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EDUCATION IN INFORMATION TECHNOLOGY USING COMPUTER-ASSISTED INSTRUCTION SYSTEMS

IMPORTANT ASPECTS OF COMPUTER- AND MULTIMEDIA-BASED ACTIVITIES TO EDUCATION FOR NATURAL SCIENCE AND LIFE-MEDICAL SCIENCE IN THE UNIVERSITY

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ABSTRACT

Computer-assisted instruction (CAI) has been used for educating about 3,500-students in our junior college. The earliest yet still most widely used mode of CAI was the practice format. Learning the computer and its format emerged as a central goal, both because it was regarded as an important skill in itself and because it was hoped that it would help develop general problem-solving skills. The computer-based system went the furthest in providing a supportive environment for teachers to create educational programs in several different subject areas. The authors introduced the computer system for education, called Desktop Publishing (DTP), providing tools for easily producing high-quality graphics, animation, and music. The appearance of a document produced on a DTP system can look almost as good as one produced by a professional publisher. Powerful tools such as word processors, graphics and animation editors, communication networks, and engaging educational programs widen the range of options for teachers, students, and business managers to take an active role in meeting the computer challenge. A major objective of any change is to produce education of better quality.

What the authors see, finally, is the construction of a computer-based system which offers a range of highly motivating activities for an increasing educational effect.

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INTRODUCTION

Early efforts to develop computer-assisted instruction (CAI) were largely oriented towards drill and practice. The Stanford project developed and tested nationwide systems for arithmetic and reading in the mid-to-late-1960s (Suppes[1], 1966; Atkinson & Wilson[2], 1969). However, none of these efforts at CAI were widely adopted (Bitzer & Skaperda s[3], 1970). One of the major factors for the lack of acceptance was cost. There was a second major problem with drill and practice approaches, keeping students motivated and avoiding frustration. In the late 1960s, at the time that the "free-school" movement was at its height, Papert and others at MIT started the LOGO Project. The LOGO approach viewed both learning to program and the acquisition of subject matter as important aspects of computer based activities. The work of the LOGO Project was named after and based on LOGO, a computer language that students could easily learn and use. More importantly, they restructured knowledge domains (for example, geometry [Papert, 1971[4]; 1980[5]], music [Bamberger[6], 1972], and Physics [Abelson & diSessa[7], 1981] so that students using LOGO could easily explore and master them. The project started by Alan Kay in the early 1970s at Xerox Palo Alto Research Center, set out to provide users in general and students in particular with a powerful tool for fostering learning through active exploration of the possibilities of using personal computers for learning, even when the notion of computers inexpensive enough for individuals to own seemed a pipe dream.

Computer activities should be designed so that users have as much support as necessary (especially at the initial stages), but also have the ability to go beyond that support. An adult expert can play an important role in providing dynamic support, both by suggesting new goals within an activity and by suggesting (or simply making available) new activities. Activities should be designed so as to enable and encourage peer interaction and help. Educational computer activities should be designed so that they enable the students to gain in expertise as they further engage in those activities. The role of motivation in bringing about learning cannot be overestimated. Students can be forced to engage in activities they do not like, but unmotivated or frustrated students are unlikely to achieve the intended goals of the activity. Educators are well aware of the need for motivating activities; once educational goals are set, much efforts is developed to the question of how to design motivating activities to achieve these goals (Levin & Kareev[8], 1980).

In this paper, the authors will begin by describing some of our earlier attempts to use computers for education. Then the authors will outline the range of activities available with proposed systems, both to explore the range of possible educational uses of personal computers and to gain some insight as to why computer activities can be motivating. The authors will suggest a model of educational design for educational computer activites which motivate students and develop teamwork and cooperation. In a subsequent paper the authors will recommend some actions those involved in education can take to deal with the challenges posed by personal computers and computer-based technologies.

COMPUTERS IN SCHOOL AND OFFICE ENVIRONMENTS

The authors have seen how computers have become an integral part of most schools today. As software is improved and new application software programs or new releases of old standbys are developed, it's pretty safe to assume that making computers our school and business partners is a wise decision. In order to produce the best results for the mental and creative activities involved in school and office work, an integrated school and office systems, designed to assist in human intellectual activities, should be used to create an environment that provides the necessary information and services when requested at all times. School and business organizations are hierarchies made of different levels of authority and responsibility, such as the structure and the hierarchy, shown in a plan for a new hospital information system started by Yoshihara et al. (Project) in the early 1980s at Miyazaki Medical College (Yoshihara, 1994[9]; 1995[10]). The total hospital information system, called PHOENIX, began its functions for the first time as shown in Fig.1.

