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ABSTRACT

This document contains the transcript of a 1986-1987 videotape of case studies at five institutions representing the broad range of postsecondary education: a research university (The University of Michigan), a comprehensive regional university (Eastern Michigan University), a community college (Washtenaw Community College), and two liberal arts colleges (Denison University and Kenyon College). The case studies were conducted in an effort to gauge the types of computer usage, instructional problems using computers, the impact of computer assisted instruction on student learning, the role of computers in higher education, issues involved in computerizing a campus, and a host of other related issues. All interviews were videotaped and diverse perspectives were compiled and edited into a coherent summary. This transcript examines the changing character of instruction in writing, foreign languages, natural and social sciences, mathematics, and professional training, as well as the costs of computing and providing computing resources. Appendices contain a description of the case study design, interview guides, videotape index, case study synopses, and faculty census form. (DB)

The Electronic Classroom in Higher Education: A Case for Change

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Preface

Computers have long been a part of higher education. They play an important role in managing the institution—organizing everything from faculty payroll to student transcripts. In many disciplines they play an essential role in the conduct of faculty research. But it has only been recently that computer technology has been recognized for its potential to help students learn. A few institutions, such as Dartmouth College and Carnegie Mellon University, made a bold commitment a few years ago to become computer-intensive, putting a computer in the hands of every student and encouraging faculty and students to discover new ways to use them in support of student learning.

Should the rest of higher education follow the lead of these computer-intensive institutions? Does the computer have a central role to play in learning and instruction in colleges? Does its potential warrant massive investments in hardware, software, and support staff? At this point, there is no agreed-upon answer to these questions Educational computing is too new to assess its ultimate value.

To gain some guidance in answering these questions, we sought an indication of the computer's value from the handful of pioneering faculty who have been experimenting with different ways to use the computer with students. In 1986 and 1987 we conducted case studies of five institutions that collectively represent the broad range of postsecondary education. These include a research university (The University of Michigan), a comprehensive regional university (Eastern Michigan University), a community college (Washtenaw Community College), and two liberal arts colleges (Denison University and Kenyon College).

At each institution a census of the instructional computing applications was conducted. Using these data we identified the innovators and selected from among them to represent curriculum, types of use (tutorials, simulations, tools), and date of adoption.

We interviewed the innovators and a number of administrators to ascertain their perspective, and that of their institution, on the appropriate role the computer should assume in today's college curriculum. We videotaped the interviews with faculty innovators, students, department chairs, deans and provosts. Faculty were asked to describe key instructional problems they faced and how they saw computers solving them. They were asked to assess the impact of the computing innovation on student learning and characterize administrative support for their project. Finally, we asked them to assess the current and future role of computers in higher education. For administrators the focus was on issues in computerizing a campus for instructional applications, including allocation of resources and costs.

A systematic analysis was made of the transcripts, searching for consistent themes that could explain the character of the electronic revolution. We took our cameras to each campus, first to the classes and labs of the faculty we interviewed, then to the broader environment seeking evidence of the computer's impact on student and faculty life. Over many months we built case-study videotapes of each of our primary institutions: Eastern Michigan, Washtenaw Community College, and The University of Michigan. We then visited Kenyon College and Denison University, using the same procedures. We again combed the transcripts, added the perspectives of these two colleges, and produced a summary video that pulled together common themes of the revolution. New to the summary video was the additional perspective on costs gathered from subsequent interviews with administrators at each of the institutions. (Details of the methods used can be found in Appendixes A and B. Synopses of the four videotapes are in Appendix D.)

The video report provides an important perspective on the revolution. It shows aspects that are almost impossible to convey in print. the nature of the hardware and software, the reconfiguration of space, the interaction of students engaged in computer-based group activities, and the "tone" of the reports by faculty and students as they describe their experience with electronic forms of teaching and learning.

Many viewers of the video expressed the desire for a print version. While the videos capture important dimensions, video programs are still not widely used in the academic community. Even those who have viewed the videos expressed a need to reflect on topics in a more leisurely fashion—especially the topic of costs.

The reader will find here answers to questions such as these: How are computer-using faculty integrating computers into their classroom and into the curriculum? How do students feel about computer-based activities in their course work? What does it cost to provide a campus with access to educational computing? What does the future hold—will the current excitement for educational computing decline or will it grow in importance?

Part I. The Changing Character of Instruction

With slight modifications, this text is a transcript of the videotape: The Electronic Classroom in Higher Education. *An index with approximate locations of the material on the VHS videotape can be found in Appendix C.*

At colleges across America there is a quiet revolution going on. The instrument of the revolution — the microcomputer — is being used in many different ways to provide students with a rich and diverse set of learning opportunities — opportunities that go well beyond what is possible with such traditional tools as lectures, discussions, laboratory experiences, and books.

The revolution is not limited to a few disciplines. Advocates can be found in fields as different as physics, political science, English composition, and music. On any one campus the number of faculty who are using computer-based activities in their teaching is small. But the conviction of these early adopters is strong, and their non-using colleagues are looking on with interest.

A number of forces are at work to spread the enthusiasm and practices of the pioneers more widely. Faculty and administrators are discovering that the computer is an important tool for their own productivity; colleges are challenged to keep pace with current technology if they are going to attract new students; and the computer industry is aggressively pursuing the higher education market. The pace of change from traditional to electronic tools is increasing rapidly. Institutions are looking for guidance as they wrestle with costly decisions affecting the learning opportunities of their students.

From the National Center for Research to Improve Postsecondary Teaching and Learning (NCRIPTAL) at the University of Michigan a research team conducted case studies of five institutions between the fall of 1986 and the end of 1987. Collectively these institutions represent the range of institutional types and student needs found in higher education. The experiences of their faculty, administrators, and student bodies provide insight about current practices and point to future directions.

The University of Michigan is a state-supported research university. With 35,000 students, many classes are large — sometimes as large as 500 students — and it is difficult for faculty to provide as much personal attention as they would like. Some years ago the university made an institutional commitment to become a computer-intensive campus.

Eastern Michigan University is a comprehensive state-supported university with 22,000 students. The provost sees the computer as the ideal catalyst to improve teaching, but Eastern's resources are more constrained than those of the University of Michigan.

Washtenaw Community College has 9,000 students. The college is looking for new ways to help students improve basic study skills. The college must also provide computer experience for students aspiring to jobs in the nearby high-tech industries.

Denison University and Kenyon College are liberal arts colleges. They share the basic philosophy of providing students with a liberal arts education by providing small classes and personal attention. Denison embraced instructional computing many years ago, thanks to a corporate equipment grant and a president enamored with the computer's potential. Kenyon lacked these ingredients, and turned to the computer much more recently. But an aggressive new director of computing is rapidly changing the Kenyon campus, illustrating the importance of leadership in shaping a response to the electronic revolution.

Each college has a fascinating story to tell, although there are more similarities than differences among them. We started with a census of the faculty to gain an overview of campus use. From this census we selected faculty who could illustrate the range of educational uses. In videotaped interviews they described how they used the computer and how it affected their teaching and their students' learning. We then video-taped their classrooms, showing the software in use and recording the reactions of students. Finally, administrators detailed the costs and shared their views of the appropriate role of the computer in their institution. This is a report of what we found.

The early pioneers in educational computing were found in physical science departments. In the last few years, however, faculty in other areas have recognized the computer's value in organizing course material, testing for mastery, illustrating difficult concepts, simulating reality, and allowing for efficient use of lab time. Educational computing is becoming a part of the learning environment in writing and language courses, the physical and social sciences, as well as business, engineering, and music.

Writing

> **"So the student begins to value more his or her ability to play with that text, which is precisely what I think contemporary teachers of writing want to effect."**

At Washtenaw Community College, the computer has had far-reaching consequences for the teaching of English composition. In 1985 the English department set up a computer-based writing lab. In addition to an integrated software package that includes a word processor, students have access to several tutorial programs that cover the mechanics of spelling and grammar.

Many composition students do all their writing on the computer. The English faculty think the innovation has had some important effects on the basic processes of writing and revision—especially for remedial writing students.

Ruth Hatcher, English Department,
Washtenaw Community College:
They tend not to have written much before. They don't like what they've written. They don't think they write well. They don't like their handwriting. It's painful for them physically — mentally — to write something and share it with someone else. The word processor and the use of the Apple II in the writing lab have enabled them to look again at their writing and to want to look at their writing again. For one thing, what they produce is pretty. It looks good, it's in print, it gives them a classy form they can look at. They like that, they are proud of that.

They also like looking at a screen, and perhaps for once we have some positive transfer from television. They are used to looking at a screen, and they would like to see what they have done on a screen, and they will look again at their writing to change it. That is one of the hard things to get the early writer and maybe the more advanced writers as well to do — to look again at their writing and make changes and edit and proof-read. Now they are willing to do that because they like the form that it is in and because it is easy to change.

Dan Minock, English Department,
Washtenaw Community College:
The student finds that the paper that he or she is working on exists on the screen, but that it is tremendously mobile. It can be changed and moved around. A lot of things can happen to that paper before it is printed out. So the student begins to value more his or her ability to play with that text, which is precisely what I think contemporary teachers of writing want to effect.

The open environment of the writing lab encourages students to discuss their writing.

The atmosphere of the computer lab is different from that of the typical writing class at Washtenaw. Students turn more to each other and less to the instructor as the sole authority in matters of writing.

