Torsion Field School Network

What may someday become one version of the ‘ultimate’ educational system is my design of a torsion field school network.

In June 1962 I read an article in Look magazine about programmed textbooks. A teacher claimed that one of her eighth-grade students took a programmed algebra text home, learned the whole course in four days, and tested 100% at the ninth-grade level. I myself as a high school junior in a very small northern Wisconsin high school over a rainy four-day Easter vacation in 1959 had solved all the problems in several chapters of an advanced algebra textbook. As there were only a half-dozen students in the class, for the remainder of the school year, our teacher allowed us to advance through the textbook at our own pace. Every so often we would stop to talk about advanced algebra.

That fall of 1962 I asked one of my electrical engineering professors John Asmuth at the University of Wisconsin-Madison “Why not use programmed textbooks in engineering courses?” He through a series of private chats in his office explained to me that programmed learning would make engineering courses too easy to learn. Furthermore, rote learning doesn’t facilitate imaginative thinking and sepaunit out the sharper students.

(Later on when I was not attending engineering school I learned Boolean algebra – which is the basis of computer logic theory – with a programmed textbook without the help of a teacher. Ironically this one fundamental engineering subject I taught myself was the most useful to me when I worked as a technical writer with 18 Silicon Valley computer design and manufacturing companies including Amcomp, Timex, Control Data Corporation, Amdahl, Ampex, Verbatim, Mohawk Data Sciences, and Hewlett-Packard,)

Not satisfied with my professor’s answers, I tried to visualize a better educational system. After considering as impractical various changes to the rigid Labor Day to Memorial Day conventional course routine, I set out to design a completely different educational system as a hobby. I finally finished (???) my design of a school network of segmented courses in 1991!

One dozen to four dozen upper elementary schools, junior high schools, senior high schools and/or colleges are to be linked into a single network. The school network's three-layer computer system would comprise of a network coordinating and scheduling computer as the top layer, an administrative computer in each school as the middle layer, and personal computers as the bottom layer. The network's customized software would include network management and coordinating functions, two layers of software for the teachers to support 100 different functions, and 25 different functions for the students, only one of which is computer-assisted instruction. Each student’s personal computer would have a monitor capable of also displaying televised or recorded classes.

The typically huge scale of a school network would economically justify the simultaneous teaching in parallel of all week-long segments of each course year round with no seasonal constraints. Segmented courses would still include the standard features of conventional courses such as classes, graded examinations, and credit load units.

Short quizzes on each segment with unrecorded pass/fail grading would provide quality control. Successful completion of a segment becomes an input datum to several system software routines involving selection for scheduling of short series of classes and sometimes graded examinations, segmented course weekly progress reports, student status reports, and student interest groups which replace ‘grades 1-12’.

Other nonstandard features of segmented courses include modifications of the project management tools Programmed Evaluation and Review Technique (PERT) and Critical Path Method (CPM), unique statistical techniques for selecting series of two or three local/televised classes for weekly scheduling, nearly unlimited self-pacing, replacement of 'grades' with student interest groups, and optimum utilization of the superlearning technique.

It should be emphasized that the school network's class scheduling algorithm gives priority to scheduling of local classes over televised or recorded classes as much as possible. Local teachers also could still provide personal help to students.

Both teachers and students would be able to take sick leave or vacation at any time. When the students return to school, they would be able to simply continue with their coursework without missing any school work. At any time, a high school student for example could simultaneously be starting a course in English, halfway through a chemistry course, finishing a history course, and partway into a calculus course.

In 1992 I helped the Clark County School District apply to the New American Schools Development Corporation for a $12 million grant to build a small prototype network of six high schools in Henderson and Boulder City. Competing with 685 other grant applications, our application failed.

In 1998 I invented a major advance in torsion field communications. The theoretical maximum capacity of torsion field communications is apparently 40 billion channels of three-dimensional holographic television through the entire earth without attenuation at one billion times the speed of light. Torsion field communication systems, with components only the size of coins, are expected to eventually displace all forms of electronic communications including telephones, television, radio, fiber optic cable, and communications satellites, plus the entire Internet backbone with possibly a cost reduction of much more than half.

Schools can be located all over the solar system and still be tightly linked via torsion field communications into a 'torsion field school network'. It could help bring about world peace if for example a school in each of Nevada, Iceland, Germany, India, Israel, Bahrain, Chile and even planet Mars were linked into a single torsion field school network.

A conventional course is thought of as a small-scaled static version of the full-scale dynamic segmented course in a school network. The conversion could take several months of installing and cabling equipments. Students, teachers, segmented course monitors, and network coordinators would then all be trained. In the meantime courses continue to be taught in the conventional manner. Whenever the network finally is running smoothly, and the people had become accustomed to using the software, parameters are changed in each and all of the courses. From that time on, smart students are able to speed ahead. Slower students learn at their own pace with some assurance that they are mastering the subject matter.

The end result is intended to be a clear separation of teaching fundamentals from stimulating class discussions, graded examinations, and maintaining academic load standards.

Gary Vesperman
588 Lake Huron Lane
Boulder City, NV 89005-1018
702-435-7947
garyvesperman@yahoo.com
www.padrak.com/vesperman

(Title page of January 1989 school network design document)

Towards a Prototype Fiber-Optic Network of Computer-Based Segmented Courses for the Clark County School District, Las Vegas, Nevada

Acknowledgments

Over the past quarter-century, about three dozen people have contributed their stimulating conversation, ideas, and critiques to the development of the design. Their assistance is gratefully acknowledged.

The very substantial contribution of Cyrus N. Wells, Jr., who voluntarily worked for two solid weeks entering the original manuscript into his Kaypro computer, is especially praiseworthy. Mr. Wells also added much excellent editing and many design improvements. Mr. Wells had recently retired from EG&G as Senior Engineering Technician.

Author's Foreword

A long time ago, I noticed that the conventional system of education needs a little fixing. After considering various design changes and tossing them out for one reason or another, I found the conventional system hopelessly beyond repair. Out of curiosity, I set out to see if a completely different but better educational system could be designed. My little hobby ended up as a wonderfully entertaining systems engineering adventure.

Now that the design appears to have finally been closed in, and major problems no longer remain to be solved, it is time to build a prototype network and see if the kids and teachers would prefer the new system. Newcomers to the project should be warned that the system is strictly a design on paper. Its cost-effectiveness is uncertain. The only claim that can be made is that the design is worth pursuing.

I have documented the design as detailed as possible so as to record in one report new ideas and solutions as research proceeds. If you fall asleep as you read it, I apologize.

Before you begin digging into the details, let me try to give you a feel for the big picture. Dr. Harold H. Hailer, Chairperson, Department of Instructional Technology, San Jose State University, San Jose, California, has suggested a clever analogy: In the conventional system, students take courses in a manner similar to putting a car together on a single assembly line. The new system enables the students to put their cars together (take courses) on a rank of out-of-phase assembly lines. They can freely hop from one line to another at their convenience.

More accurately, the conventional system teaches a semester of subject matter in serial sequence. The new system breaks up semester courses into pieces small enough so that all of these pieces are taught in parallel all the time. In other words, the archaic conventional system turns out to be merely a small-scale, static version of the full-scale, dynamic version of the new system.

Schools normally do not contain enough students to enable the new system to operate economically. High-performance fiber-optics and video equipment will link a number of schools into a single network large enough to achieve the required scale. To cope with the massive bookkeeping, new and efficient management techniques will be coupled with the marvelous computing machinery that is now available. Careful equipment configuring and reliable software should enable the synthesis of a smooth-running, modern educational system.

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SCOPE

A large-scale electronic systems engineering strategy is proposed which would combine torsion field communications, computer, video, audio, computer-controlled switching, and computerized scheduling technologies into 'torsion field school networks'. Each torsion field school network would link together one dozen to four dozen metropolitan junior and senior high schools – located anywhere in the world. In particular, such an application of computer technology would fill the gap between the present utilization of computers for school administrative purposes and for Computer-Assisted-Instruction (CAI). Although combination video/computer monitors with keyboards suitable for school networks could readily be used also for CAI, the text contains only a brief discussion of how CAI would be incorporated into the school networks.

The economic and educational constraints of a school network dictate extreme minimum and maximum size limits in the neighborhood of 5 and 50 schools respectively. The optimum size may range from about 15 through 40 schools.

School network research is still continuing. The design has not yet matured from the high-risk category. However, the technologies now appear to be at hand with which to build a revolutionary educational system featuring a multitude of badly needed improvements. A long time ago a San Jose State University educational professor suggested that the computerized network of segmented courses may be the only known design that has a chance to efficiently tie together and fully exploit for education the remarkable new technologies.

SUMMARY

The school network is based on a computer-controlled system of courses partitioned into segments. After studying each segment, a student must pass a short test before proceeding to the next segment. Segment test grades would not be recorded; however, passing a test on each segment would become an input to several different software routines. Such a procedure would allow school networks to implement quality control measures to ensure more consistent academic standards.

Students would advance through their segmented courses mostly at their own rate. One to several segments would be grouped into a segment group followed by a week-long series of small classes. One to several segment groups would, in turn, be followed by a week-long series of lectures and a one or two-hour examination. In contrast to the segment test grades, the grades for these examinations would be recorded just like examinations for conventional courses. Passing a segment test would become at least one prerequisite to each series.

Conventional courses would be minimized as much as possible. However, students would, to some extent, be able to mix them with segmented courses.

A procedure employing segment or segment-group credit load units would ensure that students would not achieve less than a minimum total rate of progress through both segmented and conventional courses without penalty. Weekly progress reports would show the progress of each student, the queues for each series, and the status of the system.

Teachers in charge of monitoring segmented courses would select, on the basis of these weekly reports, the series to be taught during the next half-month. The controlling software would also nominate series for scheduling according to five criteria:

* The number of weeks passed since the series was last taught.

* The number of students eligible for the series.

* The composite criterion.

* The pseudo criterion.

* The economic criterion.

For segmented courses with enrollments insufficient to justify leaving them continually open for new admissions, and for major revisions of course material, the first segment would be aperiodically closed to new students. Otherwise, video playback devices and school television networks would enable segmented course series to remain open all the time within economic and educational constraints.

CRItical PAth sub-NETworks (CRIPANETs), comprising of pieces of both types of courses, would facilitate critical path curricula.

Student progress reports would be published monthly. Temporary student interest groups would enhance the economics of local classes, offer group competition while still preserving a sense of voluntary freedom of pace, and restore a sense of group identity.

The system hardware would include a variety of standard and custom terminals and peripherals serviced by cluster computers, a computer in each school for administering the system, access to a super-computer for scheduling all the schools in the network, video cameras, computer-controlled video switchers, computer-controlled audio switchers, and either or both torsion field communications or fiber-optic cables and interfaces.

INSTRUCTIONAL TECHNOLOGY – A HISTORY

Training

Manuals are frequently used for training purposes. Sometimes manuals are written solely for training. Training manuals are by necessity more verbose than manuals written for reference only by knowledgeable users. Regardless of the forum within which training is provided, students should still be provided well-organized, easily understandable reference literature on the subject being taught.

Configuring a training package for equipment or other subject has in recent years grown into a surprisingly sophisticated discipline. An exploration of the many options provided by modern instructional technology follows:

Tutoring

Tutoring may be the oldest ‘instructional technology’. Tutoring can be very successful and in some situations, e.g. home-schooling very young students, be worth the extra expense and time if a reasonably competent tutor and student can establish an agreeable rapport.

The ancient Greek philosopher Socrates pioneered the Socratic method of tutoring. The Socratic-type tutor leads a student to draw his/her own conclusions by continually asking questions.

A probably more useful and direct approach to tutoring on electronic equipment is to simply demonstrate how to use it and to explain how and why it works.

Petroglyphs

Prehistoric Southwest Indians may have trained their students in bighorn sheep hunting by holding classes in front of petroglyphs.

As a data storage medium, petroglyphs enjoy a proven record of durability. Negative images can probably be made of petroglyphs by using charcoal and birch bark. However, petroglyphs suffer from some significant disadvantages such as ineditability, low resolution, and immobility.

Sand

Some Southwest Indians such as the Hopis use sand paintings to graphically convey their thoughts. The Indian museum at Church Rock, New Mexico displays some beautifully colored sand paintings which often include geometric patterns.

Once they had somehow perceived the fundamental idea of the geometric theorem, the ancient Greek mathematicians carried out much of their famous theoretical research in geometry by drawing circles, lines, triangles, and so forth in sand.

As a data storage medium, sand offers some needed improvements over petroglyphs. Sand provides somewhat finer resolution, is much easier to edit, extremely inexpensive, and quite durable until the next wind.

Papyrus

Papyrus, obtained from Egypt's Nile River, was one of the first widely used media for recording people's thoughts for posterity.

Papyrus is transportable, durable and offers higher resolution than sand. Unfortunately, papyrus is probably not usable in copy machines.

Printing

The Gutenberg press was the key invention in making the printed word available to the general public.

Training manuals could now be published for operating and repairing clocks, shoeing horses, making cheese, and performing witchcraft.

Blackboard and Chalk

The blackboard and chalk, a classic training medium, became available to classroom teachers in the last century or two.

However, blackboards, while they are easy to edit and can be read by a large group of people, tend to be immobile, possess low resolution, and are difficult to copy except by hand or with a camera.

Slides

Photographic slides which could be projected on a screen in front of a class became available early in the 20th century. When combined with printed material and audio cassettes, slides have become a popular medium for both lectures and self-teaching.

Slides offer high resolution, can be easily copied, and are inexpensive and transportable. However, slides fade with use and age and are individually impossible to edit.

Transparencies

Transparencies printed with copy machines have become indispensable to lecturers.

Transparencies are durable, inexpensive, and offer high resolution. While they themselves are impossible to edit, they can be overwritten with a felt pen.

Workbooks

When books could be cheaply printed, the workbook was invented. The workbook allowed a student to write answers to questions right in the workbook. Workbooks are pedagogically very effective.

While they are reasonably inexpensive to print and offer high resolution, workbooks are impossible to edit once printed and are not easily reusable.

Laboratory Exercises

Laboratory exercises are effective aids for teaching electronic maintenance.

Laboratory exercises are inexpensive to copy or print, impossible to edit once printed, and offer high resolution.

Training Films

Thomas Alva Edison's invention of the motion picture allowed the storage of classroom lectures on photographic film. Training films have become very useful for subjects otherwise impractical to demonstrate. Training films can show the flowering of plants, handling radioactive materials, oscilloscope traces of electrical circuit operation, and many other subjects.

Training films offer high resolution, a sound track, mobility, and large screen projection. Films can be edited with some effort, are fairly expensive and lack durability.

Video Cassettes

The early eighties saw the entrance of inexpensive video cassette recorders and cameras. Video cassettes have quickly become a popular training medium since they are so cheap and easy to edit. Video cassettes also offer medium resolution, medium-sized screen projection, durability, and a sound track.

Today video cassettes have been largely replaced by digitally recorded video disks (DVDs).

PowerPoint

The computer program PowerPoint provides lecturers a convenient medium for colorfully presenting information a page or 'slide' at a time. However, the merits of PowerPoint usage in the classroom or during briefings have been found to be debatable. See http://en.wikipedia.org/wiki/Microsoft_PowerPoint.

Programmed Textbooks

Dr. B.F. Skinner, a Harvard psychologist, in the late fifties thought up the idea of programmed learning for humans. Programmed learning was an outgrowth of his earlier work in teaching pigeons to do useful work in manufacturing quality control and feedback control systems. He had reasoned that if pigeons could be taught using cognitive feedback methods, surely humans were smart enough to also benefit from such advanced teaching methods.

Programmed textbooks are frequently written by first writing small pieces of information and questions on 3-x-5 note cards. The author orally teaches a student with the cards one at a time. If the student doesn't understand something as the author goes along, usually because the piece of information was presented out-of-sequence, the author modifies and shuffles the cards accordingly. With the next student, the modified lesson sequence should go more smoothly since the necessary correction had been incorporated – similar to a feedback control system hunting for an optimum. Once a flawless lesson sequence has been written, the author reformats and publishes the lesson sequence as a programmed textbook.

Programmed textbooks have had a mixed history. One well-known publisher made the mistake around 1961 of hastily publishing programmed textbooks of poor quality. On the other hand, a Look magazine article published in June 1962 on programmed learning reported a teacher's claim that one of her eighth-grade students took a programmed algebra text home, learned the whole course in four days, and tested 100% at the ninth-grade level! (The author learned Boolean algebra using a programmed textbook, without a teacher, and has satisfied himself that the method is particularly suited for teaching intricate, potentially confusing subject matter.)

Programmed textbooks, while they can be pedagogically useful, are inconvenient to use as reference books. Sometimes their level of presentation is too slow for fast learners. An alternative design is a very wide book with three columns. The left column presents the material in a slow, detailed style in the classic programmed learning mode. The middle column condenses the material in a modified programmed learning mode. The right column presents the material in the classic textbook style which alternates between a chapter of text, and then a list of questions at the end of the chapter. A student then freely switches between the three columns according to how quickly or slowly the material is being learned.

Automatic Page Turners

Shortly after programmed textbooks came out, the U.S. Patent Office was flooded with patent applications for 'teaching machines'. The material was presented in exactly the same way as a programmed textbook. However, these machines did offer the convenience of automatic page turning.

On-Line Training via the Internet

Today's Internet provides all computer users everywhere on planet Earth instantaneous access to an unlimited variety of prerecorded training videos and occasionally live instructional classes.

Computer-Assisted Instruction

Mathematician John von Neumann's invention of computer logic circuits allowed modification of program instructions based on results of calculations. Computers enable the development of the true teaching machine where instructional sequences could be modified based on feedback from student responses.

Two Duke University students developed a computer program which allowed multiple remote terminals to time-share an expensive mainframe computer. Time-sharing enabled the first practical applications of computers to training.

Later in the sixties, two University of Illinois professors who were experimenting with using computers for teaching became dissatisfied with the cathode-ray tube for displaying information from the computer. Standing around outside after work one day, they hit upon the plasma display panel which offers rearview projection of printed matter, easier readability, and inherent volatile memory which permits data transmission over conventional telephone lines.

Their first prototype plasma display panel only had a four-by-four array of plasma-filled cells sandwiched between two glass panels. Each cell lit up when a voltage was applied to a coordinate of a horizontal wire and a vertical wire. Only a single letter or digit could be displayed. From that modest prototype flat image display grew today's enjoyment by millions of people of high-definition flat television and computer image displays unrestricted by the size and weight limitations of cathode-ray tubes.

University of Illinois' plasma panel was later incorporated by Control Data Corporation (where the author had first worked as a technical writer of computer manuals) into its Programmed Logic for Automated Teaching Operations (PLATO) teaching system. The PLATO system permitted up to 4000 plasma-type terminals to be serviced by a single Control Data 6600 mainframe computer.

In the late seventies, inexpensive standalone portable computers such as the Apple II and TIMEX 1000 (the author had worked as a technical writer on the TIMEX 2000) reached the marketplace (the TIMEX 2000 didn't – wasn't the author's fault!). Many training programs have been published for these machines.

Instructional Television Networks

Around 1980 Stanford University had developed a local television network using four over-the-air channels. Audio and video channel routing switchers route televised lectures to off-campus classrooms such as company cafeterias and classrooms. Banks of video cassette players generate, on demand, recorded lectures for closed-circuit transmission to students with TV receivers.

Video Receiver/Computer Monitor

General Electric invented a new type of television receiver which allows high-quality displays of both video and digital images. An antenna switch allows access to either video or computer systems. GE's receiver/monitor enables combining video lessons with educational computer programs. IBM demonstrated its model at the 1986 COMDEX.

Simulators

Computer-driven simulators are sometimes built for training people to operate complicated machines. Two common applications are aircraft flight simulators and nuclear power plant control room simulators. Simulators can require elaborate software and hardware engineering in order to at least closely approximate real-world conditions.

Optical Data Storage

As of the mid-l980's, Verbatim, where the author once worked as a technical writer on a magnetic disk drive, was expecting to market for $700 an optical disk drive which can read and write 40 megabytes of data. Other manufacturers were preparing to make 1-gigabyte optical disk drives costing about ten times as much.

Several students could easily time-share a single optical disk containing a complete encyclopedia, thousands of programmed lessons, mathematical routines, a spelling checker, dictionary, cooking lessons, etc.

Nowadays a stunning variety of powerful, extremely fast feature-laden computers are sold at relatively low prices.

Computer-Controlled Video and Audio Channel Switchers

The Grass Valley Group Company manufactures a line of computer-controlled video and audio channel switchers for routing televised classes plus audio and digital signals between and within the schools.

Fiber-Optic Communication

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information. First developed in the 1970s, fiber-optic communication systems have revolutionized the telecommunications industry and have played a major role in the advent of the Information Age. Because of its advantages over electrical transmission, optical fibers have largely replaced copper wire communications in core networks in the developed world. Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Researchers at Bell Labs have reached internet speeds of over 100 petabits per second using fiber-optic communication. Telephone capacity via fiber-optic cables has become so abundant and cheap that long-distance telephone fees within North America have all but disappeared.

School Networks

Fiber-optic cable could be combined with optical data storage, receiver/monitors, cameras, local area networks, the new scheduling algorithms, and certain other new technologies, to form school networks.

Fiber-optic cables can link, for example, all the high schools in Las Vegas, Henderson, and Boulder City into a single huge network. A cable could possibly even be run up 1-15 to bring the schools in St. George, Parowan, Utah, etc. into the Las Vegas school network.

The Grass Valley Group Company manufactures a line of computer-controlled video and audio channel switchers for routing televised classes plus audio and digital signals between and within the schools.

