do some of the programming and other kinds of staff support for using, and for the evaluation also....I did get an academic computing grant with some other people for developing other kinds of programs."

Typical Use of Computers/Procedure:

Series of actions in with distinguishable steps. It may include the scope of computer use, that is, use involving one or more applications. It may include place of use, that is, the classroom or laboratory. It may include taking equipment physically to class or taking the materials generated on the computer with other projection systems to class. It may also include frequency of use--regular classroom use or occasional demonstration of concepts. It may include the duration--time taken to complete each steps in the procedure; and it may have an outcome or a set of consequences.

Example:

"The review questions and posttest questions were set up to be multiple choice because that was a simple format. But there's feedback for each of the answers so students can get an explanation of why the right answer is right or the wrong answers are wrong and then get reinforcement. They can essentially go through and spend as much time as they want and as they need to understand the concepts and make sure they remember all the important ideas. These have been used in a variety of ways in the different classes that we teach. For the most part they've been supplemental to the class. Most of the same material has been covered in lecture, but these programs have been available as a supplement so students can go in and see additional visual pictures and diagrams and test themselves to see if they understand the material."

Impacts of Computer Use on Teaching, Students' Learning, and Classroom Interaction

Perception of Impact of Computer Use on Teaching

Professors' statements that describe what they have been able to achieve in teaching that can be attributed directly to computer use. These are different from statements of opinion about what they think or know that they should be able to achieve with computers.

Examples:

"So that's been rewarding in many ways personally to me, in terms of teaching impact and just the process that I've gone through."

"Anyway, in terms of the impact, I think it increases efficiency and it improves the quality of the feedback to students. I can concentrate more of my effort on the specific things in their paper as opposed to getting the general things that tend to go across every paper. So I would argue that it's been very helpful."

Perception of Impact of Computer Use on Students' Learning

Professors' statements that describes what students have been able to achieve as a result of professors' computer use for teaching. Effect may be about effectiveness or efficiency of learning the course or improved students' attitude toward learning. Effect on learning may also be about contribution of computer use to students' competencies and marketability.

Example:

"Student response has been very positive. Some students use them a lot; others use them just to go through pictures. Others don't like to look at a computer screen. But there's been very good feedback from students about how having them really helps students learn the material."

Perception of Impact of Computer Use on Classroom Interaction

Perceived difference in the classroom processes as a result of computer use for teaching. The difference may be about the mode of interaction, pattern of communication, or change in roles of students and professors.

Example:

"Well, for me it greatly improved class interaction. It really didn't have a lot to do with the technology. I did two things at once--I introduced this methodology of generating computer graphics and kicking off the lecture notes at the same time. I switched over from a lecture style more to a discussion style..."



Problem of Computer Use

Problems associated with computer use for teaching.

Example:

"In the development, I think just finding the time and the resources, the people to help do it, has been the major problem. In terms of actually using them for teaching, one difficulty for the past few years has been having enough computers available for students to use. Another problem has been just getting students to try using the programs..."

Challenges of Computer Use

Challenges that computer use for teaching pose for professors.

Example:

"I like working with computers and it's been a challenge in terms of design, figuring how best to use images and working with students."

Future of Computer Use for Teaching

How professors perceive themselves using computers or perceive that computers will be used in education in future.

Example:

"I think in the near future, we're going to see mullet-media, a variety of sorts, taking over. Quick-Time, DVI, CD-ROM."

Cognitive Mapping

Cognitive mapping is a method of modeling persons' beliefs in diagrammatic form. "In mapping we are listening for, and seeking to represent, persons' explanatory and predictive theories about those aspects of their world being described to us." (S. Jones, 1985, pp. 60-61)

Cognitive mapping comprises two main elements: persons' descriptions of ideas in the situation being considered and beliefs or theories about the relationships between the ideas. The relationship is shown in the map by an arrow or simple line. An arrow represents a relationship where one thing leads to, or is explained by, another. A

simple line represents a connotative, or non-causal link. Elaboration of meaning could be through contrast with some psychological alternative, explicitly stated or implied.