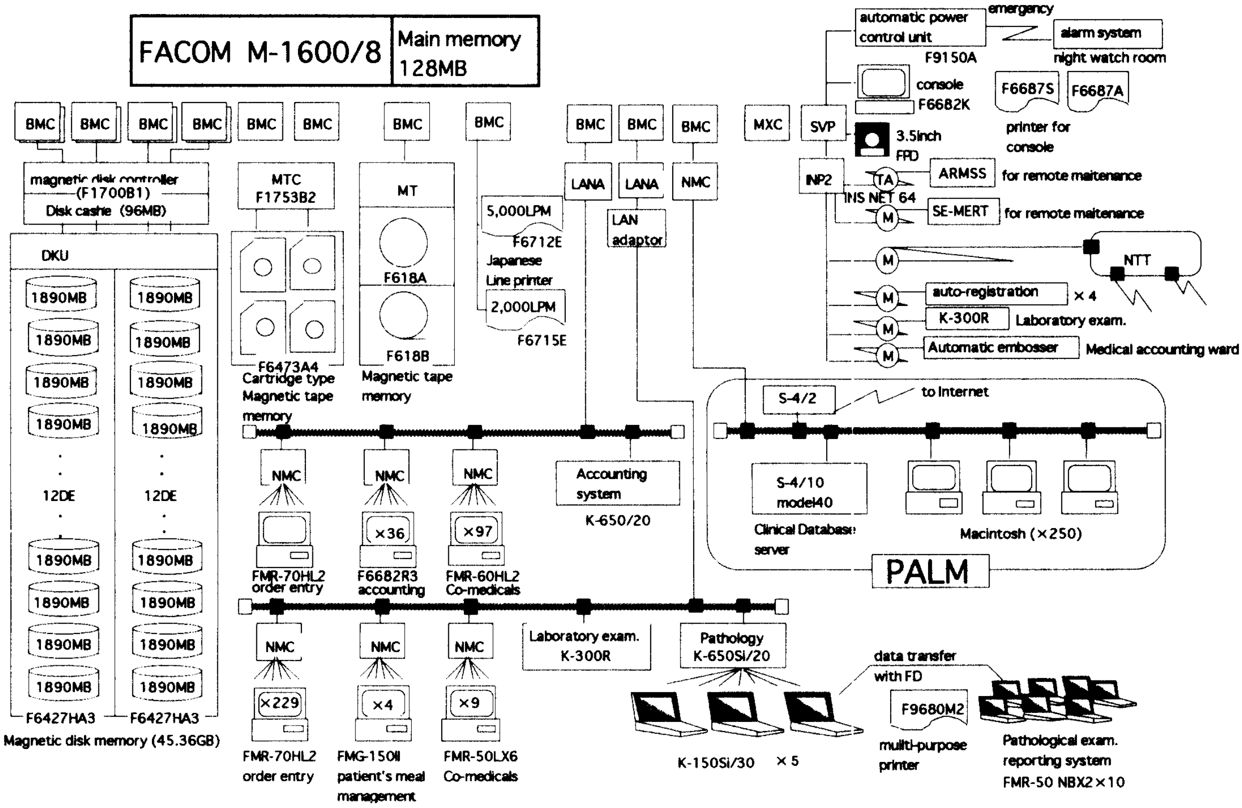

Figure 1. Model of the Medical Information System of Miyazaki Medical College.

In order to use hospital information as effectively as possible, it is important that physicians, users and other para-medical hospital personnel cooperate with each other while respecting their own spheres. Systems and management have been made available by which information is shared. The usefulness of the PHOENIX system was greatly advanced by the function of a unique personal computer LAN (Local Area Network), called PALM (Research Assistance Personal Computer LAN) (Fig.2) (Yoshihara, 1994). The PALM is a computer system for providing tools to easily produce high-quality graphics. Education in information science will be provided medical students so that they will find computer technology useful for their future work.

What are the educational implications of this dynamic support hypothesis for structuring computer learning environments? Then, our project shared the view of computer and education started by Hidaka et al. in 1990 at Miyazaki Women's Junior College (MWJC) (the Committee on Computer Utilization, that is to say the MWJC Learning Research Group; Hidaka et al[11]., 1990; Hidaka[12], 1991). The project set out to provide students with a powerful tool for fostering learning through active exploration and discussion. They developed a computer system for learning, called Fujitsu FMR-50 system, providing tools for easily producing high-quality graphics, animation, and music. The