The conventional system teaches courses in serial sequences. In contrast, an ideally configured school network breaks the courses into segments of a week or so in length, and then teaches all the segments in parallel all year long. Modified versions of two sophisticated management tools, Programmed Evaluation and Review Technique (PERT) and the Critical Path Method (CPM), enable the teachers to administer and teach the segmented courses with a multitude of previously unavailable features and options.

To help the students and teachers efficiently handle the massive bookkeeping required, a three-layer computer hierarchy is integrated with the video network. At the top layer, a network computer schedules and coordinates the entire network. The network computer also controls the audio, digital and video channel switchers at the network control center so that audio, digital and video signals are routed to the correctly addressed schools.

At the middle layer is the administrative computer in each school. The administrative computer controls the audio and video channel routing switchers within the school with commands received from the network computer. A wide assortment of system administrative services are also provided with the aid of cluster computers.

At the bottom layer is a large number of cluster computers with access to the administrative computer, a printer, and either magnetic or optical disk storage. Each cluster computer services 8, 16 or 32 on-line faculty and student computer/video terminals. The computer system supports approximately 100 different input/output functions for the teachers, and approximately 25 input/output functions for the students.

Students can begin any course at any time of the year. Simultaneously, a student can be starting a course, finishing a second course, and be halfway through a couple of more courses. While attending each course, students can become exposed to a variety of teachers throughout the network. Classes can be local, televised or both.

School networks offer more precise quality control, more efficient year-round utilization of school facilities, greatly increased vacation scheduling flexibility for both teachers and students, and greater control by the students over their personal lives.

Examinations are graded and recorded in the same manner as in the conventional courses. Academic standards are maintained by the computer system which continually keeps track of student workloads by totaling and then averaging over the past few months credit load units assigned to completed course segments.

The segmented courses can be shut off for occasional lengths of time to permit bunching up of students into groups which can then be paced to a certain extent. Grouping can thus reduce the number of students and still retain a high student teacher ratio to keep down costs. Otherwise, the scale of the school network is so large that the only foreseeable applications lie in metropolitan junior high schools, metropolitan senior high schools, and possibly junior colleges and military training programs.

While the capital cost of a full-scale school network would typically range in the neighborhood of $100,000,000, the initial cost per student hopefully will be in the order of the cost of one large home appliance.

With all their advantages and features, it is unfortunately doubtful that school networks can be scaled down to economically accommodate industrial training programs.

Torsion Field Communications

Up until World War II, science books had a claim that airplanes would never be able to fly faster than sound. And that was true of propeller-driven airplanes; then along came rockets and jet engines. Now science books claim that nothing can move faster than the speed of light. Russian scientists have known for about 40 years that a torsion field can be generated by the *spin* of a mass.

Practically unknown to Western science, several groups of Russian scientists have been developing torsion field physics and apparatus in secret for over three decades. A torsion field is a scalar product of two electromagnetic fields (which are vector fields) under special conditions. For example, a torsion field can be generated at the interface between two magnetic fields sweeping past each other.

A lengthy list of attributes has been experimentally identified which demonstrates that the torsion field operates holographically, without regard to time and distance. Its operations are characterized by a variety of behaviors which have been described conceptually, experimentally and mathematically as functions of spin polarity, angular momentum and weighted waveform vector velocities. For example, unlike electromagnetism, where analogous charges repel and opposite charges attract, in torsion fields similar charges attract and opposite charges repulse.

Anyone can buy a torsion field generator or receiver from any of four sources in the former Soviet republics. Their devices have been constructed, operated, tested, documented and patented. They propagate information into and retrieve information out of the torsion field.

By detecting the present location of a star and comparing with its location as indicated by its light, Russian astronomers have determined that torsion fields are transmitted at a speed of one billion times the speed of light. Physicists at Los Alamos National Laboratory have transmitted Mozart's 40th Symphony at 4.7 times the speed of light using torsion field generators and torsion field sensors. The European physics laboratory CERN has determined that torsion field information can be transmitted through 20 miles of mountain without attenuation.

A unique design has been developed for a counter-rotating torsion field generator based on a newly patented micro-solenoid technology, counter-rotating mono-polar magnetic plates, mono-chromatic standing wave lasers, and some scalar parallel processor technologies from the Swiss Institute of Technology in Zurich.

Torsion field communications is arguably one of the more exotic and potentially valuable non-mainstream technologies. Torsion field communications is an immature communications medium that is perhaps at the stage of radio communications' development a century ago. At that early era of radio, practical user-friendly radio transmitters and receivers had not yet been developed for commercial sale. Amplitude modulation (AM) and frequency modulation (FM) channels, for example, eventually had to be precisely specified, standardized and allocated.

The theoretical maximum capacity of torsion field communications is apparently 40 billion channels of three-dimensional holographic television through the entire earth without attenuation faster than one billion times the speed of light. Torsion field communications, with components only the size of coins or less, may eventually displace all forms of electronic communications including telephones, television, radio, fiber optic cable, microwave, and communications satellites, plus the entire Internet backbone. Because the torsion field is non-electromagnetic, torsion field communication links would be immune to disruptions caused by unusually intense solar electromagnetic storms.

A commercial torsion field communications device has been designed which will be able to universally transmit information through the entire earth at many times the speed of light with a bandwidth wide enough to allow transmission of three-dimensional holographic television on 16.7 million separate channels.

Torsion field communications research and development has been and still is conducted by a team of very smart engineers and physicists based in Salt Lake City, Utah and elsewhere led by David G. Yurth, Ph.D. Gary Vesperman's personal contribution is the invention of a major advance that comprises part of a patent application which describes a process that is hoped will eventually become the first fully functional bi-directional torsion field communications system.

Gary Vesperman has in his computer numerous pages of fascinating torsion field information. An extensive discussion of the torsion field is included in Gary Vesperman's compilation of "Space Travel Innovations" – available in his website www.padrak.com/vesperman and also http://www.commutefaster.com/Vesperman.html and http://the-door.net/the-colorado-center/radioactivity-neutralization-methods-and-more/,

The list of potential applications of the torsion field is surprisingly long and grows longer with time. Harmless torsion field cell phones would offer instant wideband communications with other torsion field cell phones anywhere on Planet Earth without dropouts.

Other applications include revolutionary new propulsion systems, communications and remote monitoring devices, long-range sensors, astrophysical monitoring and metering devices, exotic new materials, geo-physical devices which can be calibrated to locate mineral deposits, water and subterranean structures; and photographic applications which are capable of imaging the interior of virtually any substance or structure without X-rays. Torsion field dental imagers would bypass the harmful effects of X-ray dental imagers.

Electronic Brain Wave Control

A neighbor of the author knew a doctor who was readying for marketing an electronic brain-wave control device which offered an 80% memory retention on the first introduction to information versus the normal 35% retention. (Electronic brain-wave control is supposedly also an extremely effective painkiller, popular with athletes, without side effects, for whom it is primarily being marketed.)

SYSTEM DESIGN OBJECTIVES

Much laudable effort is being made to make various improvements upon the conventional system of technical education with little apparent success. The somewhat peculiar reason for the blockage seems to be that whenever a modification is contemplated, a difficulty appears elsewhere within the system which renders unacceptable the modification under consideration. It logically follows then that one of the few possible paths left to a genuinely substantially improved educational system is to momentarily forget about the conventional system and, starting over again, design and implement a rearranged system of education. With continual modifying and evaluating, it could be possible to work out an improved system embodying many desirable but previously unattainable features, raise academic standards, and still satisfy certain basic minimum requirements.

A system such as the school network would involve tradeoffs. But, like most systems engineering problems, these tradeoffs are often difficult to quantify with precision. Judgments of the system are, therefore, necessarily at least partly subjective. As an aid to designing and evaluating such a system, the first step is, of course, to list our design objectives.

There seems to be much confusion and controversy among educators and students as to exactly what should be the philosophy and general conduct of technical education. The source of much of this difficulty appears to stem from the conflicting fulfillment of two basic goals of technical education which at present is being attempted with the conventional system simultaneously.
The first of the pair of goals under consideration here is the editing and teaching of as much of the fundamentals as possible. The second, more intangible goal comes under such headings as teaching inductively ways and means of problem-solving, testing and grading the relative competence of students, motivating students, and stimulating creative thinking. Our first, and perhaps most fundamental, systems design objective is to facilitate a clear separation of the processes for accomplishing these two goals.

By implementing various tradeoffs, a new system should impose a more desirable set of freedoms and responsibilities upon the student and the instructor.

It should provide course modularity so that the students transferring from other schools would not be impeded as much from gaps and duplications in subject matter.

It should retain major course examinations and grades.

It should make possible economical, more rewarding individual laboratory sessions with little or no duplication of laboratory equipment. The conventional system is too rigid where it should be flexible in its administration, and too careless and lackadaisical where it should impose stricter control measures on the ‘quality of learning’ instilled in students.

Students should be able to proceed at their own pace.

It should preserve the concept of the ‘minimum student credit load’.

It should facilitate the more effective and efficient study of foreign languages in short intensive learning periods of a few weeks in length.

Any educational system should have a high degree of reliability built-in through the use of affordable redundancy and fail-safe methods.

Final examinations should probably be spread out rather than be concentrated into one week at the end of each semester.

Industry should find it more convenient to handle work-study programs with a new system. Knowledge requirements are changing so rapidly that large initial batches of formal technical training are frequently made obsolete. Continuously available course modules would better facilitate continuing education. Engineering schools, for example, can probably retrain people more cheaply and effectively than industry can.

It should reduce requirements for physical plant, opeunit funds, and manpower. The conventional system may be more expensive and cumbersome than necessary.

It should provide students and instructors a more flexible, less monotonous schedule to adhere to.

It should provide students more incentive to study during summer vacations.

It should eliminate the somewhat stultifying routine of attending the same classes all semester, however interesting may be the material and the one or two instructors.

It should increase the proportion of the things constituting an educational system that can be stored piecemeal. Thus it could provide better instruction by making possible continuous and sustained small improvements.

It should expose the students to a wider variety of lecturers instead of only one or two per course per semester or quarter.

It should provide some means of separate testing to ensure thorough understanding of fundamentals and thereby conserve the major course examinations for sorting out sharper students.

It should speed up and facilitate revising course subject matter and improving learning methods.

It should minimize clerical labor.

It should provide for the optimum number rather than a fixed number of classes for each course.

It should encourage trading mundane formal lectures on fundamentals for lectures given on a level deeper than that prevailing in conventional lectures. When appropriate, lecturers should be able to assume that at least some of the fundamentals have already been learned.

Students and teachers should be able to take a vacation at any time. Students should be able to start, interrupt, and finish courses at any time.

It should facilitate the application of the ‘critical path’ method of management to curricula.

It should be reasonably simple to operate and administer.

It should be completely compatible with the conventional system of education.

It should have something for everyone.

SEGMENTED COURSE STRUCTURE

Structure of a Simplified Segmented Course

Figure 1 shows the block diagram of a simplified segmented course, which should be distinguished from the conventional course. In the upper left-hand corner of the diagram are two of the basic building blocks of the segmented course management system; the segment and the segment test. A segment is arbitrarily defined as the amount of subject matter covered in a week with a conventional course. For convenience, it would often be equivalent to a textbook chapter.

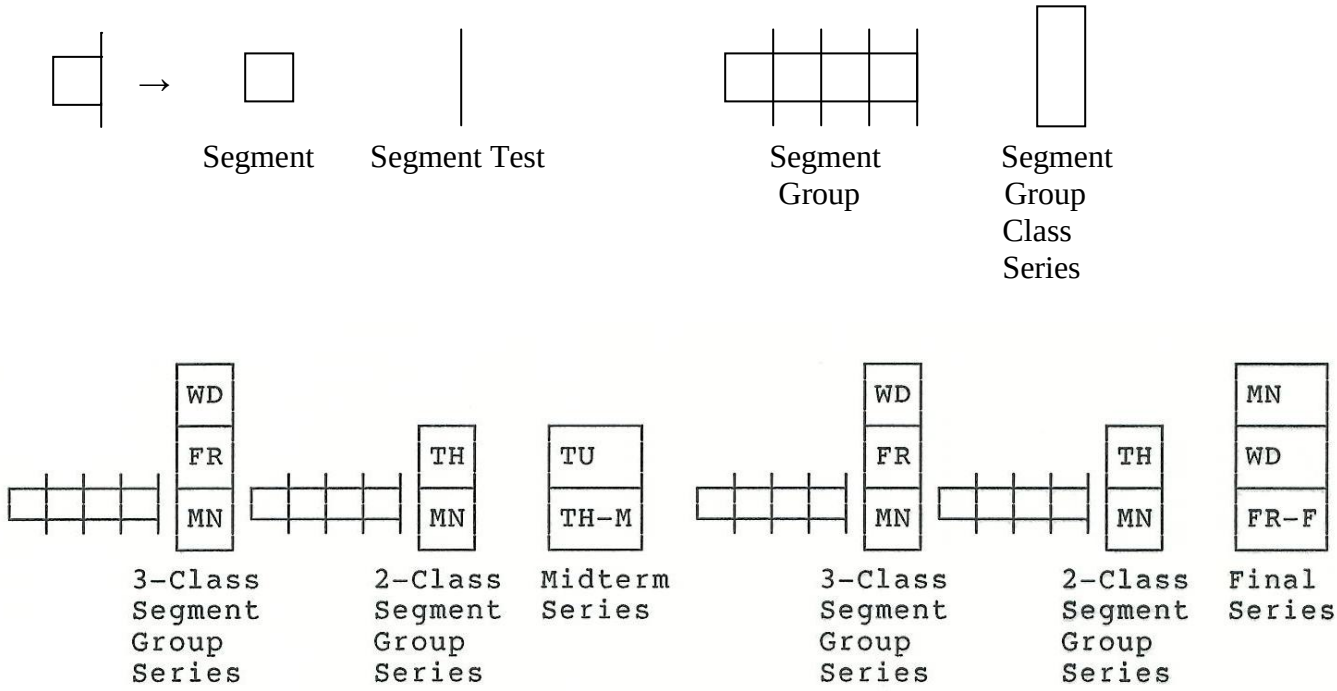


Figure 1. Simplified Segmented Course Block Diagram

After a student studies a segment, he/she is given a one-quarter-hour to one-half-hour segment test. If he/he does well, he/she may advance to the next segment in the course. If not, the student reviews and attempts to pass another test on the same segment. The segment test allows the student to demonstrate his/her mastery of the material and to move on to the next segment without waiting for other students or his/her instructor. The segment test should also be a helpful homework supplement.

Most of the segment tests would be given and graded by controlling software via a remote terminal. A few would be given and graded manually. In addition, one oral segment test is suggested on a key segment in the latter part of each course. Segment tests may be given at any time. Segment test grades would NOT be recorded; but the fact that a student has successfully passed a test would become an input datum for several different software routines periodically processed by an electronic data processing system.

In the upper-right corner of the diagram are shown two more building blocks; the segment group and the segment group class series. A segment group would usually consist of three or four segments. There may be as few as one segment in a segment group. Following each segment group, one or more segment group class series are held. A segment group class series consists of two or three small classes. The series consisting of two classes would be held on Thursday and Monday. The series consisting of three classes would be held on Wednesday, Friday and Monday.

The reason for these odd sequences will become apparent shortly. Each series would be selected for machine scheduling no less often than once every several weeks. A large enough network of schools should be able to economically allow selection of each type of series at least once a week.

After one to several segment groups, either a midterm or a final series would be held. A midterm series would consist of one relatively large lecture and either another lecture or a one-hour examination. A final series would consist of two large lectures and either a third lecture or a final examination. Examination grades would be recorded. They would be unique and usually not graded by computer.

The midterm series and the final series would be selected for machine scheduling not as often as segment group class series. The duration of the midterm and final series would be no longer than a week. The sequence of the various pieces of the course shown in Figure 1 follows the subject matter contained in the course. But it is NOT necessarily chronological.

Figure 2 is a graph of one set of prerequisites for each of the series in the simplified segmented course. The prerequisites graph for a course is filed permanently within the computer. It is followed by the processor when it is determining the eligibility of students for the various segment group class and lecture-plus-examination series in the course. The prerequisites for a series would usually be a segment for which a segment test has been passed and one or more preceding series in the course series sequence which the student either has previously attended or is attending as scheduled the previous week.

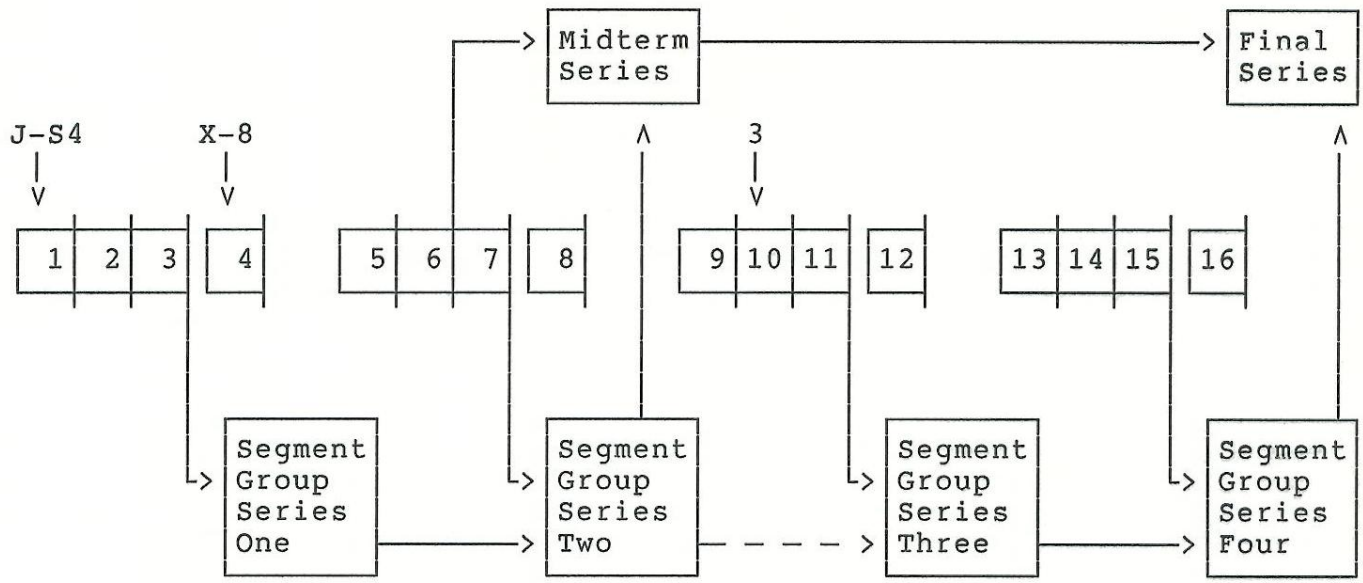


Figure 2. Series Prerequisite Graph

Segment group class series #2 would always be scheduled a half-week before the midterm series. Likewise, segment group class series #4 would also always be scheduled before the final series. Scheduling these two pairs of series in reverse a half-week apart would usually not occur. Because of class size differences, all segment group class series would be selected for scheduling more often than the midterm and final series.

The dashed arrow (— — >) between segment group class series #2 and #3 indicates that the subject matter in the central portion of the course does not preclude students from attending segment group class series #3 before attending segment group class series #2 by causing any difficulty in comprehending the subject matter out of sequence. Students are assumed to have learned at least most of the fundamentals that a segment group class series would deal with.

The ‘3’ input arrow to Segment #9 indicates that a student is eligible for a segment test on Segment #9 when he/she has passed a segment test on segment #3. But he/she would still have to study segments #4 through 8 in sequence. This example illustrates that the subject matter in some courses is not continuous and therefore permits additional flexibility not usable in the conventional system.

The ‘X-8’ input arrow to Segment #4 indicates that a prerequisite to Segment #4 is passing the segment test for Segment #8 in Segmented Course X.

The ‘J-S4’ input arrow to Segment #1 indicates that a prerequisite to the course is passing an examination which is given as part of the fourth series in Segmented Course J.

Segment tests for segments #4, 8, 12, and 16 should be passed by the student between the time the corresponding segment-group class series is selected by the controlling software for computerized scheduling and the time the series begins. It would usually take at least a week before a particular series is held after a student becomes officially eligible. The student in these cases would have time to study the final segment in a segment-group, pass a segment test, and to prepare for the segment-group class series. Of course, there would be no reason why a student is unable to attend a series immediately after he/she becomes unofficially eligible by passing a segment test. Similar patterns of prerequisites should be utilized for all segmented courses in order to minimize time lags. Segments #7 and 15 also fall into this category.

Segmented Course Variations

Figure 3 illustrates some of the variations possible with segmented courses. The hypothetical course shown begins with a two-class segment-group class series which is attended by the latest group of students admitted to the course. However, the student need not wait for the first series to begin studying Segment #1. A 15-minute video cassette, compact disk or on-line lesson, which the student plays back at his/her convenience, previews the segmented course. Passing a test on the first segment should be a prerequisite to the second and third series, which form a vertical stack and would be held in the same week. The other prerequisite would be attendance at the first series.

The vertical stack of three "2L" blocks (Series #4, 5 & 6) indicates a pair of three-hour group laboratory sessions held the week before the series (#7) of two small classes covering the second segment-group. The "3L" block (Series #11) indicates three one-hour group laboratory sessions held the same week as a series (#12) of three small classes. Series #13 is horizontally stacked with Series #11 and #12 and so therefore is automatically selected for scheduling the week after Series #11 and #12. Series #11, 12 & 13 cover the fourth segment-group. Individual laboratory sessions can be mixed in with the segments. The details concerning these individual sessions, such as building locations and instrument procurement instructions, would be available in course study guides.