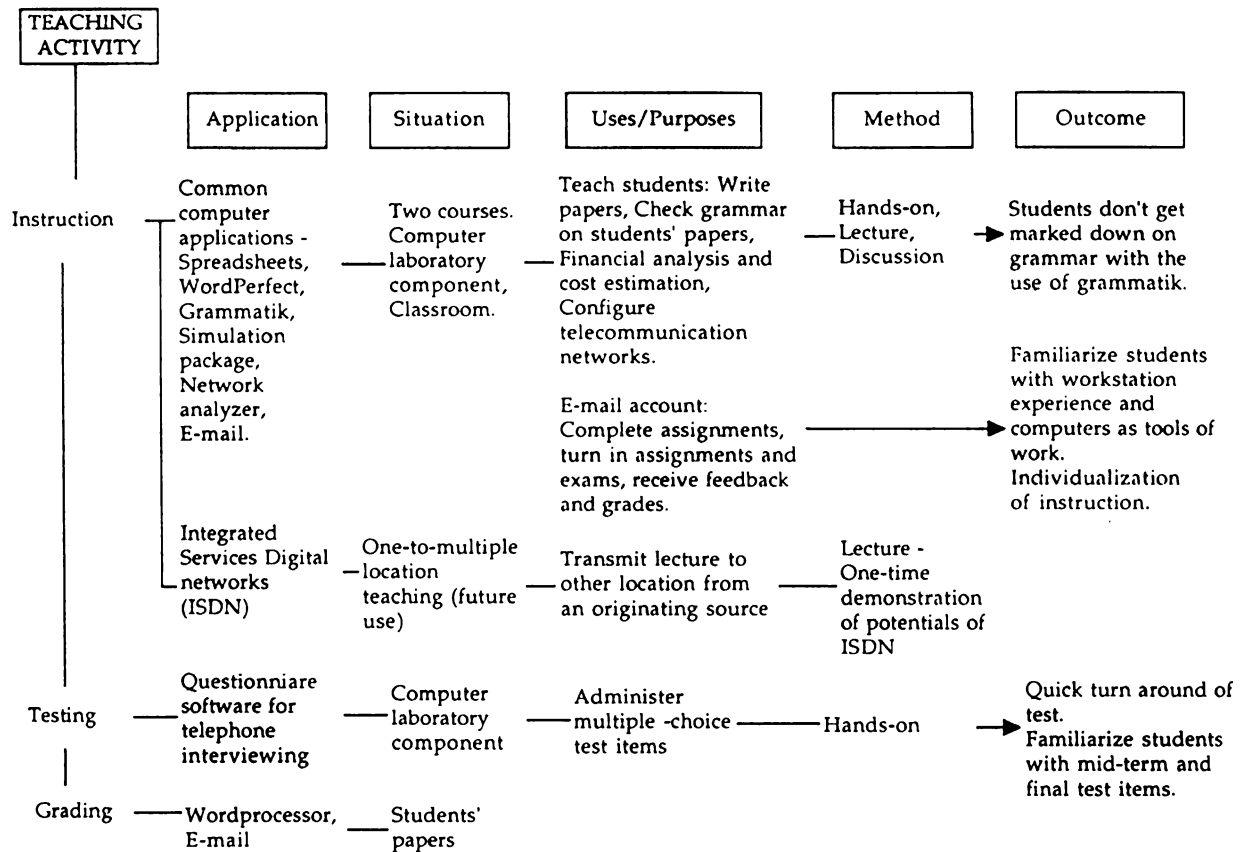
Cognitive mapping was used for the second-level coding of the data. The purpose was to uncover the different levels of decisions that professors make about computer use. Also, developing cognitive maps of professors' decisionmaking processes allowed for the emergence of meanings that professors attach to computer use for teaching. Professors' meanings became clearer as the cognitive maps revealed the detail of the conditions under which an action or decision took place, the reasons for the action, the approach used, and the outcome of the decisionmaking process.

Another advantage of the cognitive mapping approach was that it strengthened the existence of the categories identified through the first-level coding. It also allowed new categories to emerge.