Dan Minock:
One of the surprising effects of the writing lab is the extent to which students form a community — an ad hoc floating community that they join whenever they come into the writing lab. They will come up with problems in their writing; for example, a student might be trying to decide whether "then" or "than" is the appropriate word. He will ask another student, she will give her opinion which he may or may not be satisfied with. A tutor may be called in to give a judgment. If the argument gets very heated, the reference books we've got in the lab itself will be dragged into the computer room and the matter will be discussed, finally settled, and everybody can go back to his or her own work.

At the University of Michigan an experiment is going on in which students in some classes of freshmen composition do all of their work on a word processor. The experience to date leads to this assessment.

William Ingram, Professor,
The University of Michigan:
One of the things we've learned is that students do write differently when they use software designed to help them write than if they were simply using the pencil and paper. It's not necessarily clear that they're writing any better, though they certainly are not writing any worse, but they are writing differently.

One of the ways in which they write differently is that their sense of revision is different when they use word-processing software, as word-processing software enables you to move text around very easily and facilitates the kind of manipulation that is so difficult with pencil and paper. But that very facility leads one into thinking that that is revision, and it's not. Revision is more organic than simply moving sentences around from one place to another in the text. We do find, however, that students who do use word-processing software to write their papers come away from our introductory classes feeling better about the writing process. It's become easier for them, less of a hassle, less of a pain. They enjoy writing papers rather than looking forward to it with dread. So what we do accomplish is an attitudinal change, which is not necessarily a competency change.

> **"[Writing has] become easier for them, less of a hassle... They enjoy writing papers rather than looking forward to it with dread."**

Foreign Languages

Edna Coffin, a professor in Hebrew Studies at the University of Michigan, turned to the computer to individualize instruction for her students. She developed a tutorial program to teach language skills to beginning students in Hebrew. It includes drill and practice exercises on familiar words as well as tutorials on syntactic order.

Coffin also designed tutorials for more advanced applications, such as literary analysis. To conduct a useful discussion of a poem's significance, students must first know the meanings of individual words and phrases. The computer program guides students through a translation so they are better prepared to discuss the meaning of the poem.

A designer prepares the instructional overlay for the Hebrew sitcom recorded on videodisc.

Coffin believes that language instruction would be greatly facilitated by hearing and seeing interesting dialogue from everyday situations. She recorded a popular Israeli television series on videodisc. Her design team wrote a companion computer program that guides the student through the videodisc. At various points the computer stops the show and asks questions designed to see if the student understands the dialogue. If the answer is wrong, the program instructs the videodisc to replay the scene that's key to understanding what is happening. The text of key words is overlaid on the television program, and the student can ask for definitions of unknown words.

Natural Sciences

Tutorials in Biology

Lewis Kleinsmith teaches introductory biology for freshmen and sophomores at the University of Michigan. He developed several programs designed to improve students' understanding of course material. He also set up the Biology Study Center — a computer facility designed specifically for biology students. A fairly typical pioneer, Kleinsmith provides useful insight on improving achievement through the use of computer-based instruction. Students in introductory courses vary greatly in their science backgrounds. Many have had insufficient preparation for college-level courses; this is a particular problem for minority students.

Lewis Kleinsmith, Biology Department,
The University of Michigan:
In the early 1980s I saw some statistics which indicated that the average grade of a minority student taking a biology course was a D. Considering that the average course grade is closer to a B-, this is more than a whole grade below the course as a whole. This in itself was a problem, with real statistical verification. I was concerned about this problem, but it wasn't until this idea of using computers came along that I could see any way of dealing with the problem. There's no way as an instructor for 500 students that I can tutor individual students. But when microcomputer technology became available in the early 1980s, it occurred to me that this could serve as the basis for a one-on-one interaction between students who were having difficulty with the material and in essence a surrogate for myself.

> **"There's no way as an instructor for 500 students that I can tutor individual students."**

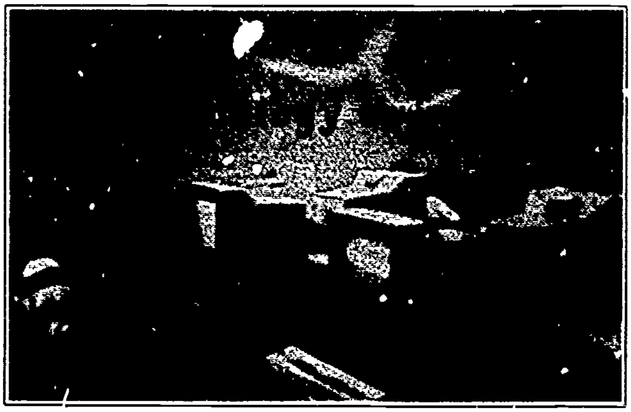
Kleinsmith reports that student achievement has increased as a result of using these programs. Having used variations of the same exam for ten years, Kleinsmith was able to document achievement gains after introducing the tutorials. The average for the whole class rose from 65 percent in the seven years before the Biology Study Center to 81 percent in the three years after. Other findings show that the tutorials serve those most in need of tutorial help. Many fewer students get scores below 50 percent. There is a special section of the course for students whose science background is particularly deficient. Typically, students in that section had scores 20 percent below the class average. Today, their performance is only one percent below the average.

Students report using these programs about twice a week in the Biology Study Center. They believe the computer-based problem sets provide a unique contribution to their learning.

Biology Student at The University of Michigan:
These computer lessons are different from the other types of instruction — lectures and discussions, and maybe just one-on-one with the professor; especially on these programs. If I answer wrong, it immediately tells me why I'm wrong, and if I answer right, I can go back and choose wrong answers to see why they're wrong. And that tends to reinforce what I'm learning. I mean, if you only get the right answer every time, then you might not get the whole picture.

I mean, I can look through my notes and understand what he was talking about, but to really reinforce it, I need to know anything else that has to do with that — that he maybe didn't cover in lecture, but which he didn't exactly expect you to know. But to really understand that point he was making, you really need to know extra details, which you probably won't need for an exam, but it sort of helps the overall understanding of the material.

Lewis Kleinsmith:
Probably the ultimate verification of this positive attitude of the students comes from the fact that there's a very, very extensive use of the study center by the students. Now this is an entirely supplemental facility. We do not require that they use these programs. There is no attendance taken. We don't keep track of how often they've used it. This is entirely voluntary and supplemental and yet we find that there's a very intensive use of the study center, especially as the exam draws closer. At times we'll have waiting lists of 100-150 people trying to get in to use these computer programs. So we know they want to use the material — that they're using it very intensively.



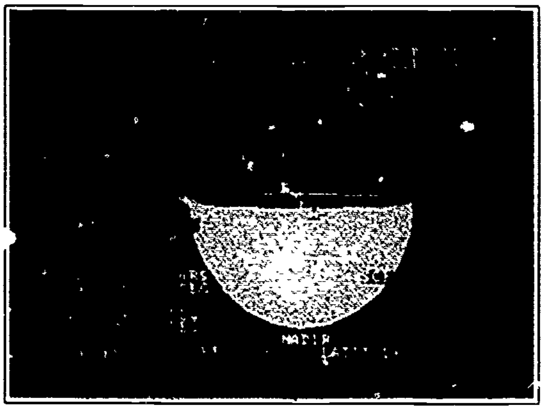
Students Interact with the Problem Sets in the Biology Study Center.

Kleinsmith also uses the computer to illustrate dynamic processes such as protein synthesis. He encourages students to use this tutorial when they have difficulty understanding the concept in lecture. The availability of this type of tutorial has had a subtle impact on his lectures.

Lewis Kleinsmith:
As a result I've freed up a little bit of time in lecture—not a whole lot, but I've freed up a little time in lecture which allows me to spend some time talking about experimental evidence and background for some of the concepts I like to develop. We haven't had time to do that before.

Simulations in Astronomy

John Wooley at Eastern Michigan University designed Skylab — a program that simulates many different laboratory-type experiences in classical astronomy. Wooley notes the impact of computer simulations in his teaching.



Skylab plots the position of the planets, sun and moon from any location on earth and for virtually any date and time, allowing students to visualize movement in the firmament over time.

John Wooley, Astronomy Department,
Eastern Michigan University:
The computer really hasn't changed what I teach, but it has changed how I teach. I do bring the computer into the classroom. I demonstrate phenomena, such as the motions of the planets and the sun and the moon, using the computer in the classroom, and showing the motions on the monitors in the classroom that I would not have been able to do before. And so I think it does make the course in fact somewhat more interesting to the student, and also more interesting to myself in teaching it. It gives us something different to do.

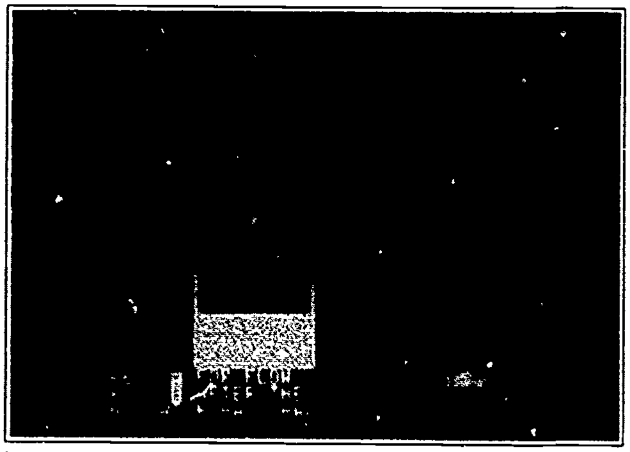
Astronomy Student:
The Skylab program really helps to visualize what the professor is talking about from lecture, since he can just draw on the board. It really helps to see what the planets are doing, and the moon in the different phases, since you'd have to wait all month to see what the moon is doing. It's neat to see it happening right before your very eyes in a manner of minutes. So it really helps to visualize what's going on in our solar system.