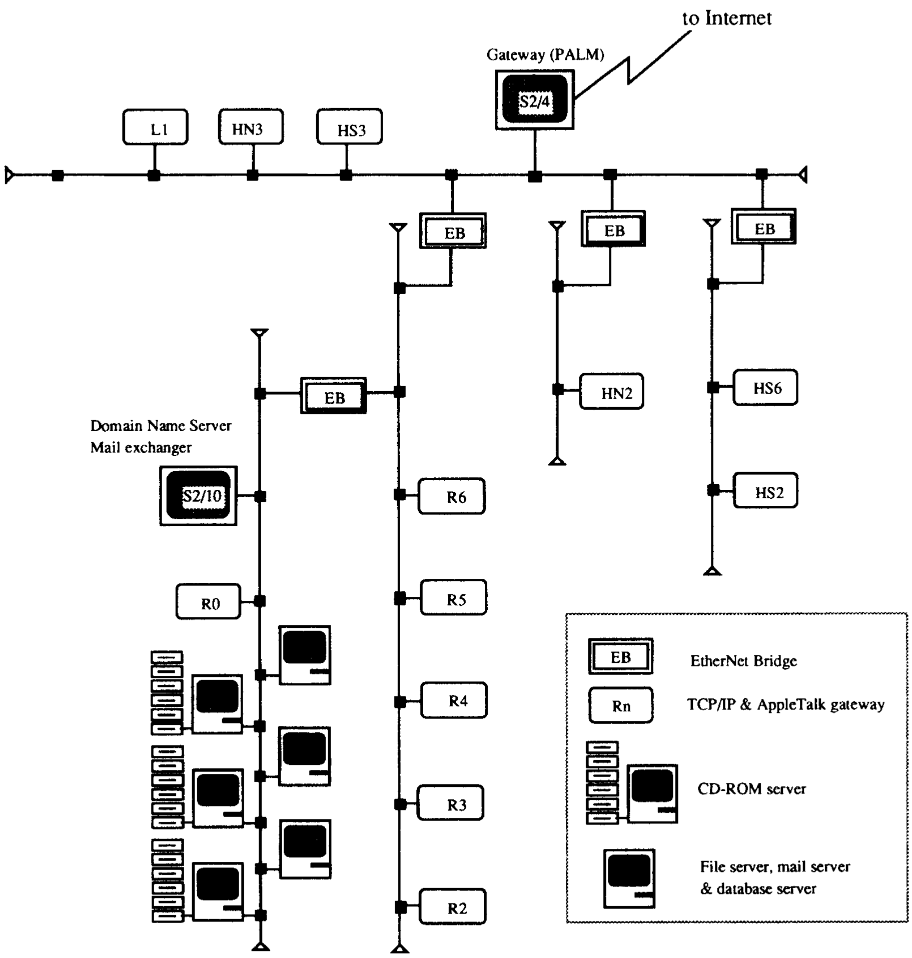

Figure 2. Network Model of Miyazaki Medical College. The network is called PALM.

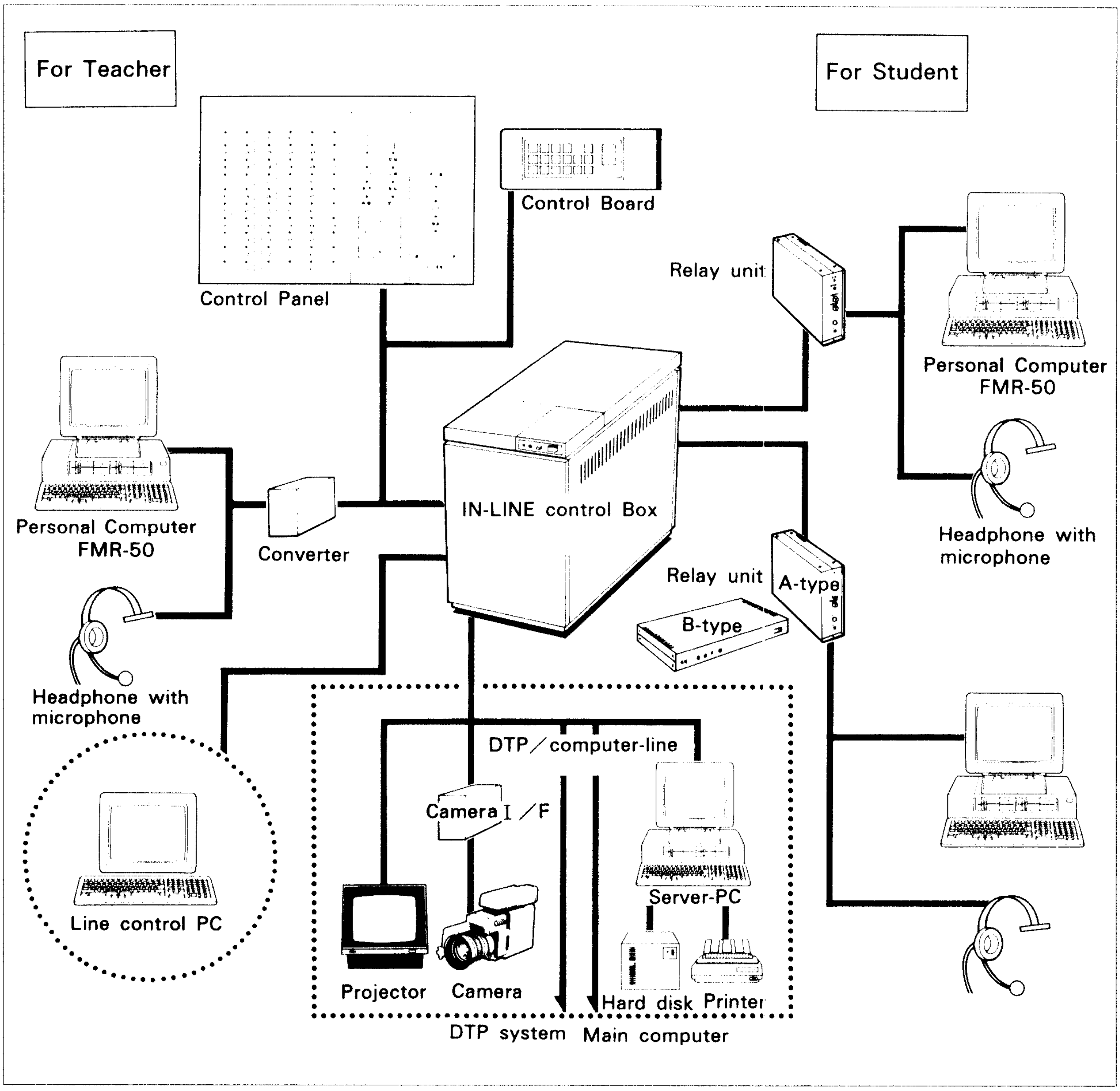

Figure 3. Model of Computer-Assisted Instruction System with Desktop Publishing of Miyazaki Women's Junior College.