The ninth segment requires passing a non-computer-graded segment test. The twelveth segment requires passing an oral segment test. Grades for these types of segment tests would also not be recorded; but passing these types of segment tests would still become inputs to several software routines.
Midterm series of two relatively large lecture sessions plus a one-hour examination would be held after the fifth and tenth segments. Their prerequisites would be set to minimize time lags. Segment-group class series immediately preceding the midterm series would be selected for scheduling up to several times between the schedulings of the midterm series.

Each student would progress through his/her courses mostly at his/her own pace. He/she would still have to maintain a minimum academic load. This is in contrast to the lock-step pace characteristic of conventional courses. A student would typically be simultaneously attending a couple of conventional courses, starting a segmented course, finishing another segmented course, and be part-way through a couple of additional segmented courses.

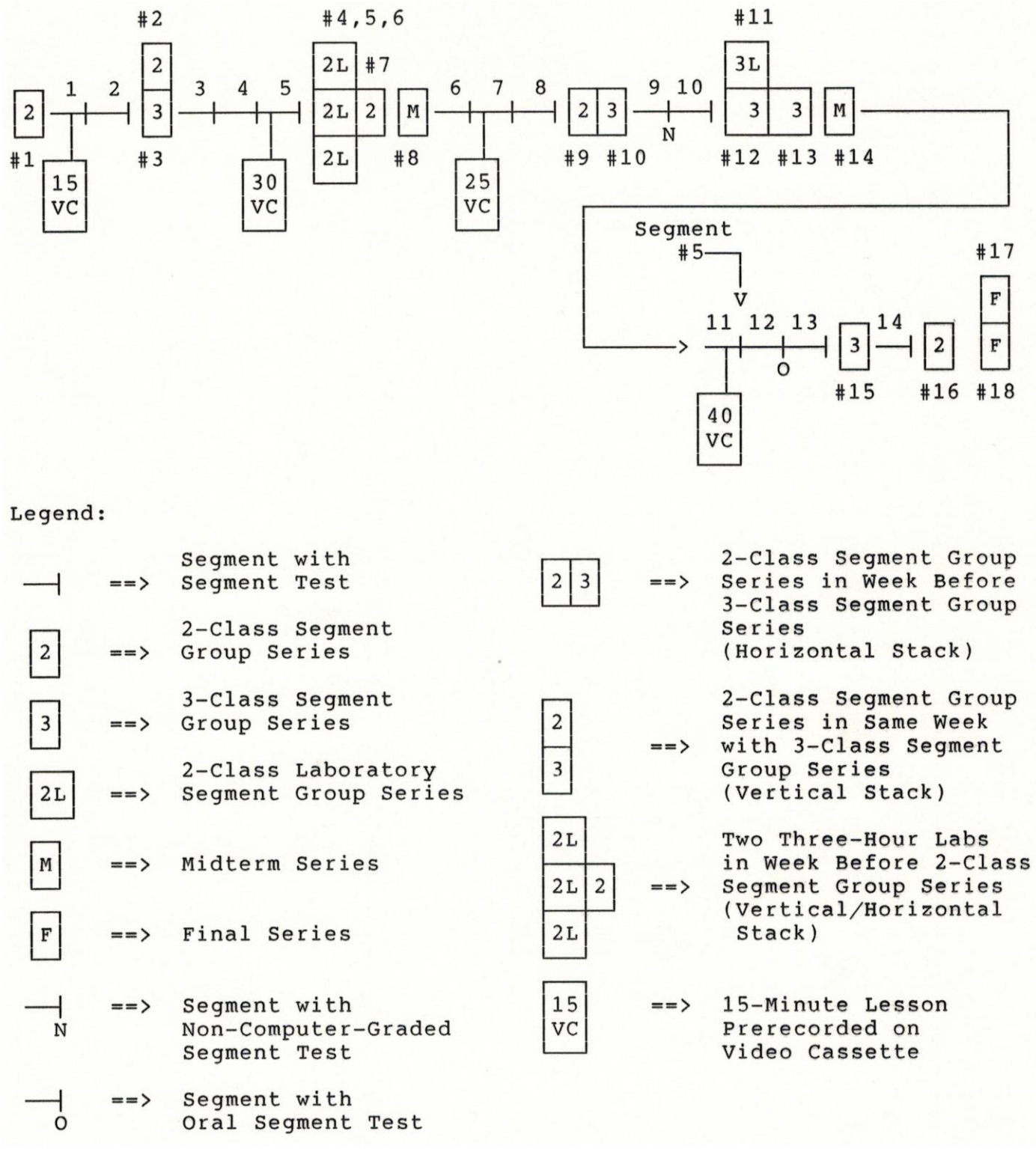


Figure 3. A Hypothetical Segmented Course

In addition to 110 minutes of prerecorded video class, the course contains a total of 40 hours of class, 14 segments, and four hours of examinations. The grading for the hypothetical course follows the grading scheme for most conventional courses by counting the two one-hour examinations at about 20% apiece, the final examination at about 40%, and the remainder of the course grade from homework assignments, papers, laboratory performance, etc.

SEGMENT TESTS

Segment Content

Segments are small parts of segmented courses containing the material for which students are responsible and on which they are usually required to pass a segment test. These tests would usually be desirable for their instructional value and are almost necessary for administrative purposes. Passing them should add to the student's feeling of confidence and enthusiasm for studying. This alone could possibly curtail student drop-out rates. "Nothing succeeds like success", so goes a well-known saying. They could also help ensure an accurate understanding of material.

The amount of material that a segment should contain would depend on many factors. The maximum length of a segment permitted by the administrative procedures and software routines in the system is the equivalent of an entire segment-group. That is, a segment-group could, when appropriate, become just one segment that includes a segment test. A segment would ordinarily consist of part or all of a textbook chapter and perhaps some sheets of notes. Sometimes it is forgotten that all of the material in a course should ideally be written into textbook form, both for ease of reference and for bookshelf economy. Hastily-written lecture notes are a rather poor substitute.

Segment Testing

If the segment is temporarily closed, students may study the material in the segment. But they would be forced to wait until the segment is re-opened before taking a segment test. When a student, after studying a segment's material, thinks he/she is ready for a segment test, he/she would go to the nearest remote computer input/output terminal. He/she would take the test and, if he/she does not pass, would review and take a different test on the same segment. After he/she has demonstrated to the controlling software that he/she is well acquainted with the material in the segment, he/she would become qualified to start on the next segment. The controlling software would not record the segment test scores. Unless the student has been excused from taking segment tests, the fact that he/she has passed a test is used by the controlling software for several administrative procedures. On the rare occasions when a segment test is given and scored manually, the instructor would notify the controlling software when a student has passed a segment.

To prevent confusing the computer-based segmented course management system with learning aids such as programmed textbooks and CAI, a combination of CAI with this system is described next which appears to possess optimum efficiency.

After a student has passed a segment test, he/she could then have the option of immediately receiving a computer-aided introductory lesson on material included in the next segment in the course. After this lesson, the student could go home and cover the material with a textbook, perhaps perform an experiment set up by himself/herself, and do some homework problems. He/she could then go back to the terminal and take a test on the segment.

Some instructors seem to feel that if a person has some difficulty learning from lectures and books, he/she does not belong in college. They feel that learning aids, such as programmed textbooks and CAI, should, consequently, not be used. Such aids have also not always lived up to expectations. However these issues are settled, the computer-based segmented course management system should be judged on its own merits and not become embroiled in unrelated controversies.

To compile segment tests, the controlling software would select at random some questions from a repertory of questions pertaining to the segment. Each question would have a time limit and a scoring value. The controlling software would ensure that the total time for answering questions is within the range allotted for the segment test. The controlling software would randomly vary values utilized in questions involving numerical calculations.

If a student fails a segment test, the controlling software would record the questions which had been asked. When the student tries to pass another segment test on the same segment, the controlling software would assemble a test with questions different than the ones already asked.

Two-Phase Segment Test Check-out Procedure

After a segment test is written and is made available through the remote terminals, it should be validated in two phases with a check-out procedure. The first phase consists of recording how many students pass and do not pass the test the first few times they take it. If a segment test turns out to be too difficult or too easy, the test writers should either revise the questions or adjust the passing score.

The second phase consists of recording the answers to any segment test that appears suspiciously defective.

CREDIT LOAD UNITS

Segment Test Credit Load Units

Credit load units would be a quantitative measure with which the controlling software could determine each and every week whether students should be placed on probation for not carrying a minimum academic load. The credit load unit for each of the segments in a segmented course would, on the average, be equal to the number of credits at which the course is rated divided by the number of segments contained in the course.

Calculating the credit load a student has carried during a specified number of weeks would take into consideration the amount of work accomplished in both his/her segmented and conventional courses. If a student's load was calculated for a semester or quarter, his/her load unit would be the sum of the number of credits earned by passing conventional courses and the credit load units earned by passing segment tests. If a student gives up on a segmented course, perhaps due to poor performance on an examination, he/she would lose all of the accumulated credit load units he had earned to date in the course. After several weeks, he/she could start taking the course over again. Figure 4 illustrates a student credit load calculation example.

Other Credit Load Units

For some students the segment test could become a hindrance rather than an instructional aid. Such students could instead inform the controlling software whenever they believe they have learned the material in a segment. This would replace passing segment tests as a software input. Credit load units for such students could then be calculated on the basis of segment-group class series attendance instead of completed segments or attendance at midterm and final series. Credit load units would be assigned to each segment-group.

```
┌──(Student enters school after a vacation
│   six weeks before the semester begins.)
│
│
│
│                        ┌──────────────────────────────────────────┐
│                        │ Student attends a one-credit conventional │
│                        │ course and a three-credit conventional    │
V                        │ course during a fifteen-week semester.    │
┌──────────────────────┬──────────────────────────────────────────┐
│ Student earns five   │ Student earns seven segment              │
│ segment credits in   │ credits during first nine                │
│ six-week period.     │ weeks of semester                        │
├──────────────────────┴──────────────────────────────────────────┤
│<===Fifteen-week student credit load calculation===>              │
│   period.                                                       │
└─────────────────────────────────────────────────────────────────┘
```

Figure 4. Student Credit Load Calculation Example

Credit Load Units for Each Segmented Course

In addition to monitoring each student's overall rate of progress in all of his/her courses, the controlling software would monitor the rate of progress in each segmented course. If a student's rate of progress drops to the minimum set for a course, the controlling software would flash a warning to the student the next time he/she logs-on to a terminal or an off-line computer with a telephone link. The warning would be triggered when no activity has occurred for at least a month, for example, or when the student has passed segment tests for only two segments in the past ten weeks.

Every week each student would have his/her current academic load calculated on the basis of work completed during the past semester or equivalent period. In the example shown in Figure 4, a student's credit load unit is being calculated nine weeks after the beginning of a semester.

To calculate the unit, the controlling software first multiplies four credits (from the conventional courses) by nine weeks, divides the result by fifteen weeks and obtains 2.4 credits. The controlling software then totals the number of segment credits earned by passing segment tests during the student's fifteen-week credit load calculation period, adds the total to the 2.4 credits and obtains 14.4 credits. If the minimum allowed load is twelve credits, nothing would happen.

If the student had failed to maintain the minimum academic load, the controlling software would display the fact to his/her dean and the student would be placed on probation, regardless of his/her grade point average, unless excused by the dean. A student could be allowed to drop a segmented course and start over either immediately, after a few weeks, or at the beginning of the following quarter or semester; but he/she would be better advised to maintain the minimum load.

SERIES SELECTING

The series scheduling procedure would consist of two basic steps: The first step would be to determine whether each series should be selected for computerized scheduling. The second step would be the actual scheduling. The entire procedure would be reinitialized every Thursday night. It would end two and one-half weeks later with the holding of the last classes and examinations of series that had been selected and then scheduled.

The procedure would begin with the computation of the series-selecting queues. Weekly progress reports would be prepared for distribution to the instructors monitoring each segmented course. Some of the series are then selected for scheduling by both the course monitors and the computer. The controlling software optimizes a schedule, which is then published.

Series-Selecting Queues and Quotas

Five types of series-selecting queues (with quotas) are recommended. The first two are simple; the number of weeks elapsed since a series was last held, and the number of students that have satisfied the prerequisites for each series. The prerequisites for a series are a segment for which a segment test has been passed, and one or more preceding series in the course series sequence which the student either has previously attended, or is presently attending as scheduled the previous week.

The third type of series-selecting queue (with quota) would be a composite of the number of students that have satisfied the prerequisites of a series, and the number of weeks each student has been eligible. When the controlling software is evaluating the possible selection of a series for computerized scheduling, a student that has been eligible to attend a series for three weeks, for example, should be given the same weight as three students that have been eligible for one week. Figure 5 illustrates a more elaborate example of computing the composite series-selecting queue.

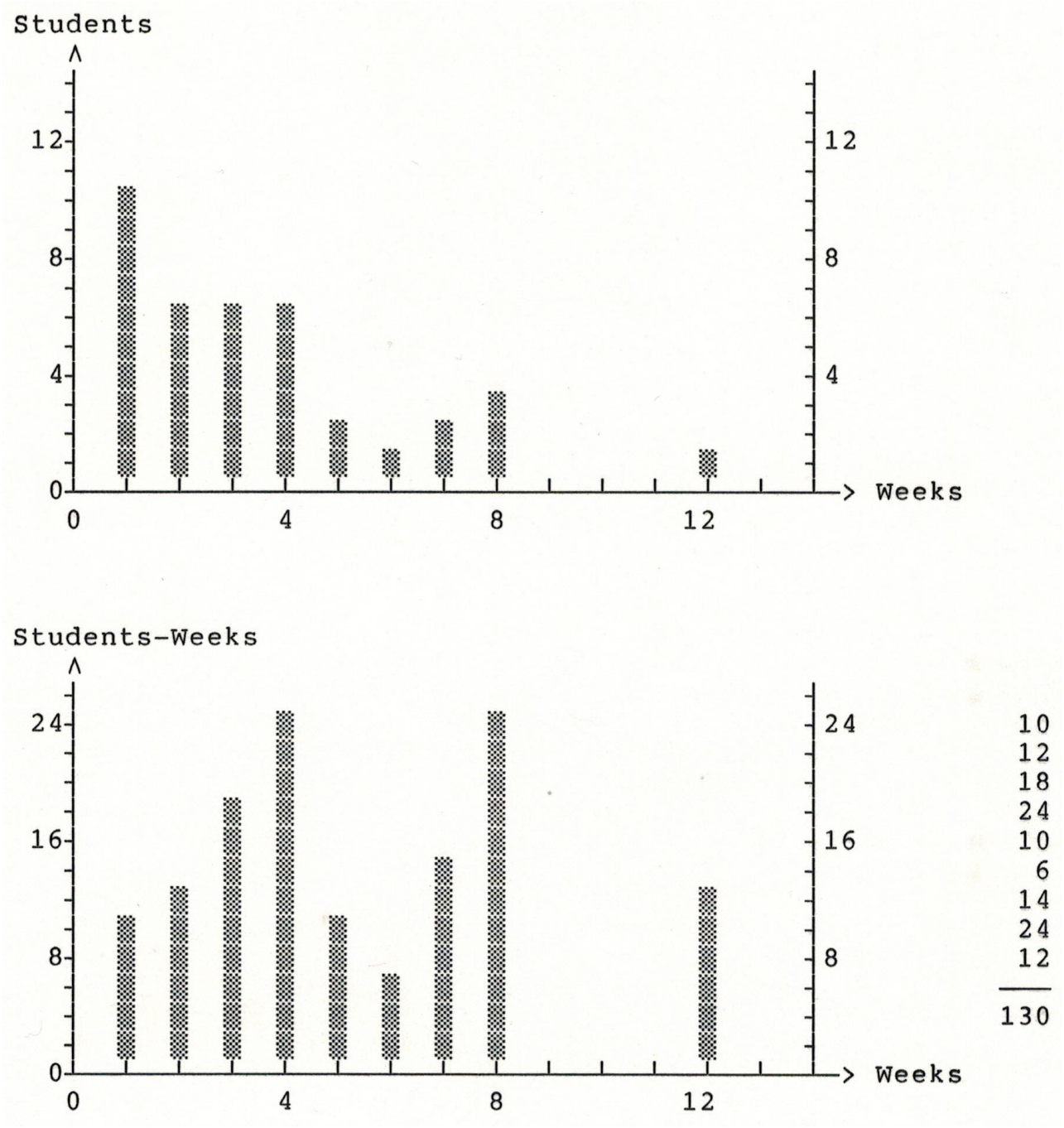
Equation 1 more precisely defines the composite series-selecting queue Q where n is the number of weeks a student has been eligible for a series, S_n is the number of students that have been eligible for n weeks, and Q is the sum of the products of S_n and n for each n. For the special case of n = 1, S_1 includes all students that have been eligible attend the series for less than a full week. S_2 includes all students that have been eligible for at least a week, but not more than two weeks. But S_2 students would be given twice as much weight as S_1 students.

$$Q = \sum_{N=1} S_n n \qquad (1)$$

A series is selected with some of the other series on Thursday nights by the controlling software for computerized scheduling the following week-ends whenever any one of the pre-set series-selecting quotas of the series is reached or exceeded by its corresponding series-selecting queue. After a series has been selected for scheduling, all five of its series-selecting queues would be reset to zero. But students who did not attend the series as scheduled would be reinstated without loss in the queues the following weeks. If a midterm or final series is selected for computerized scheduling, the segment-group class series preceding it would always be selected also and should be held a half-week ahead (see Figure 1). If a series is selected, and another series is vertically stacked with it, the other series would also be selected (see Figure 3).

A Fourth Type of Series-Selecting Queue

The system as described so far enables two segment-group class series in a course sequence, which are not horizontally stacked, to be selected by the controlling software for scheduling never less than one week apart. To enable the controlling software to select two segment-group class series in sequence for scheduling into two consecutive weeks, and the two series are not locked together into a horizontal stack, a fourth criterion for selecting series is needed.



The composite series-selecting queue is calculated to be 130 student-weeks. Since this is above the pre-set series-selecting quota of 100 student-weeks, the controlling software will select the series for scheduling unless an instructor monitoring the segmented course postpones it.

Figure 5. Composite Series-Selecting Queue Calculation Example

This fourth criterion for selecting series would be a pseudo series-selecting queue (with quota) based on the number of students who have passed a segment test for a segment that is a prerequisite of the series, and the number of students assumed to be presently attending the previous series in the course sequence. Two series in sequence should not be confused with a horizontal stack of two or more series (see Figure 3).

When a student has been progressing through a segmented course at least twice as fast as the average rate, measured over half the length of a course (including the latter part of a preceding prerequisite course), then he/she would be given twice as much weight in the series-selecting queues. Students could have their queue weights doubled automatically by the controlling software when it periodically checks their progress. Students could also have their queue weights doubled for a course when the course monitor has granted their petition and has entered pertinent data, such as the expected course completion date, into their record.

At the beginning of a course, a student could inadvertently attend too many televised series. The student could then increase, with the permission of the course monitor, his/her series-selecting weights for the remaining series in the course.

When a student passes many segment tests in a short period of time, it should be possible to re-arrange series-selecting criteria and prerequisites so he/she can stack series in one- or two-week increments.

Segmented courses are apportioned by series containing examinations. Early in each portion, an "emphasized" or "mandatory" local series could be selected when enough students are eligible. These types of series can be stacked, and would be superimposed on the regular series structure. Series with examinations would not be held back. That would help alleviate the conflict between local and televised series.

Weekly Progress Reports

After the series-selecting queues have been calculated, the controlling software would prepare a weekly progress report for each segmented course. On Friday, the course monitor would display the current report on a terminal. Temporary adjustments of series-selecting quotas could then be made. With such a report on the current status of the students and the series, the monitor could supplement computerized series-selection with human judgment.

When selecting a series for computerized scheduling the following weekend, the monitor would temporarily reduce one of the series-selecting quotas below its present queue. To postpone a series, the monitor would either temporarily increase all series-selecting quotas for the series, or directly select the series for scheduling.

The monitor could also suggest future dates for holding series so that students could pace their studies accordingly. Current weekly progress reports would always be available to students to facilitate their course-work planning.

While all series would be selected by the controlling software for scheduling on the basis of pre-set series-selecting quotas, course monitors would have the privilege of overriding the controlling software on the basis of weekly progress reports, personal requests from students and lecturers, or other considerations such as holidays.

Example of a Segmented Course Weekly Progress Report

If the first segment has been closed by the pacing procedure, include the number of students who have registered their intent to attend the course with their academic advisor's consent.

The students who have passed the segment test for each segment or are studying the first segment in the course should be included.

Example:

Segment Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of Students	3	8	0	4	5	8	3	1	9	2	6	10	8	5	5	21

The students that are eligible for each segmented-group class series should be included. They would be all the students that have passed a segment test for a particular segment, usually the next-to-last segment in a group, and those students who did not attend the series when it was last held.

Each series would have its own eligibility table.

Example:

Series Eligibility Table

One week	Number of students who have been eligible for the series for no more than one week.
Two weeks	Number of students who have been eligible for the series for no more than two weeks.

And so forth....

The weekly progress report would include the numbers of students eligible for the midterm and final series. These numbers would include students that did not attend the series when they were last held. Also included would be eligibility tables similar to the segmented-group class series tables except that eligibility requirements would be more elaborate for the midterm and final series.

Example:

Segment Group 1*	Segment Group 2	Midterm Series*	Other Segmented Groups	Final Series
1 – 3	1 – 6	1 – 42		1 – 37
2 – 6	2 – 4	2 – 19		2 – 23
3 – 3	3 – 5	3 – 8		3 – 14
5 – 2	10 – 1	4 – 21		
6 – 4		5 – 13		
		6 – 5		
		12 – 2		

* One of the series-selecting queues exceeds its corresponding quota.