"The Skylab program really helps to visualize what the professor is talking about from lecture, since he can just draw on the board."

Electronic Laboratories in Chemistry

At the University of Michigan, wet labs are still a part of introductory chemistry, but part of the lab is carried out on the computer. William Butler has found that the computer adds an important dimension to laboratory learning.

William Butler, Chemistry Department,
The University of Michigan:
The computers are useful as a supplement, and as an additional way of understanding chemistry—and I think that's difficult to get in a real experiment. In the wet lab experiment, the time involved in doing the experiment is so long that you cannot afford to have the students fail. The classroom period is just so long, and they must finish the experiment. That makes it difficult for them to have to design the experiment themselves. In other words, you must design the experiment for them, and, for example, in a titration you must tell them what concentration of standard base they will use and how much of a known sample.



In this electronic version of the wet lab students can titrate many different unknown solutions in just a few minutes.

In a simulation, you can make the students design the experiment themselves. They may fail the first time they run the experiment, but instead of taking two hours to run the experiment, it has taken perhaps only ten minutes, and so they can repeat the experiment. This is a very educational thing for them to do.

Simulations and Tools in Botany and Ecology

Computer simulations are used to supplement traditional laboratory exercises in the botany department at Eastern Michigan University.

Gary Hannan, Botany Department, Eastern Michigan University:
In our general botany course we look at a number of physiological processes of plants, including transpiration, which is the rate of water loss from leaves, and we have demonstrations set up so students can see the effects of transpiration, but it doesn't give them the chance to identify environmental parameters or monitor characteristics of the leaves. So to get around that problem we have a computer simulation of transpiration that allows them to identify environmental parameters, such as wind speed or relative humidity, and also to modify characteristics of leaves, such as leaf size, number of stomata on the surface of leaves. All of these parameters influence the rate of water loss from leaves.

With the professor's help ecology students use the computer to analyze data from their field trip.

Another professor at Eastern Michigan University, Kyle Neely, uses the computer in another way — as a sophisticated calculator. He finds the added efficiency allows him to create a much richer learning experience for students.

“We can do more sophisticated kinds of experiments, we can collect more data, we can even analyze the data in more sophisticated kinds of ways and it doesn't take as long.”

Kyle Neely, Ecology Department, Eastern Michigan University:
In the lab we're using the computer as a tool to enhance the laboratory experience. We're using the computer as a means of processing data, basically. Most of our labs in this ecology course revolve around collecting data, collecting information, and analyzing that data and trying to interpret it. What does it mean ecologically? In most of the labs we spend half the time collecting data and maybe the rest of the time simply analyzing that data and number crunching. This is not a very good use of lab time, and, in fact, maybe all the students are learning in that number crunching experience is how to use their calculator better.

So the computer allows us to decrease the amount of time that we would spend number crunching, and it gives us that time to use in more profitable ways. We can do more sophisticated kinds of experiments, we can collect more data, we can even analyze the data in more sophisticated ways and it doesn't take as long. A good example is a lab we do when we're studying forest ecology. We go out now, or maybe I should say in the past, we went out, we collected information regarding trees only, and we would try to say something about how tree data related to environmental gradients. We didn't have time to measure the environmental gradients themselves.

What we can do now is go out and not only collect information about trees, but also collect information about temperature, moisture, light, and come back and look for patterns and correlations. We could never do that before; we simply had to infer that the patterns existed. So now we can do more sophisticated kinds of things and look at more things in more depth. And I think that's really the value of the computer in the lab right now. It allows us more freedom to do other things.

A student confirms Neely's impression about the values of computer-based learning in science.

Ecology Student, Eastern Michigan University:
The computer was really helpful when we went up to Fish Lake. We went up for the weekend to collect some data on trees and shrubs and grass and so forth. Without the computer we would not have been able to compute all the data that we had up there. It was an incredible amount of data, and it probably would have taken us about three days to do all the number crunching for all the data that we had, which would have meant that we would not have known why we were up there and what we were doing up there unless we were able to interpret that data at some point. And you can't do that unless you number crunch — you have to figure it out. The computers enabled us to figure that out in an hour or so — an hour tops, really.

Kyle Neely:
The computer has two other uses in my class, too. One use is simply to model things that occur too slowly to consider within the framework of the course. For example, we can look at population growth. In most populations it occurs over a long period of time and many years. Well, we can look at population growth over a hundred years in a matter of two minutes on the computer, and that's a valuable asset. We can look at nutrient cycling or energy flow through an ecosystem in a very short time — things that are long-term studies otherwise. So that we can model things that we can't really look at.

A second use of the computer is to reinforce ideas that are presented in the course. Sometimes I present stuff in lecture that may be slightly complex and students don't quite have a full grasp of what I said. I can rely on certain pieces of software to augment what I said — to reinforce what I said. The students heard me talk about it, but they didn't really know quite what was going on. Then I go to the computer, and they get a visual image of what I've said as well, and maybe it's presented in a different way so that they even come away with more information than what I presented originally. In this way the computer has a way of reinforcing my ideas. So we can use the computer to process data, to model things, and to reinforce ideas that aren't quite clear.

Social Sciences

A Computer Conference in Political Science

Raymond Tanter teaches political science at the University of Michigan. In addition to traditional classroom discussions, he uses a computer conference to conduct a simulation of international political negotiations. Each of his 41 students assumes the role of a real person in a government agency. In a series of daily computer based interchanges with fellow agency members, students experience the realities of exercising power. Each student must study in great depth the individual whose role he or she is playing as well as the events and arena in which the person acts.

Michael Cohen, Assistant Dean for Computing, The University of Michigan:
One of the really unique features of the University of Michigan environment is our shared mainframe facilities, which are so well developed here. And that has meant that conferencing has really grown rapidly — conferencing and electronic mail. So that we have much more of that activity than many other comparable campuses do. Surprisingly, I think that may be one of the first areas of big impact on instruction. At first it looks like an administrative convenience for people to be communicating by electronic means, but when the power of asynchronous communication is added to classroom activities, it's sometimes a very fruitful combination.

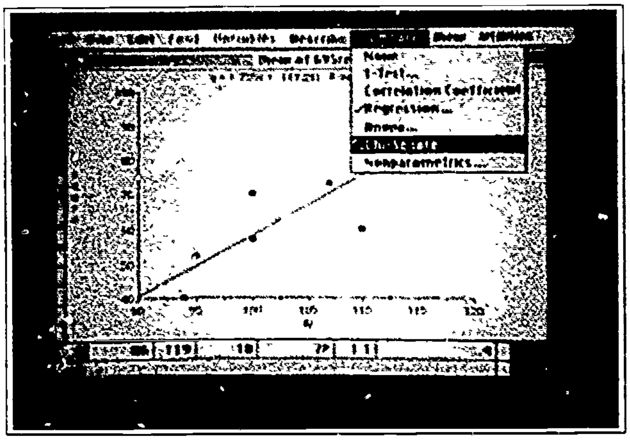
Software to Teach Statistics

The computer has entered the social sciences, mathematics, and business through the use of statistical packages — computer programs that organize and summarize large quantities of data. Stuart Karabenik describes how he uses statistical packages in an undergraduate psychology course.

Stuart Karabenick, Psychology Department, Eastern Michigan University:
The computers allow me to do many things in the course that could not be done as efficiently without computers. We can collect more data, we can collect as many as five hundred responses from individuals. Students then enter the data in files on the computer, and it teaches them the process of data entry. They then conduct various statistical tests; these tests could really not be done as well without computers. Because we can do a number of different tests, it gives me a chance to actually give them experiences with some higher-order statistical concepts like interactions of various sorts — again, which could not be done as readily without computers.

Carl Berger, at the University of Michigan, has found a statistical program that changes in a fundamental way students' understanding of statistics.

Carl Berger, Education School,
The University of Michigan:
Some problems we've had in teaching courses in introductory research in education is that, while the students can understand the research very well, they have a tough time with the statistics. In opening up the "black box" that statistics appears to be for them, efficiency of learning drops significantly. What we've found recently is that by using a program such as Statview *on the Macintosh we can increase that efficiency by reducing the time that it takes to understand the input and output of research packages. Not only is this input and output in numerical form, but you can also take care of that input and output just by a click or two on the mouse on the Macintosh to show visual imagery. What's missing, of course, as with any black box, [is that] they don't understand the mathematical processes. But I would challenge many of us to think back on those mathematical processes and try to figure out whether we remember them, or whether what we would like to remember is the overall inferential process of research.*



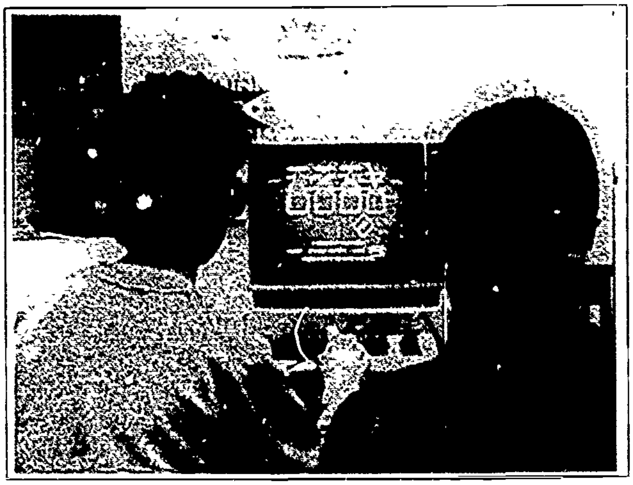
Statview provides a visual display of data relationships that enhances students' intuitive understanding of statistics.