MWJC Learning Research Group was among the first to explore the possibilities of using personal computers inexpensive enough for individuals to own. The authors were particularly interested to find out how easy it would be to integrate the computers into classrooms over the past five school years with the CAI system as shown in Figure 3.

Generally the whole class was presented with computers (Table 1). The available activities were described as well as the steps needed to operate it. In addition, teachers usually put a sheet of paper detailing the most frequently used commands next to the computer.

Table 1. Number of Students Engaged in Computer-Based Educational Activities for Natural-, Life-Sciences etc. (Lectured by One of the Authors: H.H. in His Classroom) in the Classroom over the Past Six School Years with the CAI System Shown in Figure 3.

Year	Natural-science	Life-Science	Chemistry[1]	Chemistry[2]	Infor.Pro.[3]
1991	37	*** [4]	228	49	106
92	44	***	228	5	100
93	*** [5]	78	455	54	171
94	***	58	240	27	137
95	***	47	151	23	89
96	***	50	164	38	106

1) This subject is one of the general arts-and-sciences subjects for a liberal education.
2) This subject is one of the major subjects for a science education.
3) 'Infor.Pro.' is short for 'Information Processing'.
4) This subject is the subject that served as natural-science and was newly started in 1993.
5) This subject was closed in 1993.

As described below, students worked cooperatively in pairs and groups. They helped each other resolving most problems without teacher intervention. Student "experts" emerged which further reduced the burden on teachers. The wide variety of activities available on computers greatly increased the chances that each student could develop expertise in some aspect of computer usage.

DESIGNING EDUCATIONAL COMPUTER ACTIVITIES

There are computer activities which can be viewed as providing the student with some tools, then allowing them to use these tools in whatever way they please. In this section we outline the range of activities available with our systems, both to explore the range of possible educational uses of personal computers and to gain some insight as to why computer activities can be motivating.

Writing. Computer activities differ in how much freedom they give the student. The students can apply the tools to create a variety of unique stories, drawings, or music. One of the most significant uses of computers is for word processing. Today, word processing is the most widely adopted of all the new office technologies. More and more of the people who make their living crafting words are replacing their typewriters with personal computers. Figures 4 and 5 are samples from the reports created by students as examples of what can be done with our CAI system in our classroom studies for the subjects shown in Table 1. The authors also have used a large set of such interactive reading and writing activities, which Levin et al. call "interactive texts" (Levin et al.[13], 1985; Levin[14], 1982). Part of the reason novice students have difficulty in organizing and expressing their ideas is that they have to deal simultaneously with problems at many levels. The authors have confirmed that students enjoy creating stories with these kinds of interactive writing activities, and that the impact carries over even to their writing with pencil and paper. The authors also confirmed that some students were eager and able to go beyond the use of the original options provided.

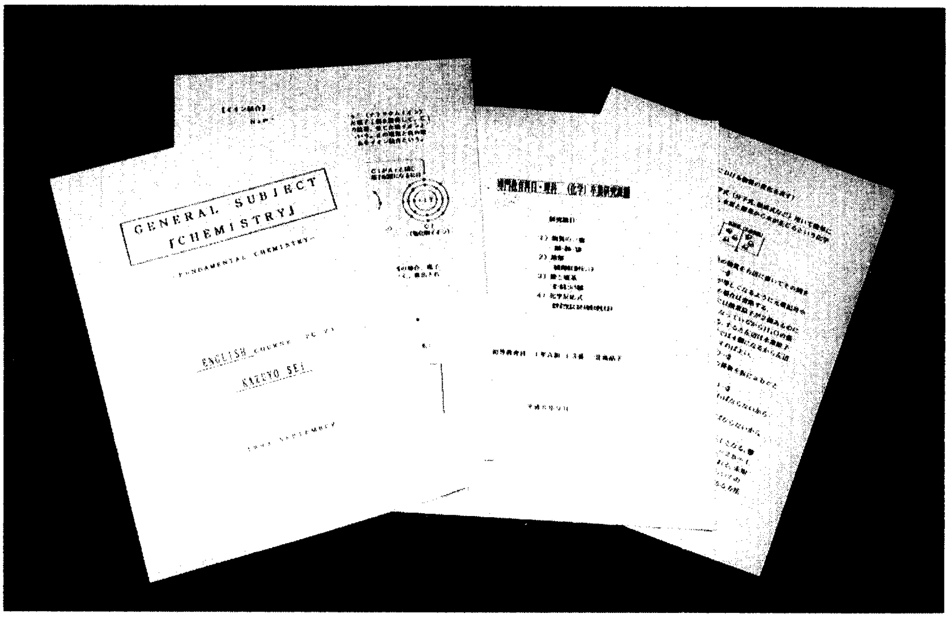

Figure 4. Pages from reports created by a student as an example of what can be done for chemistry of general and major subjects (two left and two right, respectively) in a classroom.