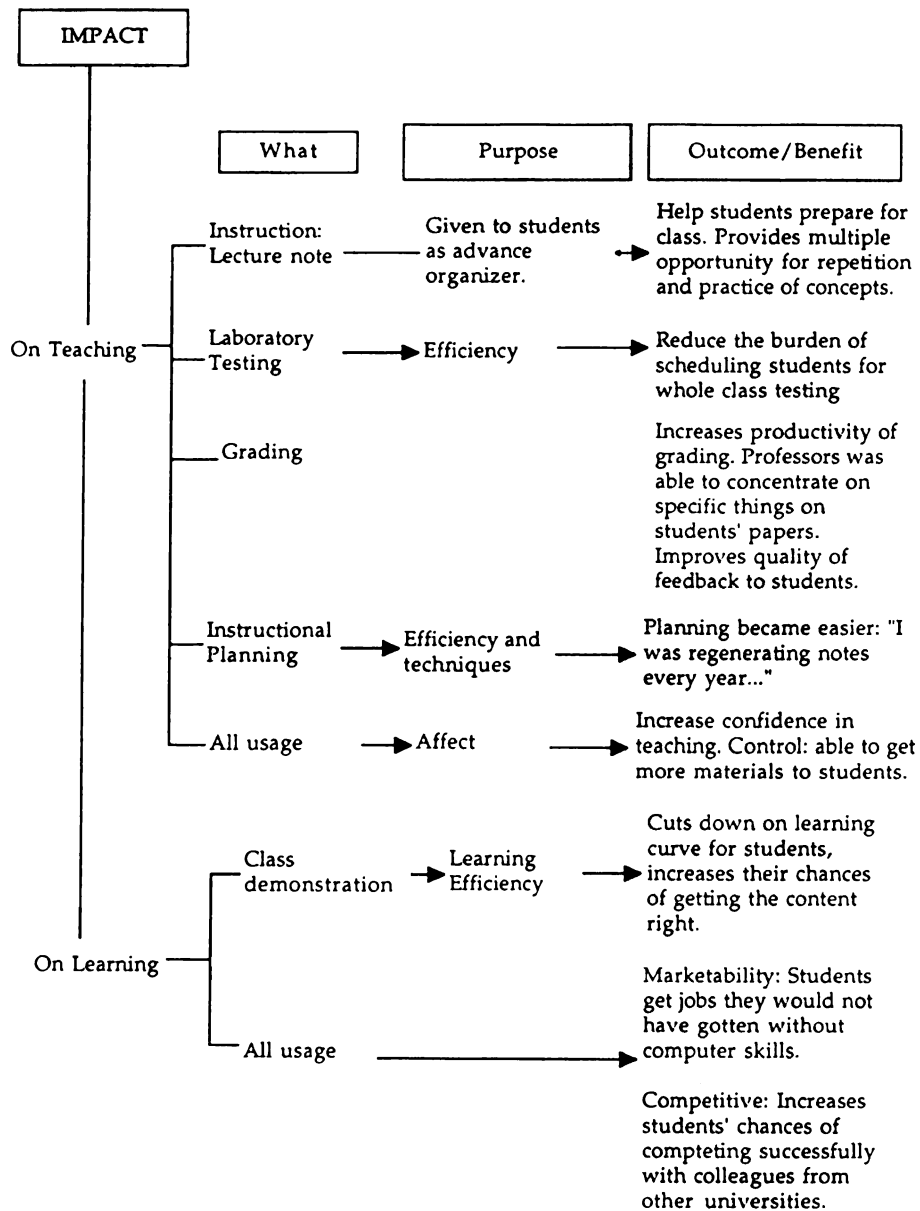
Each transcript was coded inductively using cognitive mapping approach. Categories and themes generated were discussed in Chapters Three through Six. Below is an example of a coded transcript using cognitive mapping.