The first number in the pairs shown above is the number of weeks the students have been eligible for the series. The second number indicates the number of students that have been eligible that number of weeks. Unless it is overridden by a course monitor, the controlling software would include the series in the list of series to be scheduled.

The weekly progress report would include the current total series-selecting queues and quotas for each series in the segmented course. Queues and quotas would also be displayed for each school in the network.

Student predictions, if any, of estimated time of segment completions.

Student preferences for course completion dates.

Student preferences for series to be emphasized when series are selected, or not selected, for scheduling. To minimize abuse, the student's reason will be included in the report. The course monitor can either accept or deny the request. Typical reasons would be upcoming medical treatments and vacations.

The status of the system, such as network news and equipment availability, would also be reported.

SERIES SCHEDULING

While suggestions and guidelines for scheduling series are offered below, the specific series scheduling policies and procedures in each school district or university would depend on the circumstances.

Series Scheduling Schedule

Figure 6 shows a schedule for selecting, scheduling, and publicizing segmented course series, collecting series attendance reports, the normal weekday for each class of each type of series, and an examination schedule. The schedule is initialized every week. It begins in the first week with recording of lists of students not attending the first session of the each series that had been previously scheduled. These lists would also include the names of students that had attended and become eligible to attend by passing a segment test after the schedule had been published. These lists would be considered when the series-selecting queues are calculated.

Generation of Weekly Progress Reports

On Thursday nights, the students on the series non-attendance lists, and the students included in the queues of series that had not been scheduled the week before, would each have the number of weeks he/she had been eligible for a series incremented by a unit. Segmented course series that had not been scheduled the week before would have the number of weeks elapsed since the last time they were scheduled incremented by a unit. New series-selecting queues would be calculated. New weekly progress reports for the courses would be generated and made available. The course monitors would interact with the controlling software, on the basis of these reports, on Fridays.

Final Selection of Series for Scheduling

On Friday nights the final calculation of series-selecting queues would be made. All of the queues with their corresponding quotas for all series in all courses would then be compared. All of the series which have a queue reaching or exceeding its quota would be selected for scheduling. During the remainder of the weekend, the controlling software would be very busy scheduling series, facilities, students, reserved class periods, lecturers and examinations. In fact, working out the schedule for a very large school district might require such vast processing capability that only the most capable machines available would be able to do the job with acceptable timelessness, economy, and reliability.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
First Week	First Sessions of Previously Scheduled Series Generate Lists of Non-Attending Scheduled Students and Lists of Eligible Attending Unscheduled Students			Compute Queues; Prepare Reports	Course Monitors Review Reports; Select Some Series	Final Selection of Series; Schedules of Classes and Examinations
Second Week	Class and Examination Schedules Distributed and/or Displayed on Terminals		First Class of 3-Class Segment Group Series	First Class of 2-Class Segment Group Series	Second Class of 3-Class Segment Group Series	
Third Week	Second Class of 2-Class Segment Group Series	Third Class of 3-Class Segment Group Series				
	First Lecture of Final Series	First Lecture of Midterm Series	Second Lecture of Final Series	Second Lecture/Exam of Midterm Series	Third Lecture/Exam of Final Series	

Figure 6. Schedule of Classes and Examinations

Scheduling

The controlling software would use the list of students eligible for each series and schedule them into reserved class periods. Class periods would probably not need to be reserved for the student body of an entire school, or even an entire department. Facilities would be allocated from a list of available laboratories, classrooms, and lecture auditoriums to each series. Instructors would also be assigned to each series.

Faculty Scheduling

To provide a reasonable schedule for instructors, the following information for each instructor would be recorded:

- All of the series that each instructor is qualified to teach.
- Series preferences and priorities.
- The hours during the week when the instructor is available for scheduling. This could be updated by the instructor from a terminal to reflect personal business variances.

Since instructors probably would be expected to be present for a minimum number of class periods during a quarter or semester, reductions of class periods committed to teaching during one week could be followed by an increase in subsequent weeks. Instructors could thus reap the benefits of a variable teaching load.

Schedule Publishing

The optimum time to publish series schedules is Monday morning following a weekend of series scheduling. The controlling software will know where students and faculty are located on Monday morning from the previous week's schedule. Schedules can be published to the first student or instructor location on Monday. The controlling software would retain the lists from the current schedule for use the following Monday.

Series Attendance Lists

The controlling software would print out, for each instructor scheduled to teach, a list of students scheduled to attend the class. Exceptions to the list, such as students attending who became eligible after the list was compiled as well as absentees, would be recorded on the local terminal.

It should be noted that this last seemingly trivial procedure is one of the more important features of the system. For the benefit of students who may have been eligible for a series a relatively lengthy period, the procedure prompts the controlling software to select series for scheduling sooner than it would if allowed to default. Again it should be kept in mind that the student should always be busy. A longer-than-average delay for a given series would usually be traded for a shorter-than-average delay associated with the following series in the course sequence. By allowing time for subject matter to be absorbed, students should be able to benefit from such delays.

Reserved Class Periods

Figure 6 shows the weekday on which each session of each series would normally be scheduled. Two-hour final examinations could be given on the last day of any series (providing two are vertically stacked).

However, the final series should be given priority. Then the last segment group series in the segmented course can be scheduled the previous half-week to allow students who are almost done with the course to finish up. Midterm series for the same reason should also be given priority to midterm examinations. There would be more midterm series than final series. Midterm and final series would be given higher priority than segment-group series, but segment-group series could be scheduled into class periods reserved for midterm and final series whenever possible.

Postponement of Series and Examinations

Occasionally, the controlling software would encounter an irreconcilable scheduling conflict between two pre-selected series, and neither series can be scheduled as a week-long series of evening classes. The following series-postponement procedure, utilizing the current composite series-selecting queues and quotas, is recommended: The series with the greater ratio of the difference between its composite series-selecting queue and quota, to the quota, should be the one selected for scheduling. The other series would be selected for scheduling the following Friday night.

Conventional Course Scheduling

Whenever conventional courses are being scheduled for the following quarter or semester, each student would be interviewed to determine his plans for future course-work. He would then pre-register for both conventional and segmented courses under the direction of his academic advisor. With this data it would be possible to forecast the demand for segmented courses during the next quarter or semester. Scheduling conventional courses would be complicated by the necessity for reserving class periods for segmented course series. Computer simulation of future schedules for conventional courses could require several software-directed interviews with each student. Cost, space, teaching manpower, and other constraints would also be considered.

Segmented course series schedules would not need to be as highly optimized as conventional course schedules.

Series Switching

The controlling software can gain additional flexibility by being allowed to switch series. For example, a two-class segment-group series which is normally held on Thursday and the following Monday, could be inserted into a pair of periods reserved for midterm and final series.

Series Stacking

Using the four types of series, various combinations of series could be stacked for various purposes. For a half-day field trip, four or five two-class segment-group series could be vertically stacked in one schedule, with the other long session used for something else.

An intensive treatment of a topic could be accomplished by horizontally stacking two or more series over two or more schedules.

Series can be both vertically and horizontally stacked over two or more schedules. Students may have to verify that they can attend all the classes.

Remote Statusing of Critical Equipment

Before actually beginning the scheduling of the network, the controlling software should transmit signals to initiate self-tests of critical equipment, particularly cameras and computer-controlled audio and video routing switches. Based on their status responses, the software will allocate available channel connections and equipment when scheduling.

Adult Education

Once a network of schools is linked together, an impressive array of system resources make possible new variations in adult education. Packages containing CAI, video cassettes, DVDs, books, etc., can be made continuously available, along with instructors to answer questions. System resources can be made available outside of normal school hours. People in different locations can hold meetings over the video network. All this can be scheduled by the controlling software.

CRItical PAth sub-NETworks

CRItical PAth sub-NETworks (CRIPANETs) would have to be allowed for during series schedulings. They permit a greatly increased creativity in assembling curricula and segmented courses. CRIPANETs are defined and discussed in detail below.

Study Sessions

The last step in the scheduling process is to assign students who have not been assigned a conventional class or a series to attend. They could be assigned to leftover seats in a television studio classroom or assigned to empty seats in classrooms with instructors on hand to tutor and answer questions, or they could be assigned to computer classrooms. Computer classrooms normally would have the highest assignment priority.

Biasing Series Schedules Away from Video Towards Local Classes

At first glance, the school network seems to emphasize video telecasting. What may not be clear is that selecting and then scheduling series of classes is a dynamic phenomena where it is possible to bias the types of classes in one of several directions.

Based on experience, knowledge of the students and teachers, and school district policy, the teacher who is assigned to monitoring each segmented course will *try* to determine which school(s) will host a particular series of classes the following week, which series will be taught as a prerecorded lecture (presumably with superlearning music), taught as a laboratory or field session, and so forth.

The network dynamics will tend to emphasize video over local classes if the teachers and students allow the computerized selecting and scheduling procedures get away with it. The monitors and students will have to try to pace themselves so they can take advantage of local classes and student interest groups. There will always be students out sick, on vacation, transferring in or out of the city, falling behind, or getting ahead on their studies.

The segmented course monitors will have to strive for a balance between CAI, local classes with interesting discussions, telecasted lectures, independent study, and prerecorded superlearning video lessons. Choices also would have to be made between teaching a class accompanied by superlearning music, and conducting a discussion with give-and-take between the teacher and the students.

SEGMENTED COURSE PRODUCTION PROCEDURE

The following would be the steps necessary to producing a segmented course:

1. Select the course subject matter.

2. Assign an identification to the course.

3. Divide the subject matter into segments, segment-groups, and portions to be covered by the midterm and final series.

4. Assign identification numbers to the segments and series.

5. Lay out the course's series prerequisite graph.

6. Assign two instructors to monitor the course. One would function as back-up to the other. Individual series and laboratory instructors would be assigned as needed by the controlling software. Instructors would not be assigned to series they are not qualified to teach. Ideally, assigned instructors would best utilize their specialized fields of expertise.

7. Generate segment test questions for each segment. Use these questions in assembling segment tests. As each segment test is added to the repertory, it would be validated with the check-out procedure (see above) and its identification code, passing score and time-value recorded. The check-out procedure would store scores and answers the first few times the test is taken. It would also store any comments the student might enter after he/she has taken the test. The score would not be recorded; only the fact that the test was taken and passed would be recorded.

8. Assign a fractional credit load unit to each segment, taking care that the sum of the credit load units in the entire segmented course is an integer and equals the number of credits that the entire course is worth. For students unable to benefit from segment tests, assign a credit load unit to each segment-group.

9. Determine the five different series-selecting quotas for each series in the course.

10. The assigned course monitor would enter all the parameters and data on the segmented course, perhaps a segment-group at a time.

11. Write and distribute course guides.

Preparing CAI materials, when appropriate to the subject matter of the course, would require a much greater expenditure of time and money.

PACING GROUPS OF STUDENTS THROUGH UNPOPULAR COURSES

Whenever a segmented course's economics dictate pacing groups of students through the course, students would be aperiodically denied admission to the course.

Pacing Procedure

When a segmented course is opened after enough students have registered for it, all of the course's segment tests would be re-entered in the repertory of segment tests by a course monitor. The monitor may or may not enter the series-selecting quotas.

Every few weeks, the first segment in the segment-group following the last closed segment-group in the course (see Figure 2) would have its segment test removed from the repertory. This would be done at the discretion of the course monitor who would monitor the progress of the students being paced through the weekly progress reports.

Tentative dates, and possibly reserved class periods, would be set by the course monitor and .publicized. Two middle series could be tentatively scheduled two or three weeks apart two months after opening day. Likewise, two overview series could be tentatively scheduled three or four weeks apart three or four months after opening day. Such an arrangement would facilitate two different rates of progress for the students to ensure maximum understanding by learning at the optimum rate and to compensate for possible contingencies.

The student pacing procedure would be useful also when making a major revision of a course's subject matter.

CRITICAL PATH SUB-NETWORKS

The structure of the segmented course evolved from a study of network planning, e.g., PERT/TIME (Program Evaluation and Review Technique – a management method of controlling and analyzing an engineering or construction program using periodic time reports to determine labor status at any given time). Another project management aid is the Critical Path Method. Perhaps the Critical Path Method could also be modified for more versatile educational administration.

Suppose that a large university had converted to segmented courses in computer science, mathematics, biochemistry, engineering, neurophysiology, etc. Under conventional educational methods, students ordinarily choose courses to satisfy a major, take some elective courses, and receive their diploma after four years or so in college.

But there is also a need for graduates who are expert in several different fields. Unfortunately, the inflexible nature of the conventional college curriculum makes it almost impossible for one person to acquire, in a reasonable amount of time, such a broadly-based competence. If such a university were to modularize its courses by segmenting them and placing them under a computerized course management system, it would be possible to combine bits and pieces of segmented and conventional courses into curricula that could train such people in a reasonable amount of time.

The key to efficient administration of such curricula seems to lie in a modification of the Critical Path Method. A committee of outside consultants from government and industry, as well as professors from the various departments involved, could outline an interdisciplinary critical path curriculum. Such a curriculum would contain all and only such material considered absolutely necessary for a reasonable degree of competence in the several disciplines.

Another way of thinking about the segmented course is to consider it as if it were a standard linear sub-network of segments and series. Suppose a group of segmented courses, or standard sub-networks, is made available for use by students interested in following an interdisciplinary critical path curriculum. Since time is valuable, they should study only those parts of segmented courses that are likely to be helpful and relevant.

These segmented courses could be re-organized as CRItical PAth sub-NETworks (CRIPANETs). For example, if part of a CRIPANET should consist of a segment-group (including the corresponding segment-group series) offered as part of a segmented course, the critical path students could meet as a separate group during the series and take a one-hour final examination on the course's segment-group plus the remaining material in the CRIPANET. Other patterns in which a CRIPANET could be organized are as follows:

- A simple CRIPANET consisting of the first portion of a segmented course plus the midterm series.

- The first segment-group in a segmented course, a pair of special segments, a CRIPANET series of two lectures, and a final examination on the CRIPANET. The final examination would count 80% of the CRIPANET grade.

- An introductory special segment, a segment-group from a segmented course, another special segment, an oral segment test, and a CRIPANET series.

- A specially-written group of segments, a one-hour panel discussion by some of the critical path curriculum professors, and a CRIPANET series.

- Three weeks of lectures in a conventional course and a final examination.

The controlling software would publish periodic student progress reports. If part of a CRIPANET is also part of a scheduled segmented course, some coordination might be necessary in selecting series for scheduling and activating segment tests. CRIPANET series are computer-scheduled with the segmented course series, but they might be selected for scheduling by the CRIPANET monitor. The CRIPANET weekly progress report displays information as to how long the student has been eligible for CRIPANET series xxx-xxx-x-x (department number, CRIPANET bunch number, CRIPANET number and series number).

The administration of these CRIPANETs would be simplified if each critical path student would have his/her academic advisor approve most CRIPANETs in serial and/or parallel bunches of a half-dozen or so and enter them into the computer as such. A CRIPANET segment test would have a number (xxx-xxx-x-x-x) with no more than nine segments in a CRIPANET. The same segment test could also be used in segmented courses. Notice how convenient it would be to have both CRIPANET segment test numbers and segmented course segment test numbers represented by the same number of digits. A CRIPANET would rate no more than two credits, else it might as well be administered as a segmented course. In fact, it is likely that a CRIPANET would only rate a fraction of a credit. But a CRIPANET bunch would rate an integral number of credits. The controlling software would use a grade-averaging routine to obtain the final CRIPANET bunch grade. If a CRIPANET is rated at less than one credit, the last CRIPANET series would usually be a midterm series. If rated one credit or more, the last CRIPANET series would usually be a final series. This would help balance the demand on reserved class periods.

Critical path students would be subjected to credit load unit calculations and CRIPANET pacing schemes. In regard to minimum credit load requirements, the student should feel free to apply for temporary suspensions for research. Unique research opportunities could become available by rearranging critical path curricula to suit.

The first year or so of a critical path curriculum would consist of conventional and segmented courses only. At some point in this year, the student would qualify to continue on the critical path after attaining a reasonably-high grade point average, or demonstrating some original research result or invention. After qualifying, the remainder of the curriculum would include a high proportion of CRIPANETs. All critical path students would follow a coherent program leading to a special interdisciplinary degree.

A large university could probably economically support only a few interdisciplinary critical path curricula. But several universities could pool their resources and offer a greater variety.

SCHOOL NETWORKING

The segmented course system would require a relatively large school district or university to fully utilize a dynamic free-wheeling mode of operation, to avoid invoking the course pacing procedure detailed above, and to minimize cost. The term ‘free-wheeling’, to be more precise, has educational and economic constraints. The educational constraint is that of a student never having to wait more than about four weeks before his/her series is selected for scheduling. The economic constraint would be an absolute minimum number of students attending the series.

The minimum number of students for a segmented course would probably be in the low hundreds for year-round free-wheeling. While many schools could get by with occasional use of the pacing procedure, it would be much more desirable to have all courses open all the time. There will certainly always be sick or slow students falling behind a paced course, as well as gifted students racing ahead of the pack. An alternative to massive centralized schools is networking enough smaller, geographically-separate schools to the point where the system could ‘free-wheel’.

Suppose a student, and it would take only one, triggers the selection of a series by waiting the maximum number of weeks, and the number of students eligible for the series is below the minimum economic size. The controlling software could query students in the portion of the course just preceding the series in question to determine if enough could hurry up a little to create a pool so the series could be scheduled. Contacting these students would be accomplished by posting messages to them in the electronic bulletin board for the course on Friday mornings. The course monitor would check responses on Friday afternoons to determine the feasibility of selecting the series.

If too few students respond affirmatively, the controlling software could query the network. The administrative computers for other nodes in the network would be queried for the number of students eligible for the series. If enough students are eligible network-wide, they would be advised that the series would be scheduled, and would include them in a television series.

If there were still not enough eligible students network-wide, then a video tape or disk study session would be scheduled with a qualified instructor. Thus the system would regress gracefully to a still-acceptable level.

CLOSED-CIRCUIT TELEVISION NETWORKS

For illustrative purposes, assume a closed-circuit television network, or matrix, of sixteen schools, each containing eight television cameras. Each camera is mounted on a pan/tilt head and has a zoom lens, both remotely-controlled. Each classroom/studio would contain television monitors capable of displaying transmissions from other nodes of the network or monitoring locally-produced images.

Transmission between nodes of the network would be by either via the Internet, fiber-optic cables or microwave channels. Each school would have the capability of acting as a relay station between nodes. A network would consist of 128 video channels, 140 audio channels and twelve digital and facsimile data channels.

Electronic connections must be made between cameras, monitors, nodes, computers, etc. One node in the network would computer-control the 128-channel video routing switcher, the 140-channel audio routing switcher, and the twelve digital/facsimile channel switchers. Input to the switcher-controlling computer would be from the network scheduling computer. The switcher-controller would display the status of all network-related equipment - facilitating reallocation and repair of failed components.

In a television classroom, students could interact with the instructor in the studio/classroom originating the lesson. A priority microphone system, disabling all others in the classroom when one is activated, would enable a student to converse with the instructor without interference. All students in the classroom would be able to hear both question and answer.

Since combination computer monitor/video receivers are planned, students could also enter questions on their computer and send them to the teacher's computer monitor for display. During class, the teacher has the option of answering questions orally, or getting back to the student later.

Examinations and homework assignments could be transmitted by internal mail since all four types of series allow at least two days for mail delivery. If necessary, papers could be transmitted to addressees over facsimile channels. A clerk at each node would collect and distribute mail within the node.

SERIES-SELECTION AND SCHEDULING VS TV SCHEDULING

(In this chapter, the author is departing from the formal descriptive style for the simple reason that he doesn't have this completely figured out.)

This is the problem: As a television network increases in size, it becomes more difficult to schedule series because of the increased number of permutations and combinations. But, after a certain point, increasing the size of the network should make it easier to schedule series. A television network of giant size, covering the Los Angeles basin for example, would enable multiple scheduling of the same series every week. It thus becomes easier to find series for students to attend when working out their schedules. The problem then becomes one of accumulating enough students to justify selecting a local series.

The author found this so tricky that he decided to simply set forth a few points and let it go for the time being. It looks like an interesting problem for mathematicians to ponder.

First, a paradox, which the author shall call ‘Gary's paradox’. If schools are continually losing students to the television network because series are being formed so often that they can never accumulate enough students to form a local series, then how do the series get selected in the first place?

So far, four criteria for series-selecting queues (with quotas) have been described; the number of weeks, the number of students, the composite, and the pseudo. A fifth type would be based on economics. The problem is to determine when it would be economical to suspend the minimum number of students for the benefit of a few stragglers. One method would be to calculate the average size of the classes the previous half-year or so for the same series. In addition, the controlling software could try to predict the size of local classes for the next month or so based on class sizes earlier in the course. Even if the combined average is fairly high, it might be economical to select the series for the stragglers so they don't have to wait.

When a student has been progressing through a segmented course at least twice as fast as the average rate, measured over half the length of a course (including the latter part of a preceding prerequisite course), then he/she could be given twice as much weight in the series-selecting queues. Students could have their queue weights doubled automatically by the controlling software when it periodically checks their progress. Students could also have their queue weights doubled for a course when the course monitor has granted their petition and has entered pertinent data, such as the expected course completion date, into their record.

At the beginning of a course, a student could inadvertently attend too many televised series. The course monitor could then increase the student's series-selecting weight for the remaining series in the course. When a student passes many segment tests in a short period of time it should be possible to rearrange series-selecting criteria and prerequisites so he/she can stack series in one- or two-week increments.