Graphic and Desktop Publishing. Graphics are the images and pictures jointly created by a computer programs and the person using it. The images can take many forms, depending on the imagination of the creator: graphs, drawings, paintings, portraits, simulations, or architecture. These images can be line drawings or solids, in black and white or in vivid color. They can range from simple bar charts, or very complex 3-D images, to animation. Graphics software programs allow artists and nonartists alike to use a computer for creating, editing, displaying, and printing the images and pictures, quickly and easily.

Desktop publishing (DTP) is a concept that combines the use of a micro-computer with page-composition (graphics-oriented) software and high-quality laser printers. Anyone can use such a system to create and publish documents: departments within corporations that want to publish in-house; small businesses; writers who like the idea of self-publishing; and others. Books, booklets, brochures, newsletters and annual reports can be produced with desktop-publishing software as shown in Figure 5. Entire magazines can be designed, page made-up, and printed. The uniqueness of a DTP system lies in the page-design and composition software because it involves positioning and repositioning graphics and other elements of a page on the screen. An important feature of this software is that it enables the user to see on the screen what the entire page will look like when it is printed, a factor referred to as "what you see is what you get," or WYSIWYG.

Some page-composition software has word-processing capability. Often, however, the text is created and formatted with a word processor first and then transferred to the page-composition software to be manipulated. Some of the art is also created with separate graphics software and then transferred to the page-composition software to be positioned on the particular page being "pasted up". Final product can be printed either

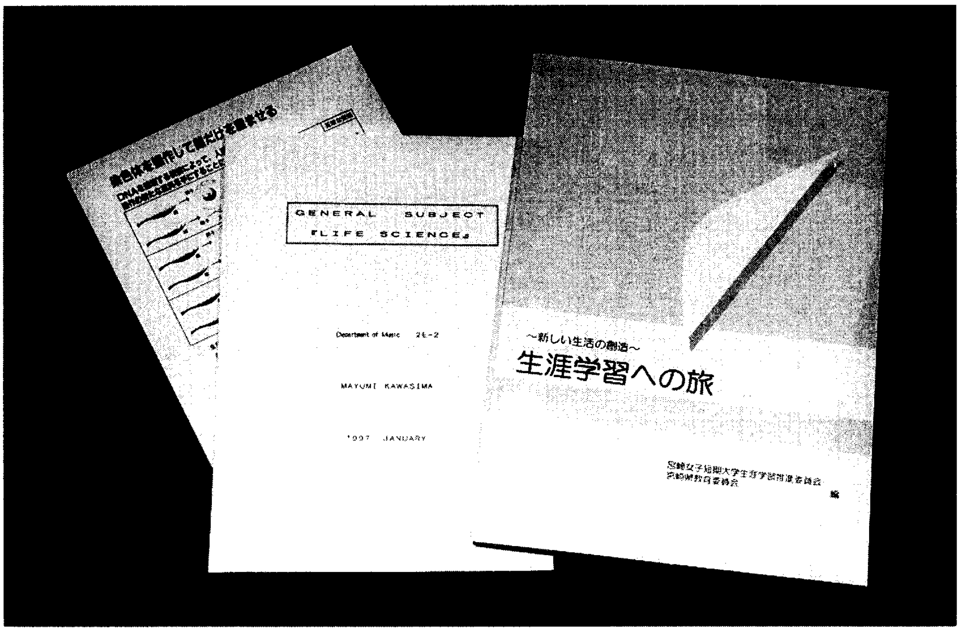

Figure 5. Examples for DTP-publishing. A page from the report created by a student as an example of what can be done for life-science of general subjects in a classroom (left and center) and the bulletin designed originally (right).

as camera-ready copy for mass printing, or copies can be printed for distribution directly from the computer. Laser printers produce type and graphics nearly as crisp and detailed as those in professionally published magazines and text-books. The term "desktop publishing" was coined by Paul Brainard of Aldus Corporation when that company's software, PageMaker, was introduced.

The report and bulletin shown in Figure 5 were created and published with DTP software. The students created reports for a life-science subject (one of their general subjects) with their computer and a DTP software program by themselves. The other bulletin, a 150-page book, which is lecture abstracts for the lifelong learning seminars directed by the MWJC Committee on Lifelong Learning-Progression, was originally designed, and its pages made up and printed using desktop publishing with a publisher. No longer does the designer need to physically cut, arrange, add, delete, and reposition these elements, or wait for a printout to decide on changes to be made. Besides the cost and time savings, the use of DTP helps the students (originators) control the creative process from start to finish.