Example of Coded Transcript









APPENDIX E

APPENDIX E**Report of Data Analysis**

Table 3.7
Categories of Software/ Applications Used by Professors in their Teaching

WORD PROCESSORS MS-Works WordPerfect Imagemate PC-Write PFS Write Notabene	PRESENTATION More Persuasion Presentation Maker HyperCard Paradox for Windows (display and analysis) Panorama (Image sequencing)	PROGRAMMING LANGUAGES Waterloo-Basic Microsoft Basic Visual basic for DOS Knowledgeware's Casetool FORTRAN
DATABASES Notebook 2 MS-Works	DEMONSTRATION PROGRAM (Locally-developed) `Spherical Mirror' Demo program `Locus of Points' Demo program	GEOGRAPHIC INFORMATION SYSTEMS ERDAS (Image surfacing) C-MAP (image mapping) ATLAS-GIS
SPREADSHEETS Microsoft-Excel QuatroPro PerfectCalc Lotus 1-2-3 MS-Works	DEMONSTRATION PROGRAM (Commercial) f(Z) Maple	GRAPHICS Harvard Graphics Swivel
GEOLOGICAL PACKAGES Rockware Stereo-PC	ANIMATION ToolBook Autodesk Animator	DESKTOP PUBLISHING QuarkXpress Illustrator Director Swivel
AUTHORING SYSTEMS ToolBook HyperCard Videologic LS/1 InfoWindow systems	CAI/CBI `Neuropathology' `Jeopardy' `CPR' `Anesthesia Equipment' `Ancient Hebrew'  <b>VIDEODISC</b> `Slice of Life'	COMMUNICATION Emc-squared Eudora Local Area Network



Table 3.8
Software/Applications Used by Individual Professors

Professor	Software/Application	Uses	Reasons for Choice
Adamson (Vet. Medicine)	ToolBook Courseware: "Jeopardy" "CPR" "Anesthesia equipment"	Development of CAI. Class presentation. Students' review.	Provided by college. Graphics and animation capability.
Boss (Arts)	QuarkXpress Swivel Illustrator Director HyperCard	Teach desktop publishing.	Makes typefaces at an angle. Three dimensional objects. Illustration of different lines. Animation.
Cain (Geology)	Stereo-PC from Rockware	Collection and manipulation of plane and linear data.	Saw a demo, has most complete range of function.
Dillon (Teacher Ed.)	Emc-squared Eudora WordPerfect MS-Word (Mac.)	E-mail communication- students and professor. Students assignments.	What was available.
Englebar (Telecomm.)	Harvard Graphics Network design simulation Lotus 1-2-3 WordPerfect Grammatik LAN	Prepare lecture slides. Teach hands-on network design. Teach hands-on financial analysis. Students' papers. Communication	Suitable for task. Taught to students as professional software.
Landon (Human Medicine)	LS/1 InfoWindow (Pilot CAI) Hypercard Videodisc ("Slice of Life")	Development of CAI Development of CAI Present images to students.	What was available. Flexible for development purpose, ease of navigation for students.
Forester (Crop & Soil Sci.)	WordPerfect Imagemate CEENet/Network	Word-processing/ Instruct. planning. Graphics. Communication/ Accessing students' record on-line.	Provided by department. Compatible with department's systems.



Table 3.8 continued.

Professor	Software/Application	Uses	Reasons for Choice
Johnson (Mathematics)	"Spherical mirror," "Locus of points" demo programs devd. by professor. f(Z), Maple (commercial programs)	Class demonstration. Complex Analysis class. Symbol manipulation.	Fun to do. Illustrate math concepts.
Kandel (Humanities)	ToolBook, Videologic WordPerfect, Microsoft-Word, PC-Write, PFS- Write, Notabene Notebook 2 PFS Excel, QuatroPro, PerfectCalc, Lotus 1- 2-3.	Development of CAI Word-processing Record Keeping Spreadsheet	Graphics & animation capability, and multimedia connections.
Mattsen (Computer Science/ Science Education)	Waterloo-Basic Autodesk Animator Knowledgeware's Casetool Visual Basic for DOS Windows-based Write VAX-based E-mail	Devt. of telecourse. Animation. Computer software engineering. Programming class. Taught to students. Teaching & communication.	Received grants. Received grants. Graphical user-interface. Current technology.
Hake (Tech. in Ed.)	MS-Works More & Persuasion TLT Presentation Maker. Hypercard Interactive Videodisc	Taught to students. Used for creating outline of lecture. Organize students' presentations . Taught to students.	Integrated software package. Easy to use, and have short learning curve. Automatic conversion of outline to slides.
Smith (Natural Science)	FORTTRAN ERDAS ATLAS GIS C-MAP 2.1 Paradox for Windows ARC/INFO 6.0 Autodesk Animator Panorama 2.0	Programming and system design class. Image surfacing. Geographic info. systems. Computer-generated maps, display and analysis of data. Database. Animation Image sequencing.	What was available. Received grants.