The ‘Average Queue-Quota Ratio Percentage’ (AQQRP) is defined as follows: Divide the current quota of each type by its queue. After calculating the first four ratios (not including the economic type), sum the quotients, multiply the total by 100%, and find the average. When the controlling software is considering whether a student should take television or local series, add the AQQRP's for the current series and the previous series in the course prerequisite graph. If the two equal 75% or more of the average, the controlling software can assume the current series is going to be scheduled soon, and can select the student for the local series instead of the television series. If the current series has an AQQRP of 25%, and the previous series also has an AQQRP of 25%, it will likely be a while before the series will be held.

Unfortunately, this means that potential selections of series for scheduling will suffer a continual drain of stragglers and speedsters, besides the occasional attrition of students getting sick and going on vacation. And, of course, there is ‘Gary's paradox’ to worry about; so local series will be even less likely to be held, and we could end up with even more television series than we would like and had anticipated.

Student Interest Groups

A possible solution to the problem of too many television series might be for the students to form "student interest groups" who will try to remain a group for at least part of the course. In a sense, each student interest group would be defending itself against the attrition due to vacations, illness, and television series. If the members of the student interest group enjoy each other's company, they might be inclined to formalize their relationship to some degree and adopt a name, such as "Eagles", "Easy Street Sweepers", or "Parity Errors". The membership of the student interest group would probably be fluid. A Weekly Student Interest Group Report, accessible at any terminal at any time, might be necessary to keep track of them. These reports could contain the identification of the student interest group, the faculty advisor, the elected leader, a roster of members, a schedule of future series, social events, etc.

One important sociological consequence of replacing the conventional system with segmented courses is that students would not have any distinct group, such as grade-levels, to identify with, and, especially in the larger schools, would have increased difficulty in forming friendships since they would be part of a swirling mob with each student pursuing his/her own destiny. By forming a student interest group, students could try to cover more than one course together, and could adjust their work pace in courses not included in the student interest group list so slower members could keep up.

If a student didn't feel compatible with the student interest group he/she was in, he/she could speed-up or slow-down his/her pace to align himself/herself with a student interest group with which he/she felt more at ease. Student interest groups would be able to schedule themselves for short vacations, bus trips to ski slopes, beaches, or the mountains since they could take vacations whenever they wished. Members not so inclined would simply switch to another student interest group which would more nearly reflect their work ethic.

Forming student interest groups should be encouraged for economic reasons as well as the sociological benefit of the students. At the same time, we don't want to come full-circle and return to the disadvantages of the conventional system. A good time for a ceremonial party would be when all members of the student interest group have completed their degree requirements, and this could occur any time of the school year. This party, which could be scheduled in conjunction with others, should be an acceptable substitute for the conventional graduation ceremony. Instead of class reunions, there could be student interest group reunions.

Series containing competitive examinations, laboratory sessions, or other special requirements, would need the elaborate series-selecting procedures much more than segment-group series. Segment-group series requirements could often easily be satisfied with television series.

If the schools in a network have enrollments in a segmented course that are all about the same size, they will on the average all have an equal chance at holding live series. But if some of the schools have enrollments four or five times larger, for example, than the smaller schools, they will probably dominate the local classes. Then the smaller schools will then have to give greater emphasis to forming student interest groups than usual in order to hold local classes at least occasionally.

Once the television network is in place, schools could help pay for the equipment by selling time outside school hours. People might realize a saving of time and money by scheduling business or club meetings at a nearby school television facility.

In a really large school network, series could be multiple-scheduled each week. If a student were faced with a long wait for a scheduled local series after passing a segment test, he/she might choose to apply for scheduling in a television series. If a television series is available and has an opening, he/she would be scheduled. If no opening exists, he/she would be placed into the series queue.

HARDWARE

Figure 7 is a block diagram of the overall hardware configuration of the system. The upper third of the figure shows the major components of the master network control center. The lower two-thirds show the major components at each local school.

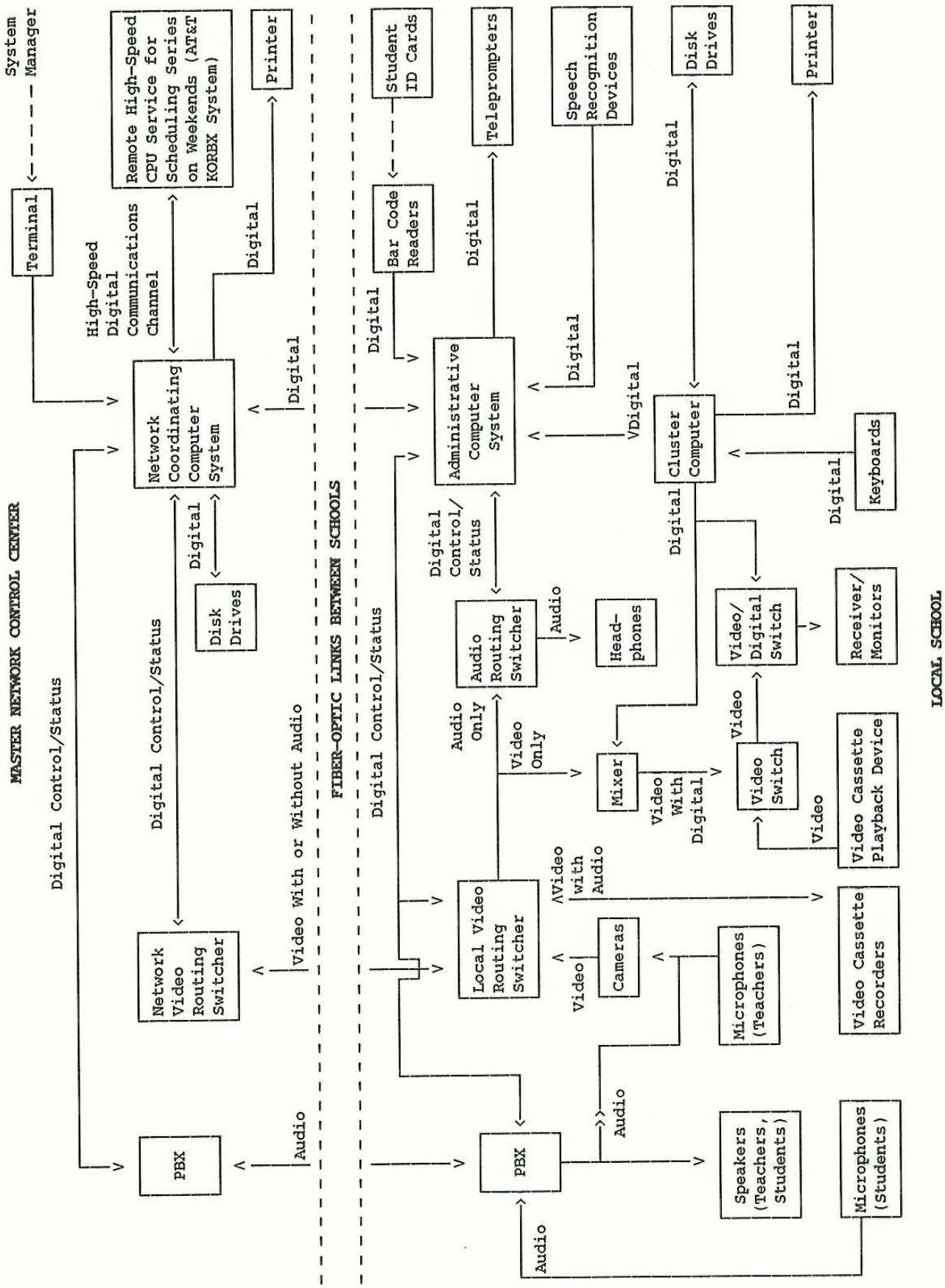


Figure 7. Overall System Hardware Configuration

Fiber-Optic Linkage Between Schools

High-performance video and digital technology at reasonable cost is now available for implementing the system in each school. The major limitation which remains is the communications link between schools. Local microwave networks provide only a few dozen channels at most. Two-way satellite teleconferencing would be prohibitively expensive. Coaxial cable can't easily use repeaters and doesn't reach far enough. The best choice appears to be single-mode fiber-optic cabling.

A report in IEEE Spectrum, March 1983, "Single-mode fibers out-perform multi-mode cables" by Donald B. Keck, claims that single-mode fibers can transmit video, high-fidelity audio, digital data and telephone calls at the rate of 1000 megahertz over a distance of 80 to 100 kilometers. These optical links do not require elaborate multiplexing schemes or repeater stations. They are immune to electromagnetic interference and are made from abundant and inexpensive silica.

The Grass Valley Group Company, a Tektronix subsidiary, markets a system of fiber-optic transmitters and receivers which can use up to five repeaters at up to 40 kilometers per link, or a total of 200 kilometers. (See 1988 National Association of Broadcasters show report below for newer, higher-performance products from Grass Valley.) Six video channels, each with two audio channels, can be multiplexed on a single fiber. AT&T markets a 1/2-inch cable with 144 fibers. This multiplies out to 864 video channels per cable.

Most school districts should have enough schools within 200 kilometers of a centrally-located hub containing the master network control center to constitute a full-sized network. Since the fiber-optic cables are non-conductive, they can be strung on existing power line poles and laid beneath the pavement when roads are rebuilt.

The Las Vegas Review-Journal reported March 24, 1988 that GTE Corp. has developed a tiny semiconductor laser that can switch on and off 22 billion times per second. It is "theoretically capable of sending 200 to 400 video signals over an optical fiber simultaneously".

Thus it is difficult to conceive of a full-scale school network saturating the prodigious video, audio, and information transmission capacity of a single fiber-optic cable.

Signal Switching and Addressing

The fiber-optic network links would carry video, audio, and digital data. To ensure that the video, audio, and digital data signals generated at each school arrive at their intended destinations, computer-controlled audio and video switching equipment would be installed at the most centrally-located school in the network.

Additional computer-controlled audio- and video-switching equipment would be installed at each school to distribute signals streaming in off the fiber-optic cable to the correctly-addressed terminals and other equipment. The switchers would also concentrate signals generated within each school for transmission over the fiber-optic network.

Master Network Control Center

The master network control center would be located at the most centrally-located school in a network. The site should be selected with some care. Schools could be added to or dropped from the network; but not the school where the control room is located. The following is a list of the principal functions anticipated for this facility:

- Provide or arrange for equipment repair. Technicians would be on-call by the schools in the network. A spare-parts depot would be maintained at the center. Keep in mind that the schools in such a network would be operating on a year-around basis, and system down-time would have to be held down to a very low level.

- Switch audio channels between the schools.

- Switch video channels between the schools.

- Switch digital channels between the schools.

- Switch audio, video, and digital channels within the school where the control room is located.

- For scheduling series, either link with an outside service center computer or house a local large-scale computer.

- Prepare, load, and validate segment tests.

- Train course monitors and instructors how to interact with the system.

- Select, prepare, and load course materials into the system. The instructors in the different schools would be encouraged to participate in this, but they would be governed by standards for each segmented course. The Local Options Chapter below does describe some provisions for exceptions to standardization, however, in local options.

- Allocate capital equipment, such as video cameras and laboratory equipment, and schedule transfers of shared equipment between schools.

- System software would provide the resident System Manager access to the entire network - including the computer-controlled switching equipment and the computerized class scheduling hardware and software.

Network Coordinating Computer

Each school would have a local computer-controlled audio-switcher (sometimes known as a Private Branch exchange (PBX)), a local computer-controlled video switcher, an administrative computer which is slaved to the network coordinating computer, a number of cluster computers slaved in turn to the administrative computer, and on-line terminals with combined computer monitor/video receivers and keyboards.

The computer-controlled audio- and video-switchers are special-purpose computers that function as multi-channel switches. Each switcher can select from among hundreds of video and audio channels. The crosspoints are opened and closed, as required, by inputs from the schedules created by the controlling software each weekend. The schedules could be stored in the switchers' own storage units. A real-time clock would step each switcher through its schedule. The status of the switchers could be reviewed and manually changed from on-line terminals when necessary.

To coordinate the thousands of terminals, computers, switchers, and other equipment which would be connected together into a full-scale school network, a network coordinating computer system would be located at the master network control center.

Computerized Class Scheduling

Technically, computerized class scheduling falls under a theoretical type of linear programming which is often illustrated by the problem of the Traveling Salesman. A traveling salesman has a number of different stops to make. Zeroing onto the shortest route that the salesman can travel, and still make all of his stops, without exhaustively testing for all of the possible combinations, has long been one of the most difficult problems in all computer science. Optimizing every week the schedule of a 50,000-student network has got to be a monstrous computation task.

In 1984, a young mathematician at AT&T Bell Laboratories, Narendra Karmarkar, revealed his invention of a new algorithm for dramatically speeding up the computer solution of this type of problem. As reported in the IEEE Spectrum, Dec. 1988, p. 16, Bell Labs has finally placed on the market Karmarkar's algorithm "… in the form of the AT&T KORBX System, a hardware and software combination that contains an optimizer, running under Unix, that controls four algorithms based on Karmarkar's algorithm. The parallel vector-computation hardware may be built by AT&T or other manufacturers, and the entire system costs $8 million to $9 million.

AT&T is already using KORBX internally to improve designs for its worldwide telecommunications network, allocating hundreds of thousands of variables, including decisions on circuit routing and capacity planning. KORBX is expected to attract large government and business customers, such as airlines, which must allocate equipment and personnel to match schedules of hundreds of flights a week."

Two possible arrangements are envisioned: The one shown in Figure 7 has the network coordinating computer transmitting all the data over a high-speed digital communications channel to a KORBX System installation somewhere in the country. The KORBX System works out the optimum schedule and transmits it back to the school network.

The other arrangement is to temporarily link the school network's hundreds of computers into a parallel processing array imitative of the ‘parallel vector-computation hardware’ mentioned in the article. It may then be feasible to pay only for leasing the KORBX software, and to partition the scheduling computations among the school network's own computers.

It is also possible that the network coordinating computer may have to be a parallel processor anyway rather than the more typical serial processor, and so therefore will be able to efficiently schedule equipment and classes with the KORBX System software.

Computer-Controlled Video Switching Systems

One or two types of video switchers may be required – depending on how the network is configured. A ‘network video switcher’ would be located in the master network control center. A ‘local video switcher’ would be located in each school. Switchers would be computer-controlled via an interface such as RS-232 or RS-422. They could also be overridden manually or from a terminal by the System Manager.

The network switcher would connect cameras in each school with some or all of the local video switchers in the other schools. Between classes, the network coordinating computer's controlling software would download a new set of crosspoint instructions to the network video switcher. Both network and local video switchers would probably be identical models but could have different sizes since they are modularly expandable. The network video switcher might do double-duty as the local video switcher for the school in which the master network control center is located.

Inputs to each local video switcher may come from the network video switcher, video cassette recorder/players, or cameras for local recording or distribution. Outputs of the local video switchers may go to monitors in the classrooms, video cassette recorders, or to the fiber-optic link for distribution to the network.

Computer-Controlled Audio Switching Systems

Video receiver classrooms (obsolete design?) could each contain several receivers. Each receiver might be in use for a different series at the same time. Each receiver would have optimum and sub-optimum seating areas. Each seat would have a headphone and a microphone. A wide-band (frequency-modulated) audio routing switcher would connect the headphone to the audio channel for the receiver the student is scheduled to watch during the recorded or televised series.

The controlling software would optimize the seating arrangements for each scheduled series. The audio configuration of each classroom would be loaded into the administrative computer. Between classes, the administrative computer would download a new set of crosspoint instructions to the network audio switcher. The audio switcher could be overridden manually or from a terminal.

The administrative computer could record instances of students being assigned to seats in sub-optimum viewing areas. Corrective action, such as providing additional receivers, might be taken.

A separate voice-grade Private Branch exchange (PBx) would be used to route vocal feedback from student to instructor. The PBX would be computer-controlled via an RS-232, RS-422, or some other interface. Each school would have a local PBX, and the master network control center would house the network PBX.

Student Audio Switchbox

An audio switch-box (not shown in Figure 7) at each student's terminal would be needed with the following functions:

- Connecting the student's microphone to a telephone circuit or audio channel to a teacher in another school.

- Disconnecting the student's headphones.

- Connecting headphones to the telephone circuit.
- Connecting headphones to the television channel.
- Connecting headphones to the audio output of a video cassette playback device.
- Connecting headphones to the music or speech synthesizer output channel of the terminal.
- Adjusting the volume of audio fed into the student's headphones.

Attendance Taking

For taking class attendance, each student will carry an IDentification (ID) card. When he or she enters the classroom, the student will run the ID card through a bar code reader mounted on the wall near each door. The school's administrative computer will read the student's ID code and then immediately enter it into its data base.

Each student runs his or her ID card through a bar code reader as he or she enters the classroom. Student's data is stored and also immediately forwarded to the teacher's TelePrompTer. As teacher waits for class to begin, the list of students attending class throughout the network lengthens.

Computer displays list of students scheduled to attend class on the teacher's console. As each student logs on, the computer asterisks or highlights student's name on list. Nonscheduled students also attending class are added to list and flagged. When teacher determines from the list that class is now seated, he or she starts class.

Teleprompters

When a teacher is teaching a class to the network (and local students, if any), the teacher should have easy visual access to a terminal or computer-controlled teleprompting device – possibly mounted on or near a camera. Figure 7 shows teleprompters linked to the administrative computer. At the beginning of a class, a list of students scheduled to attend the class will be displayed. As each student enters the classroom, or logs on at the other schools, the controlling software will indicate with an asterisk on the list that the student is now present. When all the students have entered the classroom or have logged on at the other schools, the teacher will know that it is time to begin teaching the class. If a student is out sick for the day, the list will so indicate.

Every time a student at another school asks a question, the controlling software will display a picture of the student and elementary data such as name, age, grade point average, and which segment in the course the student is currently studying. This way, the teacher should psychologically feel more at ease with remote teaching.

In one corner of each student's terminal screen, a picture and just the name of the student asking a question will also be shown. In order to identify the student attending the local class, the teacher will clearly say the student's name prior to answering the student's question. A speech recognition device will then be able to identify the student for the controlling software, which would then correctly select the picture of the student asking the question.

When the TelePrompTer flashes a message that a student has a question to ask, or when student has keyed a question which is displayed, a picture of the student is shown on the screen with such data as age, GPA, name, etc.

If a student orally asks question and identifies him or herself, a speech recognition device will ID student and again flash picture with student's data in large print. If teacher replies to student by calling out student by name, speech recognition device will again trigger flashing of student's picture and data in large print.

The teacher's console should also provide for selecting and switching on and off super learning music on the audio channel out to the actual class and over the network.

Receiver/Monitor

The student terminals would each include a combined video receiver/computer monitor. This type of monitor normally includes a video/digital switch (see Figure 7) with two inputs; one from a video source, and one from a digital source.

Mixer

A mixer at each receiver/monitor allows the controlling software to superimposed typed questions, messages, status information, etc. over the video display. (As of early January 1989, IBM doesn't make such a mixer. IBM's Las Vegas branch office suggested checking with third-party computer or even television equipment manufacturers.)

The KORBX System should find it easier scheduling a school network than conventional schools because the students would not always be attending class. So therefore the KORBX System would have more holes for additional flexibility. To further ease the scheduling logistics, some combined video/computer monitors may NOT be connected to a video/digital mixer; these monitors would not be connected to the video network. They would be connected only to the cluster computer and video cassette playback device. Assume that the KORBX System finds a video network overload, possibly due to a shortage of switcher channels, while scheduling the network. The KORBX System could then still off-load students to this type of terminal which would be located in overflow classrooms. Whether this scheme would actually help the KORBX System schedule classes and assign terminals would have to be verified by an operations research study.

Administrative Computer

Each school would have its own administrative computer. In addition to mundane chores, such as payroll and inventory control, this computer would perform many of the administrative procedures required by the system.

Cluster Computers

Cluster computers would be scattered in strategic locations around each school. A printer would be attached to each cluster computer to publish reports, etc. Disk drives would store the data required by the system.

Eight, sixteen, or thirty-two terminals in the form of combined video receiver/computer monitors would be connected to each cluster computer. These terminals, when on-line to the cluster computer, would enable students and teachers to interact with the computer network in a myriad of ways.

It appears that students would need access to both on-line terminals and off-line personal computers. The off-line computers, used for such functions as CAI, could go on-line with the cluster computers. When off-line, the computer storage would be floppy disks or memory cartridges. When on-line, the computer would function as a terminal with full access to all the facilities of the network. If off-line computers are too expensive or too cumbersome to use with the network, then the students will access the network strictly through on-line terminals.

A UNLV professor has observed that students tend to abuse personal computers with disk drives. He advised installing only on-line terminals.

SYSTEM SOFTWARE

A fairly large amount of specialized software with menus and internal system housekeeping routines would need to be written for supporting the system and course-specific equipment requirements, instructional material, segment tests, etc.

System Manager

The network's System Manager would be at the top of the hierarchy with a special menu which provides access to everything – including the KORBX System and the computer-controlled audio- and video-channel routing switchers.

Teachers

All teachers would start with a main menu. Each field in the main menu points to a sub-menu. Examples of sub-menus are schedules, network equipment status reports, course progress summaries, and formatting student status reports.

Segmented Course Monitors

Teachers who are trained to monitor courses would have access to certain more complicated sub-menus not available to the other teachers.

Students

The students would start with a completely different main menu. Each field in the main menu points to a sub-menu. Examples of sub-menus would be CAI, segment tests, student interest groups, their current class schedule, and their current course status report.

UNIX Operating System

The KORBX System runs under the UNIX operating system. UNIX reportedly has been extended to, or combined with, the MS-DOS operating system, which runs the vast majority of school software such as CAI lessons. However, UNIX is not universally accepted so it can not be safely assumed that UNIX is appropriate for school networks.

ADA

(The author wrote the following in the early 1980's. While the basic features ascribed to ADA are desirable regardless of language, ADA itself currently doesn't appear to be a viable candidate for computerized fiber-optic school networks.)