Students were allowed to work by themselves or to choose a friend with whom to work during their turns. Pairs of student working together substantially reduced the number of problems encountered requiring outside help. When student worked in pairs, a large percentage of the low-level problems encountered by one student were immediately solved by the other. Moreover, students working in pairs were able to divide up the work among themselves thereby dealing with the complexities of new situations in an efficient way.

The authors observed a recurring progression in the way students engaged in computer activities during the classes for our educational subjects. Student "experts" emerged for different computer activities. The student who had learned a simple task would often increase the level of complexity of the tasks attempted. The progression from low-level to expert-level performance occurred almost every time we introduced a new computer activity to the class. Once a student became proficient at a particular activity, other students would turn to her for help rather than call a teacher. Since there were a relatively large number of activities, expertise was widely distributed among students.

Our observations suggested that computer activities, when properly organized lead to a considerable increase in cooperative peer interaction, more so than almost any other classroom learning environment. Students gained in computer skills and self-confidence. Students became motivated to achieve at intended tasks. Students were able to gain competence since they became motivated and enjoyed their assigned tasks. Unmotivated and frustrated students could not have achieved educational goals so well.

As educators, we are well aware of the need for motivating activities. We know that our students are unlikely to learn from being forced to perform activities they do not like. We were able to design computer activities which enabled the students to gain expertise, remain engaged, and master their subjects.

PROGRESSION TOWARDS A MORE CREATIVE COMPUTER EDUCATION ENVIRONMENT

The technologies of the Information Age are growing faster, wider and deeper at a constant but remarkable rate. The speeds of computation and transmission of information are doubling every eighteen months and this rate has been sustained since the advent of the thinking machines just over fifty years ago. At about the same rate of increase, the volume of data which is typically stored on a computer system and the volume of data which passes between computers through various telecommunications links has been increasing. The power, affordability, availability, and accessibility of the new technologies has resulted in the Age of Multimedia and Distributed Intelligence and will lead to the Age of Virtual Reality. Computer related technologies have successfully entered the classroom in other countries. We should be preparing Japanese students to use the tools of tomorrow.

Media. Information can be transmitted by various media. From the time when our first ancestors grunted or gestured, man has been searching for better ways to store and transmit ideas; spoken language, pictures, symbols, written language, graphs and charts, photographs, the printing press, telegraph, telephone, movies, phonograph records, radio, television, audio and video tape, compact disc, and binary data streams. Each of these media has contributed to the ability of human beings to express themselves and communicate with each other and with future generations. The later media have facilitated communications on a global scale, allowing a single person to reach an enormous audience. Such access to the world has created what Marshall McLuhan called the "Global Village". Today we can talk directly or pass messages with people almost anywhere. Friends living on separate continents can have daily contact which formerly could be done only by people living in the same village.

Multimedia. Multimedia is not new. If some prehistoric caveman pointed to his primitive pictogram and vocalized at the same time, he was giving a multimedia presentation. Early writing was frequently mixed with decoration or illustration. Photographs were captioned. Moving pictures added sound. Radio became television. Words and music were mixed in song and opera. When a medium was enhanced with a second or third medium, the intensity or depth of the message was somehow increased. A book with pictures, charts, or illustrations could tell a story better, more clearly, in an easier to understand, or a more interesting way. Illustration presents more information or presents information more densely.

Only recently has the computer emerged from its number crunching past into the text, pictures, sounds and motion video of multimedia. The original purpose for the development of computers was to manipulate large quantities of numbers. The Analytical Engine, an early mechanical counting machine first designed in 1834 and finally built as a prototype in 1871 by Charles Babbage, was intended to help in counting United States Census figures. ENIAC, the first electronic computer, was developed to calculate weapons trajectories, a task that had involved hundreds of mathematicians working by hand during World War II.

"A picture is worth a thousand words", may be an understatement in the world of computer technology. Although an illustration on a printed page may take up the same space as a thousand words, on a computer, the picture of a tree may take a million times more data space than the word "tree". The movement toward multimedia computing has required the massive amounts of computing power now residing on so many desktops and laptops. Only in the last few years have computers had enough computational power and storage to manipulate the vast amounts of data required for mixing the presentation of words, sounds, and pictures. Even today's computers cannot handle the multimedia to which we have grown accustomed through other sources. Anyone who has watched a movie on a computer screen knows that it is still quite inferior to the view seen in a theater or even on television. This is because today's typical computers still cannot process enough information fast enough. The computers which are used to transport multimedia data are also too slow.

The most common unit for measuring computer storage and data transmission is the byte. Think of a byte as a single keystroke on a keyboard, the space required for a digit, a letter or a symbol. A fast telegraph operator could transmit close to one hundred bytes a minute. A very fast typist can produce several hundred bytes of computer data in a minute, perhaps four or five bytes per second. (If a very fast typist could type twenty-four hours a day, three hundred sixty five days a year, for fifty years, a typical computer's hard disk would become full.)

The information contained in a sound or picture can also be measured in bytes. Sounds stored in a computer, in fact, occupy byte space. Sounds transmitted through various media at different speeds have different quality. For example, ordinary telephone communications or AM radio transmit sounds at up to 1000 bytes per second.