Mathematics

Janet Hastings at Washtenaw Community College uses several drill-and-practice programs in her math courses. She teaches a course designed to counteract math anxiety and finds that the computer provides the combined advantage of instructional support and motivation.

Janet Hastings, Mathematics Department,
Washtenaw Community College:
I think the computer is a great aid to motivating my students. Using the computer in the classroom makes some of the topics more interesting to the students; it makes certain concepts like a game instead of just a challenge; it puts the idea of grasping a concept in a better framework for the kids and other students and takes away the anxiety. I really think it makes the classroom experience richer.

In more advanced courses, Hastings also uses the computer as a tool. Students can explore concepts by visually manipulating them. They can also experiment with the nature of functions and their limits, conduct comparisons between functions, and examine the properties of inverse functions.



Remedial math students find added motivation when they do math on the computer.

Professional Training

As computers permeate businesses, professional training must be responsive, incorporating the computer itself into student instruction. This is a major force pushing computers into higher education.

Respiratory Therapy

At Washtenaw Community College, Ann Flint notes the technological changes in hospitals that prompted the respiratory therapy department to incorporate computers into the curriculum.

Ann Flint, Respiratory Therapy Department,
Washtenaw Community College:
I came to think that maybe our students should be exposed to computers while they were in school — to not think of them as a frightening experience and to learn with them in a simple way so they could come to feel comfortable with them. Also, more and more computers are being introduced in the hospital with our equipment — computerized ventilators, computerized cardiac output machines, computerized monitors of various sorts for patient

monitoring. The students are going to have to learn how to use those.

Interior Design

The growing use of computers throughout the interior design field is having an impact on curricular decisions at Eastern Michigan University. Deb Dilaski-Smith talks about those changes and the financial benefit that computer-based design skills can bring to a graduate.

Deb Dilaski-Smith, Human Environment and Computer Resources, Eastern Michigan University:
The use of computers in this course, as well as, hopefully, in additional courses, is changing the way we're thinking about assigning projects in the future. We're hoping to assign more required projects; for example, required floor plans from a computer printout in lieu of the typical drafting blueprints that we normally see in our course work. We are also going to be requiring the students to turn in their typed version of projects and specifications as printouts from the computer. Before it's been an optional portion of their life, but we are now wanting them to really become fluent with computers.

It's interesting that those students who have had a CAD minor and have graduated are able to claim about $10,000 annually more in their income when they do graduate and obtain a job. They're snapped up in terms of their job. We recently had a student who is finishing up her sic studies this coming December. She already has been hired for a position, and the company is willing to work around her schedule until she graduates in December. So our students are quite marketable with that type of a minor.

Engineering

Computer-aided design and computer-aided manufacturing are rapidly changing the nature of engineering education in almost every specialization. Lynn Conway at the University of Michigan describes the challenge.

Lynn Conway, College of Engineering, The University of Michigan:
A real challenge has been developing in recent years in engineering education because the classroom has increasingly become distanced from the advanced means of production. In microelectronics, in various areas of process technology, use of advanced materials — in all of these areas — the means of producing actual designed objects are very expensive, often very sophisticated. The classroom doesn't have access to those processes, typically.

No one university can afford to have all these means of production right at hand. It turns out that a very, very important application of computing to engineering education has been to provide a means of, in a sense, connecting the classroom with the means of prototyping of engineering design. In fact an important example is in the design of computer chips — the silicon chips which actually make computing technology possible.

At The University of Michigan, students are learning how to design computer chips — the very heart of the computer — with the aid of the computer itself. A special computer network allows students to send their designs to a manufacturing plant in California. The designs are translated into a computer chip that contains many student projects. Once the chip is returned, students have the opportunity to perform tests on the actual chip.

Business

Business School students mastering the fine points of spreadsheets.

University of Michigan Business School faculty report fundamental changes in the curriculum as a result of integrating computer applications into instruction.

Kathy Willis, School of Business Administration, The University of Michigan:
At the Business School, we've revised the curriculum substantially to include a variety of computing exercises. These allow all of those people taking classes at the Business School — RBA, MBA, and the executives — to experience a great deal of computing. They are particularly involved in analytical exercises such as marketing and financial simulation; there's a negotiations model, a lot of database searching, and in particular, the spreadsheet.

Thomas Kinnear notes that use of the spreadsheet has evolved since it was first introduced into courses.

Thomas Kinnear, School of Business Administration, The University of Michigan:
Previously, you might get some small illustrations in accounting of the Lotus 1-2-3 application. What you see now is very sophisticated modeling done with the spreadsheet type of format, and the student often isn't even aware that they're working within a spreadsheet format.

Kinnear notes that the computer has changed the character of the assignments students turn in.

In the last year or so there have been many changes in the way students make use of personal computers and computing in general. You see it from the end product very readily, by the types of papers that you see. From a word processing point of view they're correct — spell-checkers take care of things, proportional spacing. The graphics are probably the most phenomenal thing that you see as a receiver of these kinds of materials; excellent presentation graphics and reports and when they do an oral presentation. It really changes the nature of that part of the quality of what you receive.

Music Education

In music education, James Froseth uses a computer and slide projector to show proper and improper techniques for playing musical instruments. The students must judge whether or not the person in the slide is playing the instrument correctly. He speaks of the difficulty many good musicians have becoming good teachers.

Music education students are tested on the fine points of playing the clarinet from computer-activated slide displays

James Froseth, School of Music, The University of Michigan:
They have extensive background in performance; they are trained and educated to play these instruments. They are very knowledgeable, but very often I found in the past the knowledge wasn't enough. It was analogous to an M.D. who knew all of the diseases and cures but wasn't trained to diagnose patient problems. So these programs are designed to give students the skills to implement the information they receive. They simulate the teaching process where you have to deal with the student's problem, diagnose, and prescribe a remedy.

The programs are designed to be tutorial in that they describe the elements of instrumental performance that make it correct when it's correct and then provide a sequence of exercises where the student is to apply this information. We find that some students have a great deal of skill at the start. They are very used to noticing, and others are not very skilled in noticing things visually.

In the Music Video Synthesis Lab, David Gregory composes music to accompany a video of a dance performance. Students from music, art, and dance collaborate in this facility to produce all-electronic performances.

Music Performance

The Music Video Synthesis Lab is a new facility on the University of Michigan campus. It has a central role in an effort to bring together technology and the performing arts. Students use the technology to explore and experiment with graphic design, choreography, and music composition.

The Macintosh computer is an important tool in this lab. It facilitates both the creative tasks of music composition and arrangement and the production tasks of recording and playing back music generated on the synthesizers. Any composition that has been entered into the computer through either a microphone or a keyboard instrument can be viewed in conventional notation, edited or arranged differently, and then played back with the changes. The entire musical score and all its parts can be printed as a product barely distinguishable from a publisher's version.

The range of uses of computers across these institutions is diverse. In no college was the computer being used in every department. But given the potential of the computer to enhance learning opportunities in virtually every area of academic endeavor, it is likely that its use will grow dramatically as the possibilities are realized and the resources become available.

Part II. The Costs Of Computing

Many institutions are now facing the issue of identifying and finding the resources that will provide students with a productive and educational computing environment. It is an expensive proposition to computerize a campus. The computer itself is only a small part of the equation. To this must be added the cost of facilities, software, and training. As with all technologies, initial investments are only the tip of the iceberg; annual operating expenses can quickly equal these costs. With a technology that is rapidly evolving, obsolescence can make today's state-of-the-art purchase into next year's dinosaur. The experiences of the five colleges provide the range of typical costs for departmental labs, institution-wide microcomputer centers, and training.

Providing the Resources

Departmental Labs

Historically, microcomputers were first located in departmental labs. The cost of a lab depends on equipment cost, availability, and level of user support. At the low end of cost is a facility for the chemistry department at Eastern Michigan University. Established in 1979, it has fourteen Commodore Pets housed in an unused and windowless storeroom. Ten of the computers were donated, resulting in initial start-up costs of less than $6,000. No expenses were allocated for annual operations. (See Table 1 for a breakdown of costs.)

Today's standards for equipment and volume of student use require much more than this facility can provide. The chemistry department is currently seeking $90,000 to set up a new lab and expects to spend $40,000 for annual operating expenses.

Table 1. EMU Chemistry Lab Costs. (In $1,000s)

Category	*Initial*	*Annual*
Renovation/Maint	$ 0.3	$ -
Utilities	-	-
Computers[1]	4.5	-
Software	1.0	0.5
Supplies	-	-
Personnel	-	-
Total	**$5.8**	**$ 0.5**

[1] Computers included 14 Commodore Pets of which 10 were donated.

The Writing Laboratory at Washtenaw Community College has 18 Apple II computers to serve the developmental writing needs of 900 students each semester. The college estimates that it cost $34,000 to set up in 1985 and about $3,000 a year for aides to assist the students (See Table 2.)