To encourage competition, as well as standardization, among software suppliers, a common programming language would be essential. Such a language, ADA, is now available. It is the standard language for the U.S. armed forces, and as such will be well-supported, and would ease what could otherwise be a major roadblock to the system's development.

James Fawcette's article in High Technology (February, 1983), "ADA Tackles Software Bottleneck", convincingly sets forth the case for using ADA in school networks. The following comments on this article highlight advantages for school networks:

- ADA is state-of-the-art. Mr. Fawcette quoted Jean Sammet, Software Development Manager for IBM's Federal Systems Division, saying that "No other language has all of the features of ADA. Many of ADA's features have appeared in the past (scattered among other languages, the author presumes), but they haven't been put together in the same effective way.".

- The standardization of ADA will be rigidly enforced by the Department of Defense; thus any program written in ADA would run on any computer for which an ADA compiler has been written.

- “The package concept may be ADA's most significant feature." Software could be modularized into standard building blocks. Each block could be written and individually tested before the entire program is assembled. An ADA program package for a control procedure or segmented course in one school could be utilized by all nodes on the network, or by other networks. Selling software to other networks could be one method of reducing out-of-pocket software costs.

- ADA is an easy-to-learn, high-level language. ADA programs are written using concise, English-like statements.

- ADA is easier to debug than other languages. Errors are restricted to the modules in which they occur. Problems in one module are less likely to affect the program as a whole. Reliability of the entire system is enhanced.

These additional advantages were gleaned from ADA – An Advanced Introduction, a book by Narain Gehani:

- The ADA program controlling the system can be partitioned with a high degree of efficiency. Sub-programs can be executed on different computers concurrently. When a program controlling part of the system on one computer needs to exchange data with another computer in the system, it can do so with ADA's input/output statements. For example, the video- and audio-switchers can synchronize their operations by comparing connections and crosspoints using these kinds of statements.

- Another interesting example is to allow a course monitor to determine how a student is performing in another node of the network. The monitor could send a request to the controlling software on the other node. The student could be queried for the information at his/her next log-on to the

system, or the answer could be extracted from his/her records and returned. The ADA language is admirably suited for this kind of data-swapping in a multi-computer environment.

- In addition to concurrent execution of parallel processes, the ADA program can be partitioned into ‘foreground’ and ‘background’ sub-programs. Much of the ADA program controlling the system should be invisible to the user. A student would be aware that, for example, when he/she successfully completes a segment test, that datum is entered into several controlling sub-programs. Obviously, he/she should not be able to see this kind of background manipulation. The system must be protected from mischievous or inadvertent pollution.

  In the same vein, a course monitor should be aware of only those programs that require his/her interaction. The only place the operation of an entire ADA program would be visible would be at the master network control center.

- Mr. Gehani implies (on page 280) that ADA can interact directly with hardware such as the video- and audio-switchers. However, he warns that using this particular facility is asking for trouble. Evidently, debugging this type of application is not easy.

- ADA is described as being able to interface with other languages; thus the ADA program could interface with existing CAI software. The ADA program can also interface with existing class scheduling algorithms.

- ADA enables concurrency in a multi-computer environment.

STUDENT PROGRESS REPORTS

Monthly, or when a student has received a grade, the controlling software would publish a progress report. This would replace the conventional report card issued at the end of a semester or quarter. It would list the segments for which segment tests have been satisfactorily completed. It would list the series attended, the examinations taken and the results. It would show the credit load the student has been averaging the past few months. It could include comments by his/her academic advisor and course monitors, and it would show the status of courses the student has qualified for but not yet started. To protect the student's privacy, access would be limited by log-in password procedures.

Students would be scheduled for counseling, during study sessions, every four weeks. Thus, a student needing special assistance or encouragement would receive it on a timely basis. If a student misses his/her counseling session, it would be repeatedly rescheduled until it was completed.

LOCAL OPTIONS

For political reasons, each school in a network should be allowed as many local options as possible without degrading the overall efficiency of the network. This would be even more true of colleges and universities, who are highly concerned with maintaining prestige and high academic standards.

<u>Local Credit Load Units for Network Courses</u>

A local school should be able to assign credit load units to network courses which differ from units assigned by the network.

Local Minimum Credit Loads

A local school should be able to establish minimum academic credit loads which differ from loads established by the network.

Partial Participation in the Network

A local school should be able to elect to join a network by only converting some but not all of its conventional courses to the segmented format. A local school straddling the boundary of two adjacent networks could elect to convert some of its conventional courses to the segmented format in one network, and other conventional courses to the format of the other network. A school entering an already-established network should be able to convert courses over a period of time.

A local school with partial conversion would pay a price, however, in loss of series-scheduling flexibility. Students could expect longer delays for series to be scheduled for them. Series scheduled by the network could sometimes fall during hours when students are attending local conventional courses.

Local Grading Options

Grades would normally be based on examinations and homework assigned by network instructors. A local school could supplement network grades with grades earned from local quizzes and homework. A local school could thereby retain a sense of individuality by awarding its own students local grades and still take full advantage of the network.

INPUT/OUTPUT FUNCTIONS PERFORMED BY STAFF MEMBERS

The following Input/Output (I/O) functions would be performed by staff members at a computer terminal:

Course Registration I/O Functions

Entering the identification of students who have registered their intent to study closed courses with their academic advisors.

Entering the identification of students who are eligible to begin a course after receiving permission from their academic advisors.

Adding to, or eliminating from, all lists and queues those students that have entered or withdrawn from the school. The number of weeks they have been eligible for each series would not include vacation time, except when they drop a segmented course.

Listing students for the monthly network-wide graduation ceremony.

Segment Test I/O Functions

Entering the identification of students who have passed non-computer-gradable segment tests.

Entering or changing the data stored in the repertory for a segment test, such as its identification number, the questions and answers, the number of questions a student must answer correctly, or any other criterion to make a student eligible for a segment test on the next segment.

Initiating two-phase segment test check-out routines.

Displaying information from the two-phase segment test check-out routines.

Replacing repertory segment tests with new ones.

Activating and deactivating segment tests for pacing students in groups through unpopular courses.

Authorizing students who have failed several segment tests, yet have somehow convinced the monitor that they have mastered the subject matter in the segment, to advance to the next segment.

Entering the number of different segment tests a student could fail on the same segment before he/she is flagged on the weekly progress report. The course monitor would thus be alerted to floundering students and could arrange for tutoring or other assistance. Arrangements could be made by exchanging electronic mail messages with other teachers with specialized knowledge of the subject.

Entering more than one type of segment test in a segment. This would compensate for students with wide ranges of ability.

Setting different passing scores for varying levels of ability among the students.

Assigning to each student a percentage of segment tests allowed to be passed.

Reviewing segment test pass/fail histories for each student in a broad category of segmented courses such as mathematics and history. when not enough failures, either adjust the percentage score up to a more difficult level, or assign a more difficult repertory of segment tests to the student. when too many failures, either adjust the percentage score down to a less difficult level, or assign a less difficult repertory of segment tests to the student.

Credit Load Unit I/O Functions

Entering or adjusting segment and segment-group credit load units.

Instructing the controlling software to adjust accumulated segment credit load units when a student has dropped a course. This involves subtracting the student's credits earned in the course from the total credits earned during the current credit load unit calculation period.

Setting the minimum rate-of-progress in each course. This would be in addition to the minimum rate-of-progress set in all the courses that each student is taking. Rates of progress are based on credit load units as described in above.

Granting a student's request for a suspension of the minimum rate of progress set in a particular course.

Segmented Course Structure I/O Functions

Entering or changing the identification number of a segment, segment test, segment-group class series, midterm series, final series, or the segmented course.

Entering or changing the prerequisites for the series in each segmented course. The actual sequence of segments and series should be described in the course study guides.

Some students may do much better with a teacher's verbal introduction to subject matter than reading a written introduction. For other students, it may be the reverse. For still other students, either way may not make much difference. Where possible, students should be given a choice between passing segment tests as prerequisites to series, or the other way around for segment-group series.

Entering allowable combinations of midterm and final examinations in the same series. These may or may not allow review periods in the same series. For example, a two-class series could combine midterm and final examinations in the second class and a review session in the first class. This would be practical for students taking courses in calculus and physics. It wouldn't hurt anything if the students couldn't understand a few questions on material they hadn't studied yet.

Entering more than one level of segments and series to compensate for students of wildly varying abilities and interests.

Entering prerequisites and other special parameters for CRIPANETs.

Structuring and entering parameters and constraints for one-time special courses which use network resources.

Allowing the KORBX System to merge the second class of a two-class segment group with the first lecture of a final series as part of a horizontal stack. Otherwise, these mergers should be discouraged to minimize confusion. (Such series can be scheduled during offset hours so as not to conflict with each other.)

Allowing the KORBX System to merge the third class of a three-class segment group with the first lecture of a midterm series as part of a horizontal stack. Otherwise, these mergers should be discouraged to minimize confusion. (Such series can be scheduled during offset hours so as not to conflict with each other.)

Series Selecting I/O Functions

Displaying weekly progress reports.

Making changes engendered by data contained in weekly progress reports.
Entering or adjusting series-selecting quotas by:

- Entering or adjusting the minimum number of students who have passed the segment test for a segment and have become eligible for a series before the controlling software would select it for scheduling.

- Entering or adjusting the maximum number of weeks that can be allowed to elapse before a series is selected for scheduling.

- Entering or adjusting the composite series-selecting quota which is expressed as the minimum number of student-weeks. This is another threshold which, if reached before the four other series-selecting queues, forces the controlling software to select the series for scheduling.

- Entering or adjusting the pseudo series-selecting quota which is the sum of the number of students who have passed a segment test for a segment that is a prerequisite of the series, and the number of students assumed to be presently attending the previous series in the course sequence. Two series in sequence should not be confused with a horizontal stack of two or more series (see Figure 3).

- Entering or adjusting the economic series-selecting quota which is the average size of local classes for the past half-year - combined with the average size of local classes predicted for the next month or so.

A series is selected for scheduling by the controlling software whenever any one of the five series-selecting quotas for the series is reached or exceeded by its series-selecting queue.

If a course monitor desired to postpone a series for at least a week after reviewing the weekly progress report, he/she could temporarily raise all of the series-selecting quotas to a higher level so the controlling software would not select it for scheduling the following week. The controlling software should provide for automatic restoration of the quotas to the previous levels after the schedule is published.

After reviewing a weekly progress report, the monitor could have the controlling software select a series for scheduling that would not otherwise be selected until sometime later with its current quotas. He/she would accomplish this by temporarily reducing the quotas to a point where the series would be selected immediately. The controlling software should provide for automatic restoration of the quotas to the previous levels after the schedule is published.

Entering the identification of students who inform their academic advisors that they plan to study the course at least twice as fast as the average and have been granted their petition to have their series-selecting queue weights doubled.

Entering segment-group performance data for prerequisite courses to be used in determining rates of progress. For the latter part of the course, the preceding segments would usually constitute an adequate base for rate-of-progress calculations. This rate of progress could be used to determine whether the student's queue weight should be doubled if the student is accomplishing course work at least twice as fast as the average. For earlier segment groups in the segmented course, segment groups in other prerequisite segmented courses should be filed for determining rates of progress.

Entering the identification for students who have missed scheduled examinations and the examinations missed. The controlling software can then place them in the selecting queues for the missed examinations. The controlling software would have to retain information so it can properly increment the number of weeks the student has waited for the series containing the missed examination. This procedure would • strongly influence the composite series-selecting queue and will cause the controlling software to select the series for scheduling sooner than normal.

To avoid scheduling series with classes falling on holidays, the monitor would initiate a search for all the series of one or two of the four types which would fall on the weekday of the holiday. When selecting series for scheduling, the series on the list generated as a result of the search would be eliminated.

<u>Series Scheduling I/O Functions</u>

Reviewing the individual series teaching assignment schedule.

Entering or adjusting the student-maximum in a segment-group class series before the class is split by the controlling software into two or more different rooms or reserved class periods, usually for laboratory sessions and field trips.

Entering or changing the instructor qualification list for segmented courses.

1. Reviewing and correcting the list of students scheduled and/or eligible to attend a segment-group class series or the first lecture in a midterm or final series, to be printed as an attendance list for the session.

2. Entering, by Thursday night, the identification of students who have attended a segment-group class series or a midterm or final series to establish eligibility for the following series in the prerequisite graph. If this step is not completed, the identification of students who have attended the series, but had not become eligible in time for scheduling the previous weekend, would have to be entered anyway.

3. Entering, by Thursday night, the identification of students who have failed to attend the first class or lecture of a series to be used as part of a new list of students eligible for the next scheduling of the same series.

Entering teacher scheduling changes, preferences, and class periods for which they cannot be available to teach.

Entering or adjusting the average queue-quota ratio percentage for each series (see above). This is a fixed percentage which helps the controlling software determine whether to save students for local classes or immediately schedule them into televised series.

For students about to transfer out of the school network into a conventional school district, set up special series sequences in the network which follow the conventional schedule.

Formatting the class attendance form for each series. The administrative computer in each school could have attached to an input channel a form reader capable of reading punch cards with special pencil marks. A more convenient class attendance input procedure may be to have students run ID cards through bar code readers.

Entering the identification of students who have attended the first class of a series but who have missed one or more classes (not examinations) in the series. After completion of the series schedule for the next half-month, the controlling software could use this list to fit the classes missed into the students' schedules.
Entering locations and sizes of classrooms where all non-local examinations are to be given.

Entering the circumstances under which students could be transported to another location for better utilization of facilities. Transportation required should be specified.

Coordinating make-up examinations between teachers in the network.

To aid in economics, examinations can sometimes be separated from series and given network-wide. Then in each school, a single teacher can proctor a group of students taking examinations in different courses and different types (midterm or final) in each segmented course. Examinations are otherwise included in series along with review sessions.

Receiving a laser printout of seating assignments for examinations. The controlling software also prints out the examinations in such a sequence that the proctor will be able to pass out the correct examination to the correct student.

Entering the distribution addresses of students and proctors. After the controlling software has scheduled television series, mailing lists would be compiled for tests and homework assignments for each teacher. Each television instructor would have a clerk who would mail out tests to proctors and homework assignments to students.

Entering the parameters for laboratory series. These parameters would include an inventory of equipment to be scheduled, such as test equipment. All laboratory spaces (the number of students that can be accommodated at each table, for example) must be identified. Capital equipment shared by more than one school would be identified for scheduling and shipping. Some series would be individual-oriented to allow hands-on experience with equipment. Group-oriented laboratory series would require entering both the minimum and maximum number of students to be accommodated.

Before a student leaves for a vacation, his/her academic advisor should be given the dates of departure and return. The advisor would then enter the student's identification and the two dates. The controlling software would then be able to schedule the student immediately after his/her return.

Student Interest Group I/O Functions

Entering the minimum class size of a student interest group.

Entering data on the student interest groups, such as the name of the group, the identification of the elected leader, announcements, and suggested schedules for upcoming series. These series could cover more than one course. A roster of members of the student interest group during the current week-and-a-half of series would be compiled, and a new list would be published every Wednesday. The list would be compiled from lists of students in series that the student interest group had been selected to attend the previous Friday.

Removing data on a student interest group which has graduated or disintegrated.

Matching student interest group sizes to the sizes of available local classrooms.

If a smaller school wants to hold a local series and doesn't have enough students, it could occasionally be ‘loaned’ a few students from nearby larger schools, even though the other larger schools may have enough students to hold their own local series.

Video I/O Functions

Identifying series that should be supplemented with a video cassette and supplying the library index number of the cassette.

Entering the preference for a televised series or video cassette session in case of difficulty in scheduling a local class, with the school library index number for the tape or disk. This could occur because too few students are eligible for scheduling for the series. When thus informed by the weekly progress report, some students could elect to speed-up or slow-down their work. Some could also find it convenient to take a vacation.

Entering the maximum number of students in televised series beyond which audio feedback from students to teacher is impractical.

Entering the seat numbers of optimum and sub-optimum viewing areas for each video receiver. Each classroom should have a number of receivers with overlapping viewing areas. The controlling software would need this information to optimize available video resources. Left-over seats could be assigned to students for study sessions.

Receiving training on interacting with the system.

Entering the types of media, and qualifying conditions, appropriate to each series. A series can be taught using local facilities, color video cassettes, gray-scale video cassettes, freeze-frame color video cassettes, freeze-frame gray-scale video cassettes, still slides with or without audio, overhead viewer, tutoring, electronic tablet with or without audio, compressed video, and films. Qualifying conditions could include the unavailability of a film projector or a qualified instructor. These conditions could change weekly. The order of priority for selecting the media types for each series should be specified.

Loading the physical location, type, identifying designation, computer I/O port number, audio switcher channel number, and video switcher channel number of each terminal.

Loading the physical location, type, identifying designation, switcher channel number of each camera.

Loading the physical location, type, identifying designation, switcher channel number of each video cassette recorder.

Loading the physical location, type, identifying designation, switcher channel number of each pair of headphones.

Loading the physical location, type, identifying designation, and PBX channel number of each microphone.

Loading the physical location, type, identifying designation, and PBX channel number of each loudspeaker.

Loading the physical location, type, identifying designation, and administrative computer I/O port number of each bar code reader.

Loading the physical location, type, identifying designation, and administrative computer I/O port number of each speech recognition device.

Loading the physical location, type, identifying designation, and administrative computer I/O port number of each teleprompter.

Loading the physical location, type, identifying designation, and administrative computer I/O port number of each computer-controlled video channel routing switcher.

Loading the physical location, type, identifying designation, and administrative computer I/O port number of each computer-controlled audio channel routing switcher.

Loading the physical location, type, identifying designation, and administrative computer I/O port number of each computer-controlled PBX.

Loading the physical location, type, identifying designation, and administrative computer I/O port number of each cluster computer.

Loading the physical location, type, identifying designation, and cluster computer I/O port number of each disk drive.

Loading the physical location, type, identifying designation, and cluster computer I/O port number of each printer.

Loading the physical location, type, identifying designation, and cluster computer I/O port number of each keyboard.

Loading the physical location, type, identifying designation, and cluster computer I/O port number of each receiver/monitor.

Reviewing the seating assignments for each class facility during each scheduled series. Optimum and sub-optimum seating areas might be displayed as shaded areas. The status of required equipment should also be displayed. Adjustments to seating arrangements and equipment could be made if required.

Formatting the video console or computer-controlled teleprompter display in studio classrooms. On demand, console would display names of schools connected to class, names of students in each school who are attending telecasted class, questions entered by students on their keyboards, indications of questions waiting to be asked by students on audio link, time left in class, teleprompting option, indication that the telecast is being recorded, video mode such as gray-scale or color, type and number of series that had been scheduled so teacher doesn't inadvertently mix them up, etc.

Format status line for each type of series sent by studio classroom to student monitors. At the bottom of the video screen, display the name of the class such as segment group series sequence number, time remaining in class, name of teacher, name of the school where telecast is originating from, and so forth.

Before the computer system displays a message on a student terminal, it needs to be able to status the terminal to determine whether the monitor (screen) is connected to the terminal's video channel or computer channel.

Student I/O Function Access Disablement

Disabling access to more complicated student-type I/O functions by immature students.

Enabling access to more complicated student-type I/O functions by students who have gained maturity.

Assigning students to help other less mature students interact with the system by enabling access to their disabled functions.

Student Status Report I/O Functions

Formatting the student status report for each course. Such a report would include:

Minimum rate of progress.

Series prerequisite graph.

Descriptions of laboratory equipment with procurement instructions and availability status.

Digital, video, and audio network interactions.

Series-selecting quotas with current queues.

A student progress and history record for the course, such as dates, teachers, and attendance records of series that have been attended, series currently scheduled, dates of segments for which segment tests have been passed, and status of examinations.

Lessons prerecorded on video cassette with dates viewed by each student.

Lessons available as CAI with dates viewed by each student.

Names and availability status of instructors, both local and network, who can answer academic questions on the course subject matter.

The names of the course monitors.

Information on participation in the student interest groups that have been established.

Electronic mail messages from the course monitor, instructors, other students, and student interest group leaders.

Availability of student terminals, computers, and video receivers.

Date of last print-out of student progress report.

Indication if student is being given double-weight in series-selection calculations.

Date of the last academic advisor counseling session.

Segment test passing score percentages.

Number of weeks of academic inactivity by the student.

The segmented course monitors may block immature students from access to the more complicated types of I/O functions. Teachers, classroom aides, and more mature students will be listed which have been enabled access to these functions by the course monitor.

The student status report should include scheduling work experiences and recording past work experiences.

Touch-Screen CRT Display I/O Functions

Formatting touch-screen CRT display-system interfaces for students who are too immature or handicapped to effectively use standard keyboards.

Administration I/O Functions

Formatting weekly teacher supervision reports for supervising principal. These reports, on each teacher, would include:

- Number of hours each type of series was taught.
- Number of hours proctoring examination rooms.
- Number of hours preparing and grading examinations.
- Number of hours counseling students.
- Number of hours administering non-computer-gradable segment tests.
- Number of hours tutoring.
- Number of hours at terminals monitoring network-wide segmented courses.
- Number of hours proctoring computer classrooms.

INPUT/OUTPUT FUNCTIONS PERFORMED BY STUDENTS

The following functions would be performed by students on a terminal. Immature students would be blocked from access to the more complicated student I/O functions unless they are being assisted by a teacher, a teacher's assistant, or a more mature student.

Language Choice I/O Function

By default, English will be the language of an American school network. Students may choose other languages, if available, either by necessity or for practice.

CAI I/O Functions

Receiving training on how the system works and how to interact with the computer and other equipment.

CAI, if available and needed.

Entering dates when CAI lessons were taken.

Information retrieval and library access.

Problem-solving.