FM stereo radio and compact disc quality sound need faster communications, on the order of 5,000 bytes (5 kilobytes) per second. Standard television uses about 500,000 bytes per second. The information density of high definition television is higher, and that of film is even higher. A single high resolution photograph contains about 32,000,000 bytes (32 megabytes) of information, so a motion picture (at thirty frames per second) could require almost 1,000,000,000 bytes (1 gigabyte) of data per second, well beyond the capabilities of most of today's computers. A ninety minute movie could require upwards of 5,000,000,000,000 bytes (5 terabytes) of data.

Fortunately, a lot of the information in a photograph is redundant. A small spot on a picture has a high likelihood of having almost the same color as its neighbors. Similarly, two adjacent frames in a movie are quite similar. Not all of the information has to be sent with each picture, only the changes. This allows for some abbreviation in storage and transmission which is compressed using sophisticated algorithms. Fairly good quality sounds and images can be saved and transmitted with slower technologies. Moreover, the technologies are always getting faster.

Faster Pipes and Processors. As noted above, getting improved quality of images and sounds requires transporting and processing ever larger amounts of data. The first electronic (vacuum tube) computer was called the "ENIAC" (Electronic Numerator, Integrator, Analyzer, and Computer") Completed in 1945, it weighed about 30 tons and required about 150 kilowatts of electricity to operate. It had 17,468 vacuum tubes, a clock speed of 100,000 cycles per second and could do a simple multiplication problem in about 3 milliseconds or about 300 floating point operations per second (300 flops).[15] About 25 years later, Intel developed the first microprocessor chip, the 4004. It contained the equivalent of about 2300 transistors, had about the same speed and power as the ENIAC but weighed only a few grams. One of the founders of Intel, Gordon Moore, later observed that the number of transistor circuits on microprocessors, and their corresponding power, was doubling every 18 months. This observation was such a good predictor of increases in the computing power of microprocessors that this is now known as "Moore's Law" An indication of the growth of computing power can be seen in the following listing of the release dates of the most powerful microprocessors:

History of Major Microprocessors[16]

Date	Name	No. of Circuits	Comment
1971	Intel 4004	2,300	First General Purpose Micro.
1972	Intel 8008	3,500	Allowed alphabetic characters
1974	Intel 8080	6,000	Bill Gates wrote BASIC software
1975	Zilog Z80	8,500	Hosted CP/M Operating System
1976	MOS Tech. 6502	9,000	Apple PC II, etc.
1978	Intel 8086	29,000	IBM PC
1979	Intel 8088	29,000	IBM PC/XT
1979	Motorola 68000	68,000	Apple Macintosh
1982	Intel 286	134,000	IBM PC/AT
1985	Intel 386	275,000	Allowed Windows & OS/2

1986	MIPS R2000	185,000	Reduced Instruction Set (RISC)
1987	Sun SPARC	50,000	SPARC Workstation
1989	Intel 486	1,200,000	Still in use
1993	Intel Pentium	3,100,000	Super scalar architecture
1993	IBM/Motorola Power PC	2,800,000	Power Macintosh
1995	Intel Pentium Pro	5,500,000	Latest x86 design

Today's fastest computer was built with 7264 Pentium Pro Microprocessors, each with the equivalent of 5.5 million transistors. In December, 1996, it performed 1,060,000,000,000 floating point operations per second (1.06 teraflops) for a sustained period of time, eclipsing the prior speed record by several times.[17]

Communications between machines have also been getting faster. Early Teletype machines could send typewritten messages over telephone lines at twenty-two characters per second. Today's fiber optic cables can carry digital communications at many hundreds of millions of characters per second. Even home based computers are now capable of transferring four or five thousand bytes per second working over standard telephone lines. Newer technologies promise to deliver millions of bytes per second over existing phone lines or cable television cables. With transfers at these speeds, multiple channels of movies and other data can be delivered to homes on demand. Computer communication speeds still lag other older forms of communications, but the gap is closing.

Convergence of Technologies. Not only is the computer becoming more capable of handling multimedia, such as motion pictures, sound and text, it is also becoming more like the older media. The distinctions between computers and televisions, video cassette recorders, telephones, CD players, telephone answering machines, facsimile machines, books, libraries, etc., are becoming increasingly blurred. Among the developments of the last few years:

- TV tuner cards to receive broadcast signals and display live television images
- Facsimile cards to enable computers to send and receive faxes
- Telephony cards to allow computers to send and receive telephone messages
- CD-ROM devices which play music and video CDs
- Scanners and printers to copy and/or publish
- Network cards which allow high speed connections to the Internet which enable:
  - Reading newspapers on-line
  - Browsing the art collections of museums
  - Researching any topic with the computer doing much of the filtering
  - Exchanging e-mail with friends, associates, celebrities
  - Communicating with people of similar interests worldwide
  - Libraries sharing indexes across networks and the Internet
  - Encyclopedias on line
  - Automatic hypertext documentation and translation using remote computers

Other appliances are also changing to behave more like computers. The newly developed standards for the United States High Definition Television will use digital technology for broadcast and reception rather than the older analog forms. Digital broadcasting has already started in Japan with digital satellite services. Television sets with built-in Internet World Wide Web browsing are already being sold. Digital cameras are not yet as good as film cameras but they are growing in popularity and quality while declining in cost. Even postal services are being replaced by networked computers.