Table 3.9
Categories of Hardware Used by Professors in their Teaching

COMPUTERS Macintosh Computers Mac Classics Mac IICx IBM - 286, 386, 486 IBM Compatible Zeos Notebook, Zen Commodore, DHK NeXT UNIX	NETWORK & PERIPHERALS IBM mainframe VAX mainframe Modems LAN	DISPLAY Proxima LCD display (used with overhead projector) Black and white image scanner Color image scanner TV monitor screen Videodisc player CD-ROM player
PRINTING PERIPHERAL Dot Matrix printers Laser Printers	RECORDING PERIPHERA VCR Movie Camera Camera	OTHER Science Laboratory interface



Table 3.10
Hardware Used by Individual Professors, Uses, and Reasons for Choice

Professor	Hardware	Uses	Reasons for Choice
Adamson (Vet. Medicine)	IBM 386 (Office) Lecture Hall facilities (116 IBM 386 students workstation, IBM 486 Instructor's workstation IBM mainframes	Develop CAI. Lecture & students' use. Communication.	Provided by college.
Boss (Arts)	24 Apple 512k computers, networked to printers 7 Mac IICx Laser printers Movie Camera Color and black and white scanner Editing station with VCR & TV monitor	Design courses. Film editing.	Color and graphics capability. Received grants.
Cain (Geology)	Zeos Notebook (IBM 386 compatible) Videodisc player TV monitor	Class instruction, field trips. Demonstrate to other faculty.	Portability. Received grants.
Dillon (Teacher Ed.)	IBM compatible Macintosh Macintosh lab Apple II Mac Classic Laser computers	Word processing Students use for assignments. Research center ("Playschool").	
Englebar (Telecomm.)	Proxima LCD display, Modems DHK IBM- compatible PBS telephone systems, Lab	Display lecture notes Communication Students' use Teach to students Teaching and students' assignments.	Received grants Received grants.
Forester (C& S. Science.)	IBM 286	Instructional planning and own writing.	Provided by the department.



Table 3.10 Continued.

Professor	Hardware	Uses	Reasons for Choice
Hake (Tech. in Ed.)	Macintosh IBM lab, Mac lab Science lab. interface CD-ROM Interactive videodisc Proxima LCD display	Teaching and students' use. Class demonstration. Class demonstration. Class presentations.	Better software, short learning curve for students. Received grants. Suitable.
Johnson (Mathematics)	Macintosh computer Macintosh lab	Personal use. Periodic class demonstration.	Provided by the department.
Kandel (Humanities)	IBM computers Familiar with Mac.	CAI development, own use, instructional planning.	Provided by department.
Landon (Human Medicine)	Macintosh Mac and IBM labs.	Development of CAI, teaching, and students' use.	Provided by college, professor's and students' preference, received grants, Better resolution of Macintosh screens.
Mattsen (Computer Science/ Science Education)	Commodore computers (discontinued) 300 MB Zenith computers VAX computers NeXT computers 386 IBM compatibles, networked	CAI development and students' use. CAI development. E-mail communication. Science education projects.	Received grants from US. dept. of education. Received grants from Zenith company. Dynamic allocation of disk space. Multitasking capability.
Smith (Natural Science)	IBM PC UNIX PC - 486. Video ET-Vista board TV monitor VCR Camera	Own and students' use. Mapping projects. Screen-to-video transfer.	Received grants. Professor's preference. Received grants.