Table 2. WCC Writing Lab Costs. (In $1,000s)

Category	*Initial*	*Annual*
Renovation/Maint	$ 8	$ -
Utilities	-	-
Computers[1]	19	-
Software	7	-
Supplies	-	-
Personnel	-	3
Total	**$ 34**	**$ 3**

[1] 18 Apple IIe computers

Table 3. UM Biology Study Center Costs. (In $1,000s)

Category	*Initial*	*Annual*
Renovation/Maint	$ 75	$ -
Utilities	-	-
Computers[1]	15	-
Software[2]	60	-
Supplies	-	-
Personnel[3]	-	10
Upgrade[4]	66	-
Total	**$ 216**	**$ 10**

[1] 20 Commodore 64s [2] Development of new software [3] Contributed by department [4] Upgrade to IBM PS/2 on a network, rewrite software

The Biology Study Center was established at the University of Michigan in 1984 to provide an environment where 500 students could come several times a week. The Center cost $150,000 to set up and about $10,000 a year to operate (Table 3). Of the total set-up costs, only 10 percent went into buying computers — low-end Commodores. Half the amount went into room renovation. The remaining 40 percent went into software development; if commercial software had been available, it might have been considerably less. For example, the word-processing software at the community college writing lab cost $7,000, representing only 20 percent of the initial investment.

At all five institutions the cost of annual operations was seldom identified. Help and supervision in the lab was provided by the same teaching assistants assigned to support a course before computers were used. But many of the departmental faculty we interviewed noted that the real annual costs of user support, machine maintenance, and replacement are ignored — not because they don't exist, but because there is currently no place for such items in the departmental budget. They have not yet been recognized by the administration as legitimate instructional expenses.

Public Clusters

Every institution we visited had at least one public microcomputer cluster where students and faculty could go to meet a wide range of computing needs. The clear advantage of such general-purpose clusters is economy of scale — important when many different departments require students to use computers. The disadvantage is that the needs of college departments can be quite diverse, with individual departments demanding computers of very different design. For example, the chemistry department may need Apple IIs while the business department wants IBMs. In addition to supporting diverse hardware, user support in a central facility is made more complicated when the support staff is expected to know the intricacies of multiple machines and software.

The public cluster at Kenyon College with 15 computers cost $40,000 to set up and $22,000 per year for annual operations.

The public cluster at Washtenaw Community College has 36 computers to serve the general-purpose needs of a student body of 9,000. The set-up costs were $70,000; annual operations cost $32,000 (Table 4).

Table 4. WCC Public Cluster Costs. (In $1,000s)

Category	*Initial*	*Annual*
Renovation/Maint	$ 18	$ -
Utilities	1	1
Computers[1]	46	-
Software	3	2
Supplies	2	1
Personnel	-	28
Total	$ 70	$ 32

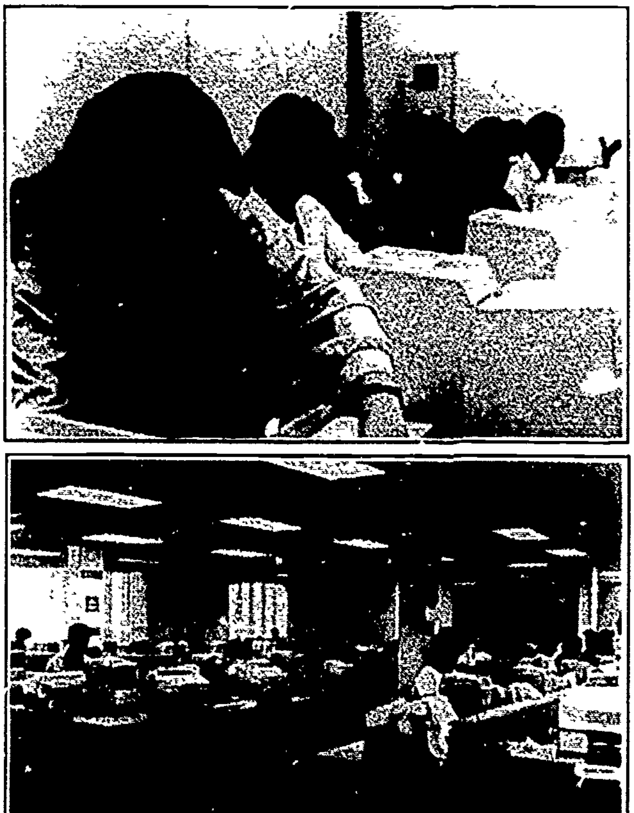
[1]30 Commodore 64; 6 Apple II

With almost twice the number of computers (63) and a more extensive software collection, the public cluster at Eastern Michigan University cost $229,000 to establish and $81,000 annually to operate (Table 5). This one cluster is expected to serve most of the microcomputing needs of 22,000 students — needs that are not met by the few departmental labs.

Table 5. EMU Public Cluster Costs. (In $1,000s)

Category	*Initial*	*Annual*
Renovation/Maint	$ 27	$ -
Utilities	-	-
Computers[1]	158	9
Software	39	5
Supplies	5	8
Personnel	-	59
Total	$ 229	$ 81

[1]63 computers: TI, Mac Plus, IBM



Public computing clusters at Eastern Michigan University (top) and the University of Michigan (bottom).

> **[In public clusters] the per-computer costs ranged from $2,000 to $4,000 for initial set-up and $900 to $1,300 for annual operating costs.**

A computing cluster at the University of Michigan contains 170 Macintosh and 19 PC-DOS computers. This facility cost $768,000 to set-up and $189,000 to operate annually (Table 6).

Table 6. UM Public Cluster Costs.[1] (In $1,000s)

Category	*Initial*	*Annual*
Renovation/Maint	$ 189	$ 8
Utilities	75	25
Computers	389	31
Software	39	-
Supplies	76	36
Personnel	-	89
Total	**$ 768**	**$ 189**

[1]One of 18 clusters to serve 35,000 students. It contains 170 Mac Plus and 19 Zenith PC computers.

Institutions varied widely in the size of their investment in public computing. The per-computer costs ranged from $2,000 to $4,000 for initial set-up and $900 to $1,300 for annual operating costs. Variation depended on three factors: the amount of renovation required for the room that houses the computers, the power of the computer, and the level of user support.

Costs By Category

The University of Michigan maintained the most accurate records on expenditures, so it is the best case to use to understand the distribution of costs involved in establishing a microcomputer cluster (Figure 1).

Start-Up Costs. For this institution, fifty percent of the cost went into the purchase of computers, related hardware, and software. Another ten percent of the budget was allocated for start-up supplies ranging from a large stock of paper and ribbons to handouts that describe how to operate the machines.

The remaining third of the expenditures went for renovating the space. Computers require environments where the temperature and humidity are carefully controlled, the power source is filtered to protect against power surges, and the light is at the proper angle and intensity to minimize glare on computer monitors. Special purpose furniture is also required to accommodate the hardware. In addition, many institutions want their microcomputers to be able to communicate with their mainframe computer or remote data bases, necessitating special networking and telephone wiring. These requirements can be quite costly when dealing with older buildings that need to be retrofitted.

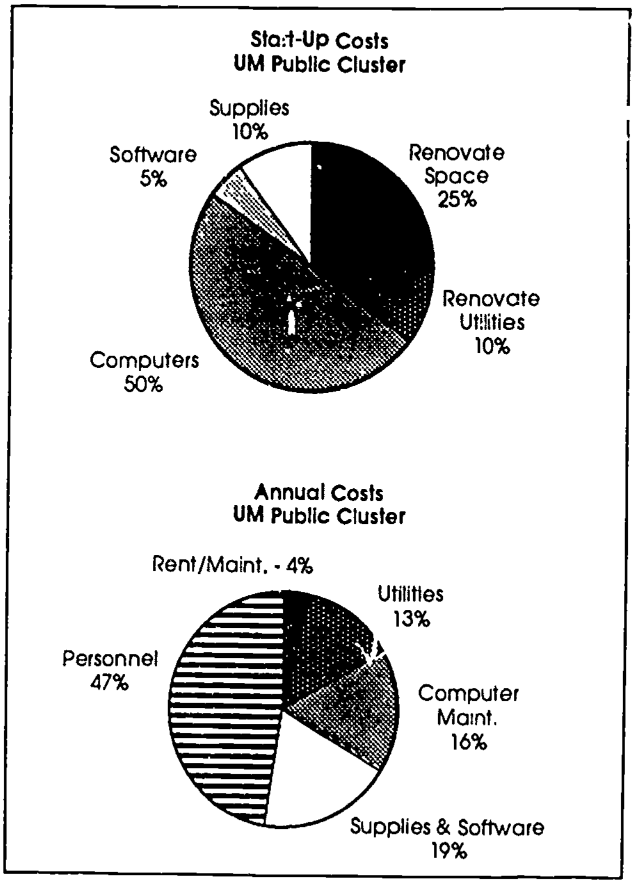


Figure 1. Initial and Annual Costs for UM Public Cluster, in Percentages.

Annual Operations. For annual operations almost half the cost (47 percent) goes for personnel to provide the necessary assistance to users. Seventeen percent goes into rent and utilities, sixteen percent toward computer maintenance and replacement, and nineteen percent toward new software and consumable supplies such as paper, ribbons and handouts.

Obsolescence

A major issue in computerizing a campus is obsolescence of the technology. Computers are evolving rapidly, with new and attractive improvements appearing almost monthly. Of the tools used by academics, the computer has one of the shortest useful life expectancies. For example, the chemistry lab at Eastern Michigan University served departmental needs between 1979 and 1983. Usage fell off after 1983. Now the department is seeking a new facility and new computers that will cost 15 times as much.