Simulation of dynamic phenomena, such as the theory of games, blood circulation, wave interference, and the Brownian movement.

Reviewing electronic mail messages from course monitors. For example, a student in need of special assistance might be directed to a tutor or special CAI software.

Segment Test I/O Functions

Segment testing and scoring.

Scheduling I/O Functions

Receiving details of individual series schedules.

Reviewing current weekly progress reports.

Course-work planning and course pre-registration.

Learning how soon a vacancy might exist for attending a local series for which the student is almost eligible.

Requesting special assistance. After a series has been scheduled, students would not normally have their school hours completely filled with classes, laboratories, etc. The controlling program would then randomly assign them to empty classrooms. If a student desired some tutoring or wanted to discuss some aspect of a subject, he/she could enter a message into the computer bulletin board requesting assistance. If an instructor is available with the necessary qualifications, the controlling software would assign them to the same room. A high-school science teacher, for example, could be with several students answering questions on Botany Segment 6, Geology Segments 1, 8, and 11, and Physics Segment 2 during the same study period.

Reviewing access schedules for computer/video terminals and laboratory equipment. Each laboratory bench position should have a timer connected to the computer network. The access schedule would indicate occupied bench positions.

Reviewing a current student status report. These could be requested at any time. The report would include lists of segment tests he/she has passed, lists of segment-group series he/she has attended, the prerequisiste graph for each course in which he/she is enrolled, and prospective future schedulings.

Requesting priority in scheduling a series for which the student is, or is about to become, eligible and which he/she would prefer to be emphasized. To minimize abuse, the reason could be displayed in the weekly progress report. The course monitor would then either accept or deny the request.

Requesting admittance to extra-curricular activities, such as volley ball, snow-shoeing, shot-put, lacross, tennis lessons, or the chess club. The controlling software would examine conditions required for each activity, such as age limits, number of teammates required, weather, skill level of the student, and availability of equipment and facilities. After academic schedules are published, the extra-curricular schedules would be arranged. Student interest groups would in particular be encouraged to attend extra-curricular activities together.

Requesting the answer to a question in his/her segment. The schedules for all students instructors, and facilities would be on file and the controlling software could match the student, a qualified instructor, and an available facility and schedule them for a conference.

Reviewing an electronic mail message that an examination the student has taken has been graded and the location of the examination paper.

Student Interest Group I/O Functions

Reviewing the current status report on a student interest group after entering the identification of the student interest group.

Reviewing list of terminal and/or cubicle locations of students scheduled for same segment series.

Video I/O Functions

Requesting permission to attend a television series for which he/she has not been scheduled, but for which he/she is eligible, during open periods in his/her schedule. It would be desirable to impose restraints on this so as to encourage attendance at local series.

Requesting a condensed version of the video recordings of the series. Students readily absorbing the subject matter in a segment-group might not need the usual lengthy explanations of the typical video recording. If a video cassette player is not available to the student, this request would be stored by the controlling software until the following weekend, when it would show up as a closed crosspoint in the computer-controlled video switcher.

Entering dates when prerecorded lessons on video cassettes are viewed.

Turning off or on status line sent by studio during telecasted classes. Status line would display name, number and type of series, name of teacher, and time remaining in class.

When a student has a question to ask teacher, he/she either enters the question on the keyboard or voices the question into the terminal's speech recognition device. The question is displayed on the screen, and if the question was properly spelled out, the student OK's the question on the keyboard and it is forwarded to the teacher to be displayed on his/her video console or teleprompting screen. If not, the student types in the necessary corrections. The speech recognition device could be the artificial intelligence type which learns how to understand the student as they interact over time. At the video console or teleprompting screen, several questions may be displayed at one time. When it is appropriate or convenient, the teacher has the option of having the question rebroadcast with a simple keyed command to all the monitors connected to the class and displayed above the status line, or repeated orally to the audience. The question remains on each screen until removed by the teacher or replaced by a new question.

Credit Load Unit I/O Functions

Reviewing his/her current credit load. The first time each week that a student logs-on to a terminal, the controlling software would calculate his/her current credit load. If he/she is approaching the minimum load, a warning will be issued.

Entering or changing personally predicted rates of progress, and desired course completion dates.

Reviewing his/her rate-of-progress report. This could be requested at any time. The rates of progress for each course would be displayed and if a single course had, for example, one-fifth of the rate of progress for the previous month, a warning would be issued. More emphasis on that course over other courses would be recommended.

Electronic Bulletin Board I/O Functions

Sending messages to other students and instructors, either within the school or over the network, using the bulletin board facility.

Entering or reviewing classified ads.

DOCUMENTATION REQUIREMENTS

System documentation requirements would include a brochure for describing the system to parents in simple terms.

Study guides for each segmented course would include details such as course structure, objectives, series quotas, television series versus video tape or disk preferences for some of the series, laboratory details, text and special requirements.

Concise student and teacher guides to terminal interaction would be necessary, along with "help" screens on the terminals themselves.

Internal maintenance and external reference specifications would have to be written for the system software.

Hardware manuals would have to be provided.

CONVERSION FROM CONVENTIONAL SYSTEM TO SCHOOL NETWORKS

Converting and connecting a school to a network represents a drastic albeit clean break with the conventional system. Fortunately, the sequence of steps required for such a conversion seems to be surprisingly painless and should go smoothly.

For a school system with summer schedules and classes starting in September:

Most of the equipment should be delivered by the end of May. The fiber-optic cables and interfaces should be in place by that time.

The computer should be operational with some terminals installed so that system parameters, such as classroom sizes, could be loaded into the disk files. Computer models of the courses could be run as part of the computer sub-system check-out.

Installation of at least most of the computer terminals, cameras, switchers, and associated equipment should be completed by the end of June. The teachers would return from vacation when the equipment is ready and receive initial training on the system.

The system should be ready for student registration by early August.

Now here is the neat trick: The segmented courses start off as ordinary conventional courses. In fact, for the first week or so, except for registering the students, the students and teachers carry on with the courses in the conventional manner. Not much attention is paid to all the fancy new equipment. Technically, the courses are single-paced, segmented courses with one long horizontal stack of series as described above.

Whenever a student finishes a homework assignment, even if it is just a blank sheet of paper, as far as the computer system is concerned, it is a non-computer-gradable segment test with a zero passing score. In other words, the conventional course doesn't have any quality control – except for the crudely inefficient procedure of flunking out and starting over a course the following semester. The teacher enters the student's name and segment completion date into the computer system.

The controlling software in the cluster computer accepts this datum and passes it on to the system administrative computer which enters it into several software routines. The series selecting queues are updated, the credit load units are updated, etc. Weekly segmented course progress reports are prepared and published.

Student progress reports are continually updated and published monthly. ‘Series’ of classes are selected for scheduling, and series are scheduled (even though they are already scheduled).

As the teachers in the various schools in the network familiarize themselves with the system, they record lectures on DVDs or online, prepare and load segment tests into the computers, and allocate series into the various parts of the segmented courses. They debate the structure of the actual segmented form of each course, and agonize over how much they should talk.

It is almost eerie, all this book-work taking place inside the computers. One by one, each of the conventional courses in each school of the network is silently converted to the segmented form. Software and courseware is tested and debugged. In the meantime, business goes on as usual. Each conventional course is temporarily divided up, artificially, into a sequence of series. Technically, the courses are temporarily also each one long horizontal stack of series.

Cameras, microphones, switchers and computers continue to be cabled. Setting up a complete network could take more than a year. Finally, all is ready. The computers are running. The students and teachers are already receiving their reports. Student interest groups are beginning to coalesce in each school and exchange messages on the local electronic bulletin board. But they are still following the locked-step pace of the conventional system.

The system switchover can happen in the middle or even near the end of a course. A teacher monitoring the course logs on at a terminal and slips in the computer-graded segment test repertories. The students start following the segmented course study guides. They already have received computer training in parallel to their course-work.

The teacher monitoring the segmented course begins to inch up the passing scores on the segment tests. Students start falling behind when they fail segment tests and have to go back and study segments some more in order to pass segment tests. Students attend lessons pre-recorded on DVDs at their convenience. The more gifted students accelerate – freed at last from the shackles of the conventional system. The students drift apart. Many of them band together to form student interest groups.

One by one, each segmented course is turned on by its monitoring teacher simultaneously in each of the schools in the network. As the students drift apart, the computer-controlled video switchers and audio switchers start running, smoothly connecting and disconnecting crosspoints. The long-dormant cameras begin transmitting the friendly faces of teachers to the other schools.

The foregoing seems to be a reasonable scenario. It is do-able. It completely allows for planning mistakes, delays in delivering hardware and developing software, and so forth without interfering in any way with the on-going education of the students. It represents a gradual, smooth transition from the old to the new which is educationally, logistically, and politically essential.

ECONOMICS

An instructional technology professor at San Jose State University once offered an astute observation regarding the economics of school networks. He thinks the school networks can be sold to the public if their cost can be brought down to the equivalent of one large home appliance per student. The annual budget of the Clark County School District is about $3500 per student. So a reasonable initial capital investment goal for a network might be $1000 per student. An equipment life of ten years works out to about $100 per student per year plus interest and maintenance expenses.

Around Christmas 1985, the author established a beginning towards calculating the cost of a network. This was a fundamentally important milestone, not because of the dollar amounts involved, but to illustrate that the network design had solidified enough to demonstrate how some of the costs can be computed. Guessing with the numbers as conservatively as possible, the cost of a 50,000-student network totaled $100,000,000.

It should be safe to assume that the cost/performance ratios of the various kinds of equipment required by a network will improve with time. The capital cost per student may have already dropped down to $1000.

(The following discussion, written approximately 1989, concerns obsolete equipment. However, some of the equipment configuration issues may remain the same. Today’s Internet, cameras, computers, etc are of course much more cost-effective. Future torsion field communications capabilities would likely enhance the economics of school networks.)

Fiber-Optic Cables and Interfaces

AT&T markets a half-inch cable carrying 144 optical fibers. Grass Valley Group's WAVELINK multiplexes 6 video and 12 audio channels through up to 40 kilometers of optical fiber. Digital can be substituted for some of the audio channels so that the computers in each school can also talk to each other. As many as 5 repeaters can be installed which gives a comfortable 200-kilometer range. Note that WAVELINK equipment and the cost figures are about five years old. Deducting 4 spares from 144 fibers, WAVELINK provides 840 video channels.

Picking the number 30 out of the range of 5 to 50 schools per network, and allowing 25 video classrooms per school, 750 video channels are required. Allocating two video studios per school for teachers who don't have any local students for a particular series of classes, another 60 video channels are required. The resulting total of 810 channels leaves 30 channels for spares and video-text.

A Model 3290-20P is a 1300-nanometer 2-rack-unit laser transmitter which listed at $19,390. This is good for 3 to 40 kilometers. Up to five repeaters can extend the range to about 200 kilometers. A Model 3291-

1RSP 1300-nanometer single-mode laser repeater listed at $13,500. A 3291-202 1300-nanometer APD Receiver Module listed at $2500.

For up to 3 kilometers, the cheaper Model 3291-201 830-nanometer Light-Emitting Diode (LED) Transmitter Module listed at $1400. However, CCSD schools most likely are far enough apart to require the laser transmitters. So each long-distance video channel would require, as a rough estimate, $24,000 divided by 6 or $3000 for a laser transmitter/receiver pair. For 800 channels (in round numbers), $2,400,000 is required. Discounting should bring this down to $2,000,000.

That is, for just two schools, 800 transmitter/receiver pairs would be required. But a network could have as many as 50 schools, with possibly 30 schools being a more typical number.

There are some fundamental configuration questions involved which could greatly increase or decrease the costs of a network – depending on how they are resolved. For instance, should each school have 800 links to the video network? Or are 100, 200 or 300 links sufficient?

There can not be more than 140 laser transmitters since there are only 144 minus 4 or 140 fibers. So the cost of the laser transmitters alone would be about $15,000 (with a discount) times 140 or about $2,000,000.

Should a single fiber-optic cable be used as a bus linking all the schools? No; because if a single link fails, the network would be broken into two disconnected pieces. The schools must be cabled in such a manner that if one link breaks, no school is disconnected from the network. A partial answer is the broken ring configuration with gateways (I worked at Hewlett-Packard on a General Motors vehicle electronics testing system which had 53 computers connected this way). Whether bus or ring, this type of configuration does not require a computer-controlled video and audio routing switcher at a master network control center. Each school still has its own computer-controlled switcher.

Another possible configuration is the star configuration. A computer-controlled video channel routing switcher is located at the master network control center. Each school transmits all of its video series to the central switcher. The switcher routs the series to whichever schools have students ready to take the classes. The video signals would pass through the switcher and could require repeaters but not transmitters.

The star configuration doesn't appear to be as practical as simply having each school broadcast to all the other schools in the network. The broadcast configuration then requires 30 schools times 140 receivers times $2000 (with $500 discount), or $8,000,000 in round numbers for receivers. But will each school really need all 800 channels?

Boulder City High School may not need repeaters as it may be within 40 kilometers of all Las Vegas schools. The Overton area schools will probably need one set of repeaters. The Caliente and Pioche area schools will probably need all five sets of repeaters.

After a certain number of schools in a network is reached, the number of channels which is required from each school as schools are added to the network must decrease since the total number of channels that a fiber-optic cable can support is fixed.

A former engineering supervisor, who lives in Henderson, Nevada, investigated applying the mathematical theory of topology to switcher configuring. He reported that topology doesn't appear to be very useful in this particular application.

A phone call to Centel some months ago elicited two figures on the fiber-optic cables themselves. One figure was $0.50/fiber/meter, and the other was $30/cable/meter. Not known is whether or not these figures include interfaces and installation.

Alternative Configurations

A possible alternative video configuration is to broadcast several sets of 105 channels over the network. Then each student can be directed to manually select the correct set of channels, and then the correct channel in each set.

Plasma Display Panel

The flat-screen, digitally-controlled plasma display panel could replace the cathode-ray tube (CRT) display. It has been used with the PLATO system sold by Control Data Corporation. However, if the plasma display is unable to accept video, it can not be used in a school network.

R.J. Williams was the author's engineering department manager at Control Data Corporation's Special Systems Division. Mr. Williams directed the hardware development of some of the largest computer systems ever built in the early 1970's. In particular, he directed the hardware development of Control Data's PLATO system which provided CAI via up to 4000 plasma-type terminals. At previous companies, he also directed the engineering of simulators for nuclear power plants, aircraft, and the Apollo spacecraft. Mr. Williams thinks the plasma terminal is much better for CAI than the cathode-ray tube. Plasma monitors are easier on the eyes, etc.

Video Cameras

In the fall of 1985, Mr. Williams and I visited Stanford University's instructional television network. Our guide, George (?), said their cameras cost about $7000. So the network cameras could cost 800 times $7000 or $5,000,000 with a $600,000 discount.

Computer-Controlled Video Routing Switchers

Grass Valley Group's (GVG) largest computer-controlled video routing switcher was a Horizon 128-x-128 Routing Switcher System. No price was listed. A 64-x-64 was listed at $151,200, and a 48-x-32 was listed at $58,750. It wasn't possible to extrapolate the cost of the 128-x-128. (See NAB Show report below.)

Assume that the star configuration is discarded in favor of the ring or broadcast configuration. Assume that other television equipment will be needed anyway (the GVG Domestic Price List as of April 14, 1985 had 19 solid pages listing such television equipment as signal generators). So let's conservatively guess at $500,000 for the local video switchers at each school. This works out to 30 schools times $500,000 or $15,000,000.

The Horizon switchers can interface with a computer via RS-232, RS-422, or DTMF communications links.

Computer-Controlled Audio Routing Switchers

Oddly, GVG had developed a computer-controlled audio routing switcher for which they had found no market, but which is needed by the school network for routing student feedback to the video teacher. No prices were listed.

Videophones

Universal Video Communications, an Irvine, California company, is said to have achieved a breakthrough in transmitting full-motion color video over ordinary telephone lines. Universal's videophones can be plugged into any telephone jack. "Until now, transmitting full motion and sound could only be done over special wide-width cables,..." "A simplified videophone will hit the consumer market for $3,500 by fall of 1988..." Los Angeles Times, August 25, 1987, Page IV-3.

Such a device would seem to promise a drastic price reduction in school network costs. The local telephone company, Centel, could lease ordinary telephone lines to the schools and provide the connections. Fiber-optic cables would not have to be laid. The expensive computer-controlled video routing switchers are eliminated. However, assuming a $500 discount, will 25,000 videophones, one for each terminal, at $3000 apiece be required? That does add up to $75,000,000. Further research is needed on this approach.

Computers

The size and cost of the network coordinating computer and the system administrative computer in each school are currently unknown.

I have been advised against using student computers with disk drives. Serious maintenance problems have been encountered with the drives. The on-line terminal is apparently the way to go.

The cluster computer supporting a large-capacity optical or magnetic disk drive, a printer, and 8, 16, or 32 dumb terminals seems to be the right approach. It would also have a communications link with the system administrative computer. The dumb terminals must also double as video receivers.

The Apple Macintosh with its video graphics capabilities impressed the author at the 1987 COMDEX convention. An instructional technology professor at San Jose State University told Gary Vesperman on the telephone March 12, 1988 that the Apple Macintosh is the most popular computer in California schools and universities.

A school network may be able to get by with two students for each terminal. When not logged on or attending video classes, students will be on vacation, studying, taking examinations, attending gym, band, local series, etc.

An interesting configuration which has been suggested is to turn time-sharing inside-out. Instead of remote terminals sharing a computer, have microcomputer-based remote terminals sharing a centralized mass data storage facility. The computer industry markets such a remarkably rich array of hardware and software that there may be several different configurations that could be effective with a school network.

Network Scheduling Computer

Scheduling such a huge network may be timely and economical only with a super-computer such as a top-of-the-line Cray or Control Data machine. The University of Nevada-Las Vegas, by coincidence at the time of writing, has been slated to receive such a machine by the end of 1989 courtesy of Uncle Sam. This machine could be used also for solving some operations research-type school network design problems by simulating the CCSD.

The cost of weekend network scheduling service is unknown.

AT&T Bell Laboratories' KORBX System is priced from $8 million to $9 million. Rental costs are unknown.

Video Cassette Playback Device

A video cassette playback device should be supplied with each combined video receiver/computer monitor. The device need not be able to record. Assuming a cost of $200 per device and 25,000 terminals supporting a CCSD network of 50,000 junior and senior high students, this works out to $5,000,000 for these devices.

Video Cassette Recorders

For recording lectures, students learning public speaking, etc. each school should have a few VCRs. Maybe $400 each? Try 30 schools times 5 VCRs times $400, or $60,000.

Video Cassettes

The cost of the video cassettes is currently unknown.

Video Production Switchers and Other Such Equipment

A school network could share a local public television station's facilities for making highly-produced prerecorded video lessons. Otherwise, one school could acquire expensive video production equipment and share them with the other schools.

Costs are unknown.

Software Development Costs

Software development costs are currently unknown.

Courseware Development Costs

The courseware for each segmented course would include segment tests, course layout costs, study guides, prerecorded video lessons, CAI lessons, books, course monitor training, and loading the parameters for the course into the computer system.

Courseware development costs are currently unknown.

Selling Time on Video Network

Some of the costs of the fiber-optic video network could be recouped by selling time to conferences, sales meetings, etc.

Total Cost of the CCSD Network

The total cost of a CCSD network will become more refined as research proceeds. Since the CCSD has about 50,000 junior and senior high-school students, the per student per year cost of a CCSD network with an equipment life of ten years will be the total capital cost divided by 500,000 plus interest and maintenance expenses.

Video Cassette Playback Devices	$5,000,000
Local Video Routing Switchers	$15,000,000
Video Cameras	$5,000,000
Laser Transmitters	$2,000,000
Laser Receivers	$8,000,000
Computer Monitor/Video Receivers (Estimate)	$12,500,000
Video Cassette Recorders	$60,000

RECOMMENDED PRELIMINARY RESEARCH PROJECTS

The scale of a practical school network is so large that before jumping into building an actual prototype, preliminary research should define network dynamics and economics as precisely as possible.

Transmission Link Between Schools

Fiber-optic cable is apparently the only practical transmission link between the schools. Coaxial cable can't handle the distances required. Satellites cost too much and can't begin to provide the required video channel capacity. Microwave relay towers may be practical for mountain hopping. Infrared transmission of video looks promising.

In the future torsion field communications could apparently enable 40 billion channels of three-dimensional holographic television through the entire earth without attenuation at one billion times the speed of light. Torsion field communication systems, with components only the size of coins, are expected to eventually displace all forms of electronic communications including telephones, television, radio, fiber optic cable, and communications satellites, plus the entire Internet backbone with possibly a cost reduction of much more than half.

Schools could be located all over planet Earth and still be tightly linked via torsion field communications into a ‘torsion field school network’. It could help bring about world peace if for example a school in each of Nevada, Iceland, Germany, India, Israel, Bahrain, Chile and eventually even planet Mars were linked into a single torsion field school network.

Software Development

Developing the software to run the school networks promises to be a fairly large task.

Audio and Video Equipment

Video cameras, video cassette playback devices (but not VCRs), microphones, headphones, computer-controlled video routing switches and PBXs, and so forth all need to be picked out and priced for large quantities. Experts in these areas need to be recruited and funded.

Segmented Course Modeling

It is still unknown how actual courses would be restructured into segmented courses. Several teams of experienced teachers should be commissioned to lay out segmented courses in the more commonly taught high-school subjects such as English, math, and history. The software, video, and transmission engineers won't be able to do their work very well until they know how many series, video channels, etc. are needed.

For instance, would a high-school network really need all 800 video channels? Note that the number of channels would be strongly influenced by the various sizes of computer-controlled video routing switchers which happen to be available. For example, a 128-x-128 switcher can handle 128 channels, but not 129 channels.