Table 3.11
Computing Resources that Professors Used

Computing Resources	A d a m s o n	B o s s	C a i n	D i l l o n	E n g l e b a r	F o r e s t e r	H a k e	J o h n s o n	K a n d e l	L a n d o n	M a t t s e n	S m i t h
Technical Support												
Self		x			x		x		x			x
Technical personnel in dept./college	x		x	x		x		x	x	x	x	x
Student/grad. assistant	x											
University-wide												
Hypermedia	x		x		x							
Instruel Media Center												
Training Support												
Short course (professional meeting)			x									
University-organized seminar and workshop									x			
Computer manuals					x	x						
Colleagues					x							
Funding Support												
Department/College												
Equipment						x		x	x		x	
Software												
Student assist.	x									x		
Teaching fund		x	x									x
University-wide												
ITCD grant	x		x		x				x	x	x	x



Table 3.11 continued.

[illegible]



Session 8 - CAI (Tutorial, Simulations, Problem Solving).

A. Objective

B. Problems

1. Saving a large file greater than one disk full
 - a. Open StuffIt
 - b. Open NEW ARCHIVE (under FILE menu). Give it a name and direct it to be saved on your own disk.
 - c. Choose ADD from OPTIONS
 - d. Select your large file and click on ADD
 - e. Click on DONE
 - f. Close the ARCHIVE.
2. Opening the ARCHIVE (the compressed file)
 - a. Open StuffIt
 - b. Open an existing ARCHIVE
 - c. Highlight file and choose EXTRACT (Remember to tell the program where to save the extracted document, probably a hard disk with enough memory).

C. Team share findings and status report

D. Continue discussion of:

E. CAI - Tandy Lab.

F. Assignment.

Figure 5.2
Professor Hake's Class Note



INTRODUCTION

This test is provided for your practice. Your actual exam will be very similar to the practice exam. This exam tests the first six expectations for the competency exam as stated in your syllabus.

TASKS:

1. Move the second paragraph of text1 to the end of text2.
2. Delete the second paragraph of text2
3. Change the size and style of the title of text2 to 14 point, Italics and bold.
4. In text2, replace all CAI with CBI
5. Change the margins of text2 to: left margin = 0.5-inch, right margin = 1.6-inch.
6. Print text2.

When you are finished, your printed document should look like the attached document.



Attached document:

ADVANTAGES OF CBI

The computer's capacity for infinite patience enables each learner to progress through CBI lesson at his or her own pace. The fast learner may zip through a programmed sequence without being held back. Students who experience difficulty can move at a slower pace, review troublesome sections, and request additional practice until the material is mastered.

In one sense all learning can be considered to be active because the learner engage in some thought process in order to learn through any means, whether by listening to a lecture, reading a book, or using a CBI program. However, the type and level of activity that is mandated by the medium varies. CBI is designed expressly to foster active student involvement in the learning process and requires frequent responses from the learner as information is presented.

CBI programs can test the learner periodically and, based on the results, can allow learners to skip information that they already know or review information that they did not master on a first attempt. Some CBI programs save student records from one CBI session to the next, thus allowing the learner to start where she or he left off.

CBI programs can be successfully used at the preschool through graduate school and research has consistently shown CBI to be equal to or better than conventional instruction in terms of student achievement, the bottom line for any CBI program.

Figure 5.4.

Assignment in Professors Hake's Class

APPENDIX F



APPENDIX F

Computing Resources at Michigan State University

Data for this section came from informal interviews, a faculty seminar, and documents published by the Computer Laboratory.

Mission of Michigan State University

Michigan State University has as its mission, promotion of research, teaching, and service to the community. MSU authorities see technology as a means of fulfilling these missions and have made a heavy investment in computing. The Office of Computing and Technology is charged with overseeing the computing facilities in the university. The Office of Computing and Technology carries out its functions through three main departments. These are the Computer Laboratory, Broadcasting Services, and the Instructional Media Center. The services of the three departments are essential for successful integration of technology and teaching in the university, especially with the convergence of technologies.

Status of Computing at MSU

The MSU Computer Laboratory provides centralized and distributed academic computing support and campus-wide digital networking and support for the university community. Many MSU colleges and departments supplement these facilities and services by operating their own distributed computing sites which are tailored to their specific computing needs. Currently colleges like Engineering, with a tradition of computing, are investing less on personal computers for faculty use, while colleges or



departments like the humanities and social sciences are investing more heavily on personal computers for faculty.

Facilities for Faculty Computing

The Office of Computing and Technology oversees the functioning of three major departments that provide computing facilities, services, and training for faculty. They include the Computer Laboratory, Broadcasting Services, and the Instructional Media Center. The Computer Laboratory provides services and facilities that are mostly computer-related. The Broadcasting Services provides telecomputing services. The Instructional Media Center provides audiovisual equipment and services. An important resource is the Instructional Software Collection which is a joint project between Computing and Technology and the MSU Library.

The Computer Laboratory

The Computer Laboratory houses a variety of computing resource and consulting services. The Computing Information Center, in particular, houses a reference library of mainframe, microcomputer, and network publications, and a list of computer-related training courses. In addition, it provides services and consultation on mainframe use, microcomputer support, network support, and specialized computing support.

The computing platforms provided by the Computer Laboratory include Macintosh, DOS, UNIX-based hardware and software housed in satellite computer laboratories strategically located across campus. There is a graphics laboratory that has Stardent equipment which allows users to produce broadcast-quality video.

Of particular interest to faculty is the Hypermedia Support Services unit which offers consulting expertise on instructional design, presentation graphics, authorware like HyperCard and ToolBook. Hypermedia Support also offers services on the use of

CD-ROM, animation, presentation graphics, slide to video conversion, video controller, and color and black and white scanners for instructional purposes.

The Broadcasting Services

The Broadcasting Services department provides access to facilities, services, and training on instructional telecomputing. It manages the Campus Video Network which provides access to live or taped course delivery, a Computer Interface that allows display of computer output on standard television screens, and production and editing of television courses. In addition, Broadcasting Services provides consultation and evaluation services on instructional development, access to multimedia classrooms, satellite resources, teleconferencing, telelectures, and videotape and videodisc production. It also maintains a videotape library and supplies videotape systems for faculty use.

The Instructional Media Center

The Instructional Media Center (IMC) provides support for photography, motion picture film production, graphic artwork, and media conversion and duplication. Specific services provided by the center include, evaluation, duplication, production, and purchasing of audio tape; demonstration, repair, consulting, and rental of computer projection systems, cameras, and VCR's; computer-generated photography; film/slide/tape to video conversion; rental of movie and overhead projectors; film production and instructional development.

In addition to making these resources available to faculty, IMC assists faculty in locating films and videos for instructional use. It also serves as a disseminating source--consulting, distributing, promoting and executing contracts regarding instructional materials developed by the university staff.



Instructional Software Collection

The Instructional Software Collection is housed in the MSU library. It maintains a software collection of over 500 titles, a reference collection which contains articles, books, how-to information, and vendor catalogs and a videodisc collection which contains about 60 titles on 85 videodiscs. Faculty can borrow software from the collection for instructional purposes.

User Groups

Apart from technical information and material, computing support is also provided through user groups. Three groups which specifically address hypermedia and instructional computing include, the Macintosh Hypermedia User group, NeXT Hypermedia User group, and the PC-based Hypermedia User group. The user groups usually have faculty and staff as their members. The groups are for persons interested in developing and using hypermedia technology. They discuss recent hardware and software developments and interface and design issues.

Scoring Office

Another teaching related service, although not involving faculty computing directly, is the Scoring Office. The services of the Scoring Office are available to instructors, researchers, and staff of Michigan State University. Services provided by the scoring office include instructional assessment, student instructional rating, and data entry. Instructional assessment services include provision of class lists on microcomputer disks, grade and record keeping, test analysis, item analysis, feedback to students, and electronic grade submission.