The Biology Study Center at the University of Michigan was built in 1984 and stocked with low-priced Commodore computers. Two years later the Commodores could still serve the basic instructional requirements. However, there was increasing demand for greater access to the programs. The most economical solution seemed to be to upgrade the Center's computers to match the PC-DOS computers in the public computer clusters and rewrite the software so that it could be used in both settings. In this case obsolescence came after two years. The Center's developer believes that it is only a matter of time before new demands will be placed on the Center to modify the software to run on other machines.

Paying the Costs

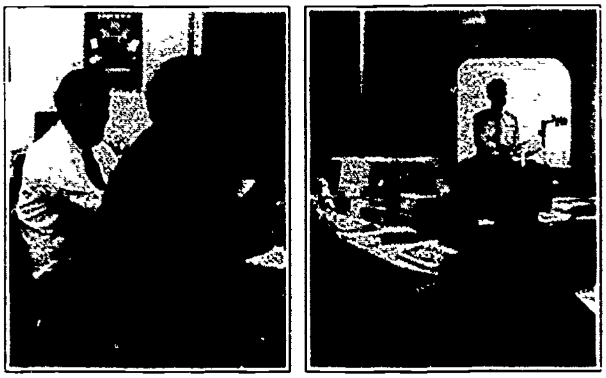
All of these factors make computing very costly. Two strategies have been tried to keep these costs off the general budget, and to do so in a way that deals with obsolescence. Both have their drawbacks. One is to have students purchase their own computers. The other is to assess a fee and use the money to provide access to state-of-the-art equipment in computer centers.

In 1984 Dartmouth College urged entering freshmen to purchase the newly released 128K Macintosh computer at a cost of about $1,000. The college provided a network hookup to link all of these machines to other shared resources. At that time the Mac's internal memory capacity seemed adequate to accomplish a great deal of work. Faculty, with the assistance of a programming group, designed software to be used on this machine. Each subsequent freshman class, however, was urged to buy a more powerful version of the Mac, and the faculty wrote new software to take advantage of the more powerful machines. By the time the 1984 freshmen became seniors, the new software would not work on their machines purchased just three years before. Students could upgrade their machines, but at a cost to each student of about $700. It has been difficult to require students to have this done, since they had the expectation that their original investment would be sufficient for their entire four years.

The University of Michigan took the opposite approach. Students are charged a user fee of $100 per semester, or $800 over the course of four years. In return, in 18 public clusters the University makes available the hardware and software most commonly demanded by faculty. The ratio of one computer for every 15 students still results in many students not having immediate access to the computer of their choice at peak demand times.

Promoting the Use of Computers

For institutions that want to promote the use of computers, training of students and faculty is viewed as essential. Some argue that faculty training is the more important of the two.



(Left) At Eastern Michigan University, Bob Ferrett introduces faculty members to productivity software.

(Right) At the University of Michigan, Bob Kozma teaches instructional design to faculty who are developing software.

Bob Ferrett, Center for Instructional Computing, Eastern Michigan University: *When we started out, the goal of the CIC was to take interested people and help them develop the computer for classroom use and instructional effectiveness. What we have found is that by offering the tool-type workshops — the spreadsheets, the word processors, the data bases — people are becoming more comfortable with computers. As they become more comfortable, they begin to see more possibilities for the use of the computer in the classroom. A number of people who had never touched a computer before are now actually developing software for classroom use.*

Eastern's center has seven computers and one staff person who designs and conducts a variety of workshops for faculty and provides individual consultation as needed. The consultations range from operating generic tools, such as word processors, to designing instructional software suitable for use by students. The lab cost $53,000 to set up and about $39,000 a year to operate. Annual operations are about half that of the main public computing cluster (Table 7).

Table 7. EMU Faculty Training Costs. (In $1,000s)

Category	Initial	Annual
Renovation/Maint	$ 7	$ -
Utilities	-	-
Computers[1]	30	0.5
Software	15	7
Supplies	1	1
Personnel	-	30
Total	$ 53	$ 38.5

Computers are 5 IBM PCs and 2 Mac Pluses

Table 8. UM Training Costs (In $1,000s)

Category	Initial	Annual
Renovation/Maint[1]	$ 150	$ -
Utilities	-	-
Computers	100	100
Software	-	50
Supplies	-	84
Personnel	-	550
Total	$ 250	$ 784

[1] 1 lecture room, 1 consultation room and 2 labs 1 with 16 networked Mac Plus computers and 1 with 16 networked IBM PCs

The University of Michigan tries to serve the generic training needs of 2,600 full-time faculty, 35,000 undergraduates, and 13,500 graduate students with a single support center (Table 8). This involves providing a continual flow of workshops on topics that range from basic machine operation to advanced use of spreadsheets. Advice is provided on hardware selection and on solving functional problems with hardware and software. A library is available with examination copies of a wide range of productivity software. More recently the center has expanded into the area of educational software, but by and large, it does not provide help in designing instructional software. This is provided by another center at the university.

The facility contains two labs—one with 16 Macs and another with 16 PCs. Another area provides space for demonstration hardware and individual consultation. A separate 70-person classroom provides seminar-style learning with large-screen projection. This training center cost $250,000 to set up and another $750,000 per year to operate. Seventy percent of the annual costs are for personnel.

The Hidden Cost — Faculty Time

Another cost of educational computing is faculty time to develop software or incorporate computing into instruction. In 1984 Lewis Kleinsmith at the University of Michigan began to develop computer programs to help his students master the difficult concepts of introductory biology. He began with the expectation that it would require little more than a six-month sabbatical. Instead, the effort required a significant fraction of his time for four years.

Totaling the Costs

The total cost of educational computing can be staggering for an institution that tries to meet all needs and demands. At the University of Michigan, Michael Cohen describes what may be the cost for a full commitment to educational computing.

Michael Cohen, Assistant Dean for Computing, The University of Michigan:
It's difficult to estimate the cost of all of this. They're really spread over so many places and so many types of expenditures. But if I had to do it I would say that the cost of the hardware students will use, whether they buy it themselves or use publicly provided hardware, and the cost of people to support the hardware and develop the software must come to on the order of $1,000 per student per year, steadily, every year. It's not a matter of investing one time. The computers wear out, become more sophisticated, must be replaced. They must be maintained. New software must be developed continuously. And people always will need explanations of how to use each stage of more sophisticated equipment. That isn't going to go away. Those costs are more or less a permanent feature of higher education.

Assessing the Value of Computers for Teaching

Is it worth it? Institutions that are making large financial commitments clearly think so. For their presidents and provosts the computer plays a central role in transforming the academy in highly valued ways. Eastern Michigan University's provost is typical.

> **"I think the evidence is rather overwhelming that computers afford opportunities for the enhancement of instruction that simply aren't present in any other technology or any other approach that we've known thus far."**

Ronald Collins, Provost,
Eastern Michigan University:
I think the evidence is rather overwhelming that computers afford opportunities for the enhancement of instruction that simply aren't present in any other technology or any other approach that we've known thus far. Computers provide the dramatic opportunity for simulation of events and activities that simply cannot be replicated in the classroom in real time. They provide the dramatic opportunity for students to interact in real time in the classroom in ways that simply cannot be duplicated by any other technology. Furthermore, computers — unlike any of the previous technologies that have impacted education — are going to be available to an ever-increasing segment of the population in their own homes.

Therefore, we have the technology and its potential use in the classroom by faculty members behind the scenes, and on the other end the teaching/learning process, by students in their own residences, in their own day-to-day life. I think there's just a potential here that we've never seen previously in education and I'm convinced we're making steps towards realizing that potential.

Andrew De Rocco, President,
Denison University:
Where does the college go when it's where it is now? I suspect that what we would love to be able to do at some point in the not-too-distant future is to configure ourselves with a mixture of copper and fiber and whatever else was required so that there would not be an installation anywhere around the institution that was not capable of voice, video, and data transmission. That a person in a classroom would have a screen available to her or him and could call up on demand whatever was required to supplement what was going on in the classroom — to bring materials out of the archives that would be visual, to bring materials out of the archives that would involve programmatic material, to bring material out of the archives that was data related, to be able to exchange from one classroom to another information so that students in different classrooms on a corresponding subject could exchange information back and forth. I suspect that time is not too far in the future.

With institutional leaders expressing this kind of conviction, we can expect to see even greater change in the future. The high cost of computing is an obstacle, but not one that will likely reverse the revolution.

20

Appendix A. Study Design

Case studies were conducted at five institutions between the fall of 1986 and the summer of 1987 Although not a systematic sample, they include the major institutional types and student populations found in higher education.

A census of instructional computing was conducted at three of the colleges — The University of Michigan, Eastern Michigan University, and Washtenaw Community College. (The census questionnaire appears in Appendix E.) The census was sent out to faculty under the name of a high-level administrator, and one or two follow-up letters were sent. The resulting database was shared with key administrators and faculty to identify any missing innovators. While it is not possible to say with certainty that all innovators were found on each of the campuses, the institutional representatives expressed confidence that all had been found.

Using data from the census and consultation with our institutional representatives, we selected individuals to be interviewed to represent three dimensions: type of computing use (tutorial, tool, and simulation), discipline (humanities, social science, natural science, and professional training), and history of computer use (early and recent adoption). At Denison University and Kenyon College, faculty innovators were identified by department heads following a telephone interview in which the dimensions of interest were described. Department chairs and higher level administrators were selected to represent an ever-broader perspective of the institution on the topic of educational computing.

Guided by the questions below, we videotaped the interviews with faculty innovators, students, deans, department chairs, and provosts. Although we tried to ask the same questions of all respondents in the same role, we took the opportunity to pursue leads suggested in the responses.