Experimental Segmented Courses

Given enough teachers and not too many students, it is feasible to structure and teach at least a partially-paced, if not fully free-wheeling, segmented course and do the book-work by hand. We should be able to learn something about the system from such experiments.

One way is to start off a class of students at the same time. Then watch what happens as the students drift apart. (This is sort of what inadvertently happened to me back in spring of 1959 in my advanced algebra class. It worked very nicely for me; I was able to progress faster than the other students.)

Student Population Computer Maturity Measurements

As a rational approach to resolving the question of whether students can handle the increased complexity of student networks, the percentage of students at each age level which can operate each of the student I/O functions described above should be measured, if possible.

Computer Simulation of CCSD Network

Once at least some of the software is written, the entire Clark County School District Fiber-Optic Network should be modeled and exercised. Undoubtedly, much of the data, such as classroom sizes, is already available on disk or online. Other relevant data would include sample student populations with expected learning rates, and the pertinent characteristics, response times, and costs of actual equipment and software.

Some fundamental questions could at least be partially answered by such a computer simulation:

Can such a large network in fact be successfully scheduled?

How many series, on the average, can be loaded into each segmented course before the scheduling becomes too crowded?

How much would a network cost to build and operate? How many teachers are needed?

How would the physical space utilization by a school network compare with the conventional system?

How would the floor area occupied by all the new equipment affect existing space availability?

The schools will be running all year long. How many students can attend school simultaneously?

How many students can be out on vacation simultaneously?

How will racial desegregation requirements be affected since busing will be pointless?

Is it really feasible to schedule series in the manner shown in Figure 6? Are there other patterns which would be more efficient?

How is the school network to be compared with other educational systems, and how is it to be accepted or rejected?

The school network design could either fail due to sloppy execution of engineering and management, or to inherent design limitations. How can correct design validation be assured?

Is the concept of the segment test valid? If not, the school network system could collapse.

Is the concept of the examination valid? If not, both the school network and the conventional system could collapse.

Is the school network too complicated for students and teachers to operate?

Even on a network-wide basis, will teachers be able to prepare examinations for segmented courses something like a half-dozen times or more often than in the conventional schools?

The teachers involved with teaching a segmented course to many schools in a single network will have to agree to a standardized version of the subject matter contained in the course, and a standard layout of series, prerequisites, segment test repertories, etc. Will they be able to agree?

Would the KORBX System have an easier time scheduling the network if it can off-load students to overflow classrooms with combined computer monitor/video receivers connected to video cassette playback devices and to the computer system, but not to the video network?

On what basis are the various series selecting quotas to be set? In particular, how long should students be allowed to wait, on the average, before attending a series?

Are the concepts of CRIPANETs and critical path curricula useful?

How the students and teachers use their time can be substantially, but not necessarily, re-arranged from the conventional system. Does the school network truly offer more efficient use of their time?

How are minimum credit loads to be established?

What is the acceptable upper boundary on the per-student cost of a school network? That is, what are the economic constraints within which the technical people must work?

What are the staffing requirements of a school network? These include computer operators, camera operators, maintenance technicians, etc.

How many weeks of vacation should teachers and students be allowed to take each year?

When would students be mature enough to shift from the conventional system (presumably somewhere down in the elementary grades) to the school network?

How much inconvenience will students experience when transferring to conventional schools, and they do not receive enough warning to re-synchronize to conventional schedules?

In May 1988, CCSD voters passed a school building bond issue costing over $600 million. How soon can the fiber-optic school network design be validated? The architectural requirements of networked schools could significantly differ from those of the conventional schools.

Personal Computer Simulation of System

As an aid to teaching students, parents, teachers, and others how the school network operates, a program should be written for personal computers which would dynamically simulate a model fiber-optic school network.

National Association of Broadcasters Show – A Report

Gordon Steffen of AMPEX Corporation, Redwood City, CA, and I toured the National Association of Broadcasters (NAB) show in Las Vegas April 10, 1988. I had worked with Mr. Steffen, who has had many years of experience in television engineering, when I was writing the manual for the AMPEX BCC-10 camera in 1980. ABC used the BCC-10 in the 1980 Winter Olympics. I had acquainted him then with my school network design project, and he had provided some useful advice and answers to my questions on television.

Mr. Steffen said to forget High-Definition TV (HDTV) for now. HDTV is too premature and costly. Mr. Steffen emphatically recommended the new Charge-Coupled Device (CCD) cameras over the tube cameras. Their cost is much less. They also are much easier to operate and maintain. Mr. Steffen showed me the AMPEX CVC-7 camera of broadcast quality which only costs $24,000 – a big improvement over the BCC-10 which sold then for around $150,000. He also showed me some other AMPEX equipment offering not quite so many fancy features, but which are yet of good quality, for a relatively low price which he thought would be appropriate for budget-minded school networks.

Two companies, Computer Prompting Corporation and Q-Tv, displayed teleprompting devices which are driven by IBM PCs. They can be used to display to a lecturer facing the camera course status information and questions entered on the students' computer terminals.

The Grass Valley Group company showed me their 128-x-128 Horizon (Trademark) computer-controlled video channel routing switcher. They also said that they now have a 512-x-512 switcher, but it was too massive to bring to the show.

I was introduced to Glenn Nichols, Applications Engineer Telecommunications. He would be configuring the school networks' fiber-optic links and channel routing switchers if any of Grass Valley Group's equipment is purchased.

GVG's WAVELINK fiber-optic interface devices have improved dramatically over the figures mentioned earlier in this proposal. I think I heard their laser transmitter can now reach 70 kilometers and are now priced at $8,000. The cost and performance of their LED transmitters and receivers also have improved.

GVG mailed some product literature. Highlights are as follows:

A lower-cost alternative to their WAVELINK system is now available. The Ez-Link (trademark) Series 87 FM Fiber Optic Systems includes an 830-nanometer laser transmitter module for up to 8 kilometers, and a 1300-nanometer laser transmitter module for up to 30 kilometers. The brochure claims EZ-Link is "ideal for video conferencing on university campuses". Perhaps EZ-Link is usable between the schools around the core of Las Vegas, and WAVELINK is required for linking up with outlying schools such as Boulder City and Caliente.

Their Model 4500 Digital Video Codec is a 45 Mb/s compact unit (3.5 x 19 x 12 inches) which allows multiplexing on a DS3 line of stereo audio, four Tl overhead channels, and two asynchronous 19.2-kilobaud data channels. The transmitted video is of commercial quality and can accommodate non-time base corrected video such as VHS and U-Matic tape.

Their Horizon Routing System features many options and modular expansion capability. Of particular interest is their HX-GPI Horizon General Purpose Interface. Each GPI has two control ports for controlling the switching of any input to any output. Each GPI port can be independently configured to connect to an RS232 or RS422 computer channel at baud rates from 300 to 38.4K (in eight steps). If necessary, a GPI port can be programmed as to what it CAN NOT control. The GPI is the key device for computer-controlled video switching.

The Integrated Machine Control System, in several configurations, can be teamed with Horizon Routing Switchers for controlling Video Tape Recorders (VTR).

The Horizon is an analog video routing system. GVG also offers the DHX-532 Digital Routing System for digital video technology. The DHX-532 can operate standalone or teamed with analog Horizon equipment.

A separate company, Matrix Systems Corporation, manufactures computer-controlled coaxial routing switchers. For example, their Model 4704 allows a computer via the IEEE-488 bus or RS232 to connect any of 40 inputs to any of 10 outputs.

Infrared Transmission of Television Channels

In November I loaned a copy of the June 18, 1988 edition of this proposal to my next-door neighbor as a start towards soliciting feedback from the general public. He thinks school networks could become a smash hit if they don't have too many computer glitches.

He also told about a California-based engineering associate's very interesting patent. This fellow has invented a communications system for multiplexing up to 105 video channels on an infrared beam. The infrared beam can pass through fog, etc. and cover an entire city. If more channels are needed, simply add

another infrared beam. HBO and other cable TV companies are looking into it. A son of President George Bush is providing some of the financial backing.

I told my neighbor to be sure and have his friend give me a call or stop by soon so I can evaluate the applicability of infrared to school networks. Mounting infrared transmitting and receiving towers on the schools could offer a huge cost saving over fiber-optic cable. As of January 21, 1989, he still hasn't been able to contact the inventor yet since he's been busy installing the first system in New Zealand. (He's probably also busy having a good time and enjoying New Zealand's summer!)

WORLD-WIDE MARKETING OF SCHOOL NETWORKS

If all goes well, the prototype Clark County School District computerized fiber-optic network will likely be completed and validated sometime during the mid-1990's.

A pool of experienced school network engineers and programmers should accumulate in the Las Vegas area by then. These people could form the nucleus of a company to design, market, install, and maintain school networks world-wide. It should indeed be a substantial business.

Each network would have to be configured and installed according to the particular requirements of each local school district. The optimum size range seems to be 25,000 through 75,000 students. The average cost of a school network may be in the neighborhood of $100,000,000.

For the western states, one network could be installed in Tucson, two in Phoenix, one in Salt Lake City and Provo, one in San Diego, one in Reno, one in Sacramento, one in Fresno, four in the San Francisco Bay area, ten (?) in Los Angeles, one in Denver, one in Portland, one in Seattle, one in Albuquerque, and one in Honolulu. Montana, Wyoming, Idaho, and Alaska are probably all too small or thinly spread out. So for the western states, we're looking at about 28 networks or around $3,000,000,000 (about the cost of one nuclear power plant). There would be an additional investment in power generation and transmission facilities.

The current population (in 1989) of Nevada is a little over 1,000,000. A school network could also be installed in the Reno area with fiber-optic cables reaching out to Carson City, Lake Tahoe, etc. So a convenient rule-of-thumb would be to assume that two school networks can be installed per 1,000,000 people. California currently has 28,000,000 and is projected to add another 4,000,000 by 1995. By 2050, California can be assumed to have grown to at least 50,000,000. By 2050, the USA can be assumed to also have grown to at least 500,000,000. Earth's population currently is 5,000,000,000. By 2050, Earth is projected to have about 10,000,000,000 people. (Just how many people do we need anyway?)

Accumulated world-wide school network sales by 2050 could theoretically go as high as 10,000,000,000 divided by 1,000,000 multiplied by two times $100,000,000 times two (assuming an average of one replacement due to wear and tear by that time) = $4,000,000,000,000.

SUPERLEARNING

There are currently about 180 validated accelerated learning techniques available around the world. One of the more widely used and documented systems is called ‘superlearning’. This technique, also referred to as ‘supermemory’, was researched and developed by Dr. Giorgi Lazanov in Bulgaria in the 1960's. Many refinements have occurred over the past three decades, including the addition of pictures on video tape by inventor Richard Ewing of Salem, Oregon.

Normally, the brain is constantly bombarded with new signals from the five senses. To prevent itself from being overwhelmed, the brain employs a filter known as the Reticular Activating System (RAS). The RAS sorts out the deluge of signals, passes through signals that are at least vaguely familiar, and *blocks new information*.

Superlearning is a technique for bypassing the RAS. There are three aspects of superlearning – special music, deep breathing, and presentation of the material to be learned. The music is of the 'baroque' style at exactly 60 beats per minute. Out of over 25,000 compositions which have been tested, only 24 have the desired effect. The use of electronically produced music, in the baroque style, works well due to precision control of the beat.

The deep, rhythmic breathing, which takes a little practice, is done in 8-second cycles – 4 seconds of inhaling, 4 seconds of holding, 4 seconds of exhaling, and 4 seconds of holding. Combined with the music, the body relaxes, bringing the heartbeat down to 60 beats per minute and dropping the brain waves down to 7 cycles per second (the borderline between alpha and theta). It is at this point, Lazanov discovered, that optimum learning occurs. The RAS is 'bypassed', and the filters that prevent new information from entering memory no longer function.

The information is presented rhythmically, whether orally or via video tape, in 8-second cycles, i.e., speaking and not speaking. This seems to allow the brain enough time to assimilate the information before more is presented. Also varying the voice's intensity and loudness helps keep the listener alert, albeit relaxed.

The effects of using the superlearning learning technique go beyond learning thousands of vocabulary words of a foreign language in just a few days. Those who have completed superleaming classes have reported increased awareness in general as well as improved concentration, creativity, positive self-image, and a general sense of well-being. Their success rate at learning new tasks is also reportedly increased.

One example of improved performance through the use of the superlearning technique is the East German 1976 Olympic team. That team took 40 gold medals during the games, second only to the Soviet Union's 56. Shortly thereafter, the Swiss Olympic ski team started using the superlearning technique and began dominating the Winter Olympic skiing competitions.

The superleaming technique seems best suited for the teaching of factual information such as foreign languages or courses where there is specialized vocabulary or many formulas (science, math, and history, for example). In the Bulgarian studies, over 500 words of a foreign language per day were introduced. After 3 months, the learners were tested and found to retain 96% of the vocabulary.

Many documented accounts of individual and group success are available. For anecdotes and an overview of the development of the superlearning technique, consult the book "SUPERLEARNING" by Sheila Ostrander and Lynn Schroeder.

Excerpts from SUPERLEARNING Book

(These four sets of two pages were excerpted from the book "SUPERLEARNING" authored by Sheila Ostrander and Lynn Schroeder with Nancy Ostrander. The publisher is The Bantam Doubleday Dell Publishing Group, Inc., 666 Fifth Avenue, New York, NY 10103. Copyright date is 1979.)

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abolish it if it didn't work. They found themselves seated in lounge chairs under subdued Iights, with quiet music playing. lt didn’t seem like a place to get down to work.

“Relax. Don't think about anything," the teacher told them. "Just listen to the music as 1 read the material."

The next day, chagrined commission members discovered that even though they were sure they'd learned nothing, they did remember. When tested, they could easily read, write, and speak from 120 to 150 new words absorbed in the two-hour session. In the same way, the grammar rules were painlessly absorbed. At the end of several weeks, despitc many firm beliefs that they couldn't learn a thing in this effortless fashion, they emerged fluent in a foreign language they has not known before. What could the government commission report?

In 1966 the Bulgarian Ministry of Education founded the Center for Suggestopedia at the Institute of Suggestology. With a staff of over thirty specialists in education, medicine, and engineering, the institute taught regular classes with suggestopedia while at the same time doing physiological and medical research in its labs to see what made rapid learning and super-memory tick.

Suggestopedia class graduates were frequentiy brought back for further tests. How much did they forget? Did the health benefits last? Not only had they learned much faster, but they didn't forget. Six months later retention was still eighty-eight percent. Twenty-two months later without any intervning use of the new language, retention was still 57 percent. Students returned on their own, too, to say how much their emotional well-being had improved from the courses.

People of all ages and all walks of life came to evening courses at the institute after a long, full workday. They arrived tired, and sometimes with headaches.

"The meditative sessions leave you feeling great, wonderfully refrcshed and invigorated," students assertcd. "There is no strain at all," they testified. "You don't get tired mentally or physically."

Monitoring equipment revealed that during the concert session, students' bodies showed a pattern similar to certain kinds of yoga meditation said to refresh and restore the body. Body proccsses slowed down to a healthful, optimum level; brain waves slowed to the refreshing alpha level. Students reported that even their headaches disapeared during the sessions with the musical memory method.

How far could the mmd expand once it started to open up? lt seemed just as easy to learn one hundred words as fifty. Classes of volunteers were formed. In a single session they were taught fifteen lessons from a French textbook covering five hundred new words. lmmediately afterward, they were given a test, and three days later, another test. Results were excellent – extraordinary. "All the words had been retained," Lozanov says.

On an average now, people learn eighty to one hundred words a day in accelerated-learning courses. The world's largest language school, Berlitz, says that two hundred words after several days (thirty hours) of intensive ‘immersion’ learning is considered successful. Unfortunately, the forgetting rate has heen almost as rapid with these high-pressure methods.

With the Bulgarian approach, 500 words a day was just ‘Mach 1’. By 1966, a group learned 1,000 words in a day, and by 1974, a rate of 1,800 words a day was charted. In 1977, Lozanov reported, some tests showed people capable of absorbing even 3000 words per day.

Unlike sleep-learning in which as many as thirty-six repetitions of the same five or ten minutes of material may be required, suggestopedia needs few repetitions. Much more information can be learned in a shorter time. Presenting material at a rate of around four-hundred data-bits an hour, the only limitation seems to be the number of hours in a day
.
When you read the reports you begin to get the feeling that right now, someone, somewhere must be setting a ncw rapid-learning record.

What are the outer limits, then, of the mind's potential? Once

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and rapid learning. Suggestopedia is used today by thousands of people in Soviet-bloc countries and is rapidly spreading through many Western countries. In addition to the regular courses at the Institute of Suggestology in Bulgaria, many special experimental eourses have been conductcd over the years at varions schools and centers. And a host of international conferences on suggestopedia have heen held in nnmerous countries.

As of 1976, there were seventecn public schools throughout Bulgaria that had bcen using Lozanov's method for all subjects for several years. Supposedly, out of the scores of children in these Bulgarian schools, *every one* was a virtual prodigy. Supposedly, first graders read advanced stories. Third graders did high school algebra. Everyone covered two years of school in four months. Childrcn learned to read in a matter of days. The 'supposedlys' began to soar off into the wild bluc yonder. Everyone had fun. Everyone loved learning. Everyone was crcative. Nobody failed. Sick children cured themselves in this new process of learning.

Dr. Cecilia Pollack of Lehman College, New York, was able to get into a Lozanov school because of high government contacts she had in Bulgaria. She observed classes in school number 122 in Sofia, an ordinary school, in an ordinary neighborhood. She watched nine-year-olds eagerly solving abstruse algrebraic equatons far heyond the capabilities normally expected of the best third graders. She saw first graders after four months of school fluently reading and discussing folk tales usually of a third-grade level. All grades in the school had completed two years curricula in four months. lt was an "incredible phenomenon," she reports.

"But whcre are the failures?" she asked, thinking of these at home who could not master bases. Surely slow learners and failures were separated off somewhere.

"There are none," school officials replied. They didn't believe IQ was innate or inflexible. Should any child lag, he or she was immediately helpcd to reach required standards. This kind of global education stimulates the whole person; it not only develops the child's mental powers much faster, they said, but also frees creativity and delight in learning at the same time.

"These appeared to be schools without failures," Pollack reports. She came back talking about "prodigious implications." Lozanov's system, she said, has "opened a world of exciting new possibilities for human developmcnt....He will have pointed the way toward educational possibilities leading to the enhancement of knowledge and the enrichment of the human personality, far beyond what we now consider possible."

If even part of what they told her is so, it is a stunning development. In 1977, at a conference in lowa, Lozanov hinted of new developments. The one-time experiments to learn five hundred foreign words in a day were supposedly now regular everyday practice in certain language courses. Canadian government observers indicate they saw classes learning four hundred words a day. In 1976, Swedish educators visited the Bulgarian schools and confirmed math rcsuits – third grade at sixth grade level.

Ivan Barzakov, a recent Bulgarian defector, taught briefly in the Lozanov schools and was at the institute for a couplc of months. He claims the reports of phenomenal results are truc. “The wholc point is to create miracles in education,” he says. Barzakov confirms the drive for secrecy that winds around mind-expanding programs in Bulgaria and the USSR. Few of the staff were privy to thc whole program, yet they did sec the end results. Secrecy also pervades training teachers in the method as well (sec Appendix).

Over the years, even the Bulgarian government had trouble believing that their childrcn were blossoming so variously. Over the ycars, suggestopedia underwent ncw rounds of skirmishes and attacks. The government again mobilizcd forces to investigate. The Ministry of Education sent teams to examine academic standards; the Ministry of Health sent doctors and psychotherapists to investigate students' health; the Ministry of Culture sent cxperts to check on the various arts used widely in courses. Long-time critics of Lozanov were hand-picked for

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After Benitez-Borden and Schuster, Iowan Charles Gritton at the Wilson Junior High School in Des Moines used superlearning to teach science to eighth graders in one-fifth the usual time. Enthusiasm for the mcthod began to run high in the heartland.

At that point, Iowa researchers, teachers, and professors founded the Society for Suggestive, Accelerative Learning and Teaching, a mouthful that's known as S.A.L.T. The Society publishes a journal and a newsletter and runs a teacher-training progrum. lt has also hosted three international conferences on rapid learning.

Just as Iowans had helped find the key to opening *outer* space with the discovery of the Van Allen radiation belts around the carth (Dr. James Van Allen and colleagues, University of lowa), maybe Iowans, with their delving into the mind's capabilities, were heading toward being among the first to explorc keys to *inner* space.

Early in 1976, Schuster convinced educators and state legislators to fund large-scale experiments. On a $100,000 grant, the achievement, adjustment, and creativity of 1,200 students in different public schools taught by twenty S.A.L.T.-trained teachers for one year, was compared with control groups. Schuster calls the preliminary findings “significant scientific documents.”

Though some of the teachcrs never got their projects going, of those that did, many found their students' performance vastly improvcd. Junior high and high school students seemcd to benefit more from rapid learning than did elementary students.

Charles Gritton was both science teacher and wrestling coach at the Woodrow Wilson Junior High – a school in a low-income neghhorhood. You'd give a good lesson, Critton says, and afterward you'd realize the kids didn't hear a damncd word you said. You'd go home at the end of the day wanting to shoot yoursclf, he says, because you'd wasted your day there, their day, and all that energy.

The kids had their own worries to think about. “When a police siren goes off down the street, there are a half-dozen kids in a class of fifty who look nervously around,” says Dr. Schuster. “If there's a knock on the door, and a policeman comes in that door, three kids go out the window. Every so often, kids don't show up in class: ‘Where've you been?’ ‘Oh, I spent a couple of days in jail.’