The major tool for these services is GRADER III, a database system which allows instructors to extract class data for use on their microcomputers or on a

mainframe. It also allows the instructor to export data from their microcomputer into a GRADER III file.

Computing and Technology Training Program (CTTP)

Support for computing is also provided through different kinds of user training. Computing and technology training is offered by the Computer Laboratory personnel to faculty, students, and staff of Michigan State University. Training is available periodically on skills that users need to effectively use the facilities provided by the Computer Laboratory, Broadcasting Services, Instructional Media Center, and the Student Information Systems.

Most of the training is offered under the Computing and Technology Training Program (CTTP). The program consists of a variety of non-credit courses and workshops on:

1. popular software for word processing, spreadsheets, databases, authoring, and statistics;
2. hardware and their operating systems including Macintosh, DOS, Windows, and NeXT computers; and
3. networking and mainframe computing.

There are courses designed specifically for students to introduce them to a variety of computing environments and facilities. In addition, specialized training is offered to faculty and staff who train others to use computing facilities. The series of courses provided for faculty focus on their unique needs for utilizing computing resources, especially in teaching. Academic applications of popular software are stressed in the training.



Integrated Technology Curriculum Development Grant (ITCDG)

A recent initiative to encourage faculty to use technology for teaching was the Integrated Technology Curriculum Development Grant (ITCDG) which is available to faculty on a competitive basis. According to Dr. Carrie Heeter, the Hypermedia Coordinator with the Computer Laboratory, the ITCD grant was initiated by the Office of the Provost for Computing and Technology. The grant is awarded to faculty to encourage them to develop teaching units that are technology-based.

The first ITCD grant became available in 1991. Forty-two proposals were received by the Office of Computing and Technology. Due to limited funds, fifteen grants were awarded to faculty representing fifteen different disciplines on campus. The ITCDG consists of funds for equipment and software, along with programming time for the development of technology-based instruction.

What is very interesting is the diversity of the award recipients which shows that computing is no longer solely the domain of the sciences. Faculty who received the award came from disciplines like Arts, Humanities, Museum, Medicine, Science Education, Geological Sciences, Telecommunication, and Natural Science. The projects for which the grants were awarded range from the development of videodiscs, computer-assisted instruction, computer graphics and animation, to computer-generated maps of an insect population.

Moreover, the unexpectedly large number of proposals received showed that some professors are very interested in using technology in their teaching. Given the right kind of support, more faculty are likely to use computers over time. Dr. Heeter believed this may be the case, judging from the increasing number of faculty using the services of the Hypermedia unit. (Conversation with Heeter: 12/3/91)

Communication and Computer Systems Advisory Committee (CCSAC)

The Communication and Computer Systems Advisory Committee (CCSAC) provides general policy recommendations that guide computing and technology at MSU. This committee works through seven technical sub-committees. One such sub-committee was the Instructional Computing and Technology Committee which provides recommendations and guidelines regarding computer use for:

- instructional delivery, e.g., tutorial, drill and practice, diagnosis, simulation, demonstration, data reduction, and gaming;
- management of instruction, e.g., class records, testing materials, and instructional materials;
- advising, e.g., course history, instructional module history, academic progress and planning;
- curriculum management, including student profiles, tracking and course evaluation;
- support services for faculty, e.g., software, courseware, and hardware expertise;
- administrative organization of, and support, for instructional computing;
- long-range planning for instructional computing;
- computing facilities for instructional computing, from microcomputer to mainframe; and
- review of faculty proposals for instructional computing (Annual Report, 1985/86).

Summary

Michigan State University considers teaching to be an important part of its mission, hence it has invested heavily in modern teaching techniques and technologies. The Office of Computing and Technology oversees the resources for faculty computing



at MSU, working through departments and committees such as the Computer Laboratory, the Broadcasting Services, and the Instructional Media Center; and the Communication and Computer Systems Advisory Committee. Centralized services were provided for faculty through the Hypermedia Unit, including training, and software assistance; and distributed computing services were provided by many colleges and departments for their faculty.

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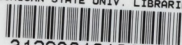
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