Faculty were asked to describe key instructional problems they faced and how they saw computing as solving them. They were asked to assess the impact of the computing innovation on student learning, and to characterize the level of departmental and administrative support for their project. At the end they were asked to assess the current and future role of computers in higher education. We then took our cameras to the classes and labs of the faculty we interviewed, interviewing selected students in those environments. We also took our camera to the broader environment seeking evidence of the computer's impact on student and faculty life.

For administrators, the focus of the interviews was on issues in computerizing a campus for instructional applications, including allocation of resources and costs.

A systematic analysis was made of the transcripts, seeking consistent themes that could explain the character of the electronic revolution. Over many months we produced case-study videotapes of each of our primary institutions: Eastern Michigan (*The Electronic Classroom in the Regional Teaching University*), Washtenaw Community College (*The Electronic Classroom in the Community College*), and The University of Michigan (*The Electronic Classroom at The University of Michigan*).

Subsequently we visited Kenyon College and Denison University, using the same procedures. We again combed the transcripts, added the perspectives of faculty and administrators at these two colleges and produced a summary video. New to the summary video was the additional perspective on costs gathered from subsequent interviews with computing administrators at each of the institutions.

Many issues that respondents discussed do not appear in the summary video. The constraints of the medium and the expectations of video viewers limit the amount of information that can usefully be included. But the video does include a balanced perspective on the issues of greatest interest to an audience seeking to understand the electronic revolution and make decisions about their own commitments.

Appendix B. Interview Guides

Brackets [ ] have two meanings. They indicate options for the interviewer in conducting the interview. They also indicate a suggested phrase given the respondent to introduce his/her response to make the response usable in the videotape report.

Faculty Innovator Interview

You have been identified as someone who is doing something innovative in applying computer technology to instruction. I would like to find out more about this, the needs that gave rise to it, your assessment of how well it's working, how students and faculty have reacted, and your assessment of the computer's role in the future.

1. First, tell me briefly about the course you teach, and how you are using the computer. [tutor students in difficult areas, provide practice with problem sets, help students organize information, simulate real-world processes].

2. How have students reacted to the computer aspects of the course?

3. Do you think the use of the computer has improved student learning? In what ways?

4. Has the computer changed what or how you teach?

5. How did your interest in using computers for instruction develop? Were there any critical incidents you recall? [If not answered already.] Did you start with the idea of seeing if the computer could solve a particular instructional problem?

6. What was entailed to set up your computer operation (e.g., hardware, space, technical support, programming)? Do you know any of the actual costs?

7. How would you describe the response of your colleagues to your use of the computer for teaching?

8. How would you describe the support of the [chair, dean] of your [department, school] for your investing time and money in the development of the computer for instruction? How about the college? How about your peers at other institutions? Has the level of support been important to the development of your software?

9. Would this software have a market outside of this institution, in other peer institutions or in high schools?

10. Three years from now do you expect you will be using the computer more or less for instruction? If more, in what new ways will you be using it? What conditions will affect the scenario (financial support, help with programming, available software, etc.)?

11. How about others in your department or field. Do you think they will come to use computers more for instructional applications? Why or why not?

12. [Optional] There are more microcomputers on campus today than ever before. They are being used by both faculty and students for many things beside direct instruction. From your view is this affecting academic life at all?

13. [Nominations of others in the department to interview.]

Dean or Department Chair Interview

1. In the last year have you seen a change in the use students are making of computers on campus? Describe some of these.

2. In the last year have you seen a change in the use faculty are making of computers on campus? Describe some of these.

3. How about the use of computers for instruction, have you seen any growth in this area? ["Computers are being used ..."]

4. At the administrative level, does [your unit] have a view regarding the use of computers in [undergraduate/graduate] education? ["My department believes..." or "The college thinks..."]

5. Let's distinguish between instructional and tool uses of the computer. First, instructional uses. Are there particular types of courses or types of students that you think might profit more from computer-based instruction?

6. Are the tool uses of computers—word processing or spreadsheets—highly valued in [your unit]? ["Facility with word processing/spreadsheets is..."]

7. Are there concrete things being done in [your unit] to encourage faculty to make greater use of computers for instruction? ["The unit is doing a number of things..."]

8. How much is [your unit] spending annually in the area of instructional computing?

9. Be a prognosticator for me. In terms of instructional computing, what do you think this [campus/unit] will look like three years from now? Will computers be more widely used in the instructional arena? In what applications? Will their use be in isolated pockets, or will there be widespread use? Will it be just in introductory courses or in advanced courses as well? ["Three years from now I expect..."]

Student Interview

1. How often do you use [the lab/the computer-based materials] for this course?

2. How are these computer lessons different from other types of instruction you experience at this college?

3. Can you tell me some examples of things you have learned from the computer lessons? Couldn't you have learned these things in other ways?

4. Would you like more of your instruction to be provided by computers? Why?

Provost Interview

In these first questions consider computing broadly, not just instructional computing.

1. How would you describe the goals of [college] in terms of computing? ["The college is aiming to..."]

2. Will this campus be different in three years as a result of initiatives taken by your office? ["The most notable changes..."]

3. Do you have a budget figure that gives some indication of the budget the [college/university] is currently devoting to computing? ["We are currently spending about ..."]

4. Computers can be used for a variety of purposes: administration, communication, research, and direct instruction to name a few. Of all the money being spent to expand computing power, roughly what proportion will be spent on computing for instruction? ["About __ percent of that will go toward instructional computing."]

5. What kinds of things is your office doing to expand the instructional uses of the computer? ["We are..."]

6. This study has focused on the variety of uses being made of the computer for instructional purposes. Be a prognosticator for me. In terms of instructional computing, what do you think this campus will look like three years from now? Will computers be more widely used in the instructional arena? In what applications? Will their use be in isolated pockets, or will there be widespread use? Will it be just in introductory courses for undergraduates or in advanced courses? ["Three years from now I expect..."]

7. There are a variety of resources you could use to foster more uses of the computer for instruction. You could provide grants to individual faculty; you could create new institutions to aid faculty in designing software for computing; you could make available programmers; you could make available computers for faculty and students. Which of these will the college/university use? Is there a mix of these that you feel is best for fostering instructional computing? ["To foster instructional computing we are..." or "We think the best mix..."]

8. Are there particular problems fostering instructional uses of the computer at a [college/university] like [name]? ["At a college/university like..."]

9. You are familiar with your peer institutions nationally. Are similar efforts going on at other peer universities? Which ones? ["Similar efforts are being made at..." or "__ is the same/unique in these respects..."]

10. Is the use of the computer for instruction similar at these institutions? ["In terms of current use of the computer for instruction our college/university is..." or "In a few years our college/university will be..."]

Appendix C. Videotape Index

With slight modifications, the text in Parts I and II is a transcript from the videotape by Jerome Johnston and Susan Gardner: **The Electronic Classroom in Higher Education**. The tape is available in VHS and 3/4" formats from The National Center for Research to Improve Postsecondary Teaching and Learning, 2400 School of Education, The University of Michigan, Ann Arbor, Michigan 48109-1259, 313/936-2741.

This index indicates the approximate location on the VHS video of the various sections of the text. To use the counter numbers, rewind the videotape fully and reset the counter on the VHS player before advancing the tape.

Appendix D. Case Study Synopses

Synopses of the four video case studies appear on the following pages. The videos are available from: NCRIPTAL — The National Center for Research to Improve Postsecondary Teaching and Learning, 2400 School of Education, The University of Michigan, Ann Arbor, MI 48109-1259, 313/936-2741.

THE ELECTRONIC CLASSROOM IN HIGHER EDUCATION

Based on case studies at five colleges, this videotape shows how computers are being used for instruction, how they are distributed for faculty and student use, how much they cost both initially and in the long run, and the leadership and support needed to make effective use of them on college campuses.

New Opportunities for Learning. Innovators describe the use and impact of computers on student learning.

- Writing: A writing lab motivates students to engage in writing and makes them more receptive to revising their manuscripts.
- Foreign Language: Tutorial programs make language instruction more efficient while interactive videodisc technology helps students understand the contextual use of language.
- Natural Science: Biology tutorials increase skill in applying principles, and animation illustrates processes difficult to capture with other media. In astronomy, chemistry, and botany labs, simulations compress time, allowing students to see instantly the effects of manipulating variables. In ecology, the computer is used as a tool to process ecology data, enabling students to analyze much more data and draw inferences from a more reliable base of information.
- Social Science: Political science students simulate national and international negotiations through computer conferencing. In statistics, graphics-based programs give students an intuitive feel for statistics.
- Mathematics: Drill-and-practice exercise improves basic math skills and reduces math anxiety. In higher math, a simulation in calculus allows students to explore the nature and limits of functions.
- Engineering. In microelectronics, student designs for computer chips are transmitted electronically to a production facility, quickly manufactured and returned, allowing students to test the quality of their design on a real product.
- Business: The use of computer spread sheets prepares students for the real world of business.
- Music: Sound emulators and computer software facilitate the composition, recording, performance, and printing of music; with digital video, students from music, dance, and graphic arts collaborate on new art forms.

Issues in Implementation.

- Distribution. Departmental clusters are convenient but not economical. Public clusters, on the other hand, serve a wide array of computing needs but require comprehensive support. Computer hardware is only a small fraction of the total cost of computerizing education.
- Training. Both faculty and students need carefully designed training.
- Hidden costs. Faculty need time and support to develop educationally sound software.
- Costs and Benefits. In spite of the high cost of computing, institutional leaders believe that computer technology offers opportunities to enhance learning in unique ways. All agree that computer use will continue to expand.