The Coming Virtual Reality Reality and the appearance of reality are being merged. It becomes more difficult to see what is at hand and what appears to be at hand. The object before you on your screen may be at your office, school or home, or it may be only a replica of something thousands of miles away. There is a new reality and it is so easy to see, hear, or touch that it defies disbelief. When you turn, the view of the space in front of you turns. Press the accelerator and you can feel the gravitational force pushing on your back and the vibration in your legs. Squeeze the tennis ball and you can feel it pushing back. Wander through a museum, glance at a sculpture, or walk around it. Look very closely and see the details. Using computers we are fast approaching an age of a new reality ... of Distributed Intelligence."[18]

The Internet has created multiple worlds, all accessible from a connected computer. One person can see the Internet as a place to study medicine or art. Someone else may use the net to read, see or hear his daily news through Internet radio stations or the most popular of all sites, CNN, the Cable Network News site. Another person sees it as a place where he chats with friends in a virtual community"[19] As Michael Heim recently put it:

> Consider the second postulate of Leibniz's metaphysics: Life consists of many possible worlds. As we continue upgrading the hardware and software, we are approaching -- in the not so distant future -- multiple virtual worlds. Online virtual worlds will be 3D immersive, interactive sensory environments. Our cyberbodies will leap out of the bland alphanumeric code as we jump from symbols to virtual reality.[20]

The vehicle for entering that new virtual reality, the domain of distributed intelligence, is the Internet. Born in 1972 under the auspices of the Advanced Research Projects Agency (ARPA) of the U. S. Department of Defense[21], the Internet, and especially the World Wide Web (the Web) part of it, is the embodiment of distributed intelligence. An unbelievably large body of information is available on just about every imaginable subject, and it is available at the click of a button. Not only is the information there, but new technologies are making it easier to find, classify, and use than ever before. The following charts show the phenomenal growth of the Internet and the Web.

Internet Growth				WWW Growth: 8	
Date	Hosts	Date	Hosts	Date	Sites
1969	4	07/91	535,000	06/93	130
1974	62	07/92	992,000	12/93	623
1977	111	07/93	1,776,000	06/94	2,738
1981	213	07/94	3,212,000	12/94	10,022
1984	1,024	07/95	6,642,000	06/95	23,500
1987	28,174	07/96	12,881,000	01/96	100,000
1990	313,000			06/96	230,000

One of the most amazing features of the web world is that it is everywhere and it is nowhere. The factories which characterize the hardware industry are nowhere to be found in virtual space. Much of the computing revolution started in "Silicon Valley", near Palo Alto and San Jose, California. But, "there will not be any geographical borders for Silicon Valley's future, because it is transforming itself to Internet Valley which is destroying any geographical limits for the new kind of human being."[23]

Educational Implications

The technology of computer multimedia was available for some time before anyone really had any good ideas about its appropriate or most effective use. Computer games were the first and remain the most common application. Very sophisticated virtual worlds are being created today for tomorrow's gamers.

The first widely accepted non-game CD-ROM which fully used computer multimedia was *Power Japanese*, a multimedia program for self study of Japanese reading, writing, listening and pronunciation. On a single multimedia computer with this CD-ROM, a student could watch animated action, listen to native speakers using Japanese, learn how to read and write all the kana and some kanji, drill oneself endlessly, record one's own voice for comparison with a native speaker, and have a good time while doing it .[24]

An Internet extension to *Power Japanese* could be built today. You click on a button on your computer screen and a picture of a room appears. There are images of other people in this room. They are symbolic representations or avatars of people from all over the world who have similarly entered this room for the purpose of practicing language. Move your avatar up to someone else's. Begin a conversation. Type in, "Konnichiwa!"

The virtual classroom of the future cannot be built yet. Computers and networks are not fast enough. We can ask, however, how the virtual classroom might look and feel... You see a door in front of you. You reach forward, turn the knob, and open it. You point at the open door and float into the room. You can see many people in the room and you hear them speaking in Japanese. Some are wearing clothing from other lands. There are men and women of all ages. Someone smiles at you and approaches. You hear the person say, "Konnichiwa!" You speak your answer.

Multimedia software for education exists now. Children's educational software in

English as well as Japanese is already teaching children how to do arithmetic, how to spell, and how to read. Other software is being used to teach foreign languages or specialized skills. New educational software is being introduced every day. The Internet and its World Wide Web exist now. These enable students to travel about in many worlds and learn in ways never before possible. In other countries, the Internet has been on campuses and in classrooms for many years. Universities were the second users of the Internet, after the U.S. Armed Forces. It has served well as a tool for research and study and will undoubtedly continue to do so.

The coming Age of Virtual Reality will further enhance the utility and power of the Internet. As educators, we must prepare our students for the multiple worlds of the future. Perhaps the most important lesson to be learned by today's students is how to use the very powerful new tools of the distributed intelligence of tomorrow.

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