THE ELECTRONIC CLASSROOM IN THE REGIONAL TEACHING UNIVERSITY

This video case study explores many of the issues surrounding educational computing at Eastern Michigan University. This university serves 16,000 undergraduate and 6,000 graduate students. A 1987 survey of its 630 faculty revealed that about 10 percent use computers in their teaching. The most extensive use is found in the physical science courses.

How Computers Are Used for Learning.

- Astronomy: Students "observe" changes in celestial phenomena over a time period much longer than a semester.
- Botany: Parameters can be varied and effects noted, data can be collected and processed, and difficult concepts explained at a student-controlled rate.
- Social Science, Mathematics, and Business: Statistical packages organize and summarize large quantities of data so students can conduct large-scale research and draw inferences.
- Interior Design: Assignments done on computers prepare students for skills required in the market place.
- English & the Humanities: Word processing improves legibility, encourages revision, and lets instructors return comments to students promptly.
- Engineering: The latest computer-aided design tools are available to students.

Computer Availability. The ratio of computers to students is 1:350; this ratio is too high for most departments to require students to use computers for their assignments. A few departments have their own computer labs, but those computers are not available for general use. The burden rests on one central lab with only 64 computers. A computer literacy requirement further strains existing resources. Faculty see the need for more computers.

Costs. The first wave of computers were inexpensive, but newer, more powerful equipment is expensive to acquire and to operate and maintain.

Stimulating Educational Computing. The use of computers is championed by a provost who sees them as a stimulus to improve faculty teaching. Monetary rewards encourage faculty to develop new software.

The Future. All faculty interviewed believe computers will play an increasing role in the education of students, and they welcome this change. Challenges remain in the distribution of computers, choosing software, and, most important, finding sources of funds.

THE ELECTRONIC CLASSROOM AT THE UNIVERSITY OF MICHIGAN

The University of Michigan's commitment to incorporating computers into instruction is making noticeable changes on the campus. This video case study illustrates an array of instructional applications and highlights the issues facing faculty and administrators as they expand the computer's role in higher education.

Computerized Instruction in Action. Tutorial, simulation, and tool applications help students learn.

- Biology: Tutorial problem sets increase skill in applying principles; an animated protein synthesis tutorial illustrates processes difficult to capture with other media.
- Chemistry: Simulations add a new dimension to labs, providing students with experience in research design and manipulation of more data.
- Hebrew: A tutorial program makes language instruction more efficient.
- Political Science: Computer conferencing allows realistic simulations of negotiations.

- Education: A graphic statistical package teaches analytical techniques from a more inferential perspective.
- Music Education: A multi-media tutorial develops diagnostic skills of teachers of instrumental music.
- Medicine: Simulations provide clinical experience to second-year medical students
- Business: Training in the use of such tools as computer spreadsheets prepare students for the "real world."

Assessing the Impact. Faculty note the effects on learning, motivation, and curriculum.

Patterns of Growth. Time and money continue to be constraints.

Costs and Benefits. Costs are initially high and benefits intuitive.

The Future. Faculty foresee different applications:
- Study skills: Software to enhance general study skills.
- Foreign language: Videodisc technology to teach contemporary Hebrew.
- Engineering: Transmission of student-designed computer chips to a production facility to be quickly manufactured and returned for testing.
- Performing arts: Sound emulators and software to facilitate music composition, recording, performance, and printing; digital video to aid dance and art.

THE ELECTRONIC CLASSROOM IN THE COMMUNITY COLLEGE

This video case study of Washtenaw Community College illustrates how, in 1987, the faculty of one community college uses computers to help meet the needs of its 10,000 students. Of 145 full-time and 300 part-time faculty, ten faculty members are experimenting with computers in their courses.

How Computers Are Used for Learning.
Community colleges serve students who typically benefit from a structured approach to learning. This is illustrated in many of the applications.
- On-line Testing: A computerized test bank provides unlimited opportunity to practice taking a test. The student decides when the test is to count.
- Chemistry: One program guides students through the laboratory reporting process; another demonstrates molecular structure.
- Mathematics: Drill-and-practice improves basic math skills and reduces math anxiety. In calculus, a simulation explores the nature and limits of functions.
- Computer Studies: Ninety-five tutorial lessons tied to the textbook provide both practice in the use of computers and individually paced learning opportunities.
- English: A computer based writing laboratory where students work collaboratively encourages students to rewrite and revise.
- Respiratory Therapy: Simulation of a cardiac arrest lets students practice making treatment decisions before they work with actual patients.

Issues in Expanding Use.
- Some faculty think the instructional potential of current software is too limited and that some learners respond poorly to high-tech delivery of instruction.
- The number of potential users far exceeds the amount of equipment available.
- The distribution of software challenges traditional methods of providing media to students.
- Computing consultants must be trained in instructional and support roles.

Costs. Setting up and maintaining the computer labs carries a high price. The Writing Lab cost $34,000 to set up and $3,000 per year to operate; the central student micro lab cost $70,000 to set up and $32,000 per year to operate.

The Future. Faculty and administrators are optimistic that the computer will play a larger role in instruction and have positive benefits for students. They believe:

- Better software will become available
- Greater impact will be realized when students get their own computers and can take software home with them.
- A $12 million, campus-wide investment will be made in more microcomputers, a mainframe computer, and a building to house it all.

Appendix E. Faculty Census Form

College: ______________________ Department: ______________________
Name: ______________________ Phone: ______________________
Campus Address: ____

☐ *I DO NOT have students use a computer as part of their learning experience in my courses.* Check this box and return. Do not complete this questionnaire.

☐ *I DO have students use a computer as part of their learning experience in my courses.* Check this box and complete the rest of the questionnaire.

☐ *I DO NOT use the computer in my instruction at this time, but would like to.* Please check this box, fill in your name, etc. and return this form to my office - you will be contacted.

1) Course number and name:__________ - ______________________

2) Course level: Undergraduate ________ Graduate ________ Non-credit ________

3) No. of students using the software: 0-10________ 11-30 ________ 31 plus ________

4) Types of computer use (select codes from page 29): ________, ________, ________

5) FIRST Type of computer use (place code here): _____

a. Name of software (if it has one): ______________________

b. Commercial ____ Locally Developed _____ Commercial, with local adaptation ____

c. Hardware required: ______________________

d. Describe all software of this type. (Example: RIVER is a simulation that allows students to make decisions about resource allocation and see the impact on a community. Students determine what policies would make better use of the river basin.)

____

____

____

6) SECOND Type of computer use (place code here): _____

a. Name of software (if it has one): ______________________

b. Commercial ____ Locally Developed _____ Commercial, with local adaptation _____

c. Hardware required: ______________________

d. Describe all software of this type

____

____

____

7) THIRD Type of computer use (place code here): _____

a. Name of software (if it has one): ______________________

b. Commercial ____ Locally Developed _____ Commercial, with local adaptation _____

c. Hardware required: ______________________

d. Describe all software of this type.

____

____

____

Codes for Computer Applications

I. DIRECT INSTRUCTION. Software is used to provide new information and/or evaluate and provide feedback on student mastery of material.

01 Drill and practice. The software drills students on their mastery of some knowledge and gives feedback on correctness; the software contains no new information that hasn't been taught elsewhere. The format may use just text or be built around a game.

02 Tutorial. The software presents new information and tests for mastery. The format may use text, animated graphics, or be built around a game.

03 Computer-managed instruction. The software tests for mastery and gives guidance on where to find new or remedial information. This new information is not in the computer software; it is found in books, videotapes, or some other medium.

04 Interactive simulation. The software simulates rule-driven environments such as a chemistry laboratory, an ecological system, social organization, or a manufacturing process. The student may ask for information about the system and apply solutions to perceived problems. The simulation responds with some measure of the system's functioning given the student's solution. Sometimes a tool such as a database or a spreadsheet is made into a simulation when an instructor designs activities around entry and query. Examples of widely used simulations are Metro Apex, River, and Catlab

05 Computer programming to teach general problem-solving strategies. Instruction in BASIC, PASCAL, or other language is used primarily as a vehicle to develop student's problem solving skills. See also #16.

II. LEARNING TOOL. Students are trained to use the computer as a tool to accomplish a task. The intent is to have students learn how to use the tool, not make the tool an instructional device itself.

11 Data base management. Filing information for later manipulation & retrieval.

12 Spreadsheets. Automated spreadsheets such as Multiplan and Lotus 1-2-3.

13 Statistical tools and other math calculators; Statview; SPSS.

14 Word processing; Wordstar, Macwrite, etc; but also text analysis programs that check for spelling and other surface features of the text.

15 Laboratory tool. Collect physical data from experiments (e.g., temperature, voltage).

16 Programming. A programming language is taught with the primary purpose of developing the student's programming skill to use subsequently to program a computer to accomplish some task.

17 Computer-aided design. (CAD, CAM, CAE); used in engineering, architecture, urban planning, art, theater set design, etc.

18 Other tools. Electronic version of traditional manual tools such as a ruler and compass (e.g. Geometric Supposer).

III. INFORMATION EXCHANGE. The computer is used to retrieve or exchange information.

21 Access data bases Bibliographies, abstracts, stock prices. Data may be stored on magnetic discs or optical laser discs; the computer is used to retrieve it.

22 Message exchange. Two-way exchange of messages.

23 Computer conferencing. Multi-way exchange of ideas.

24 Other. Computer applications not captured in the above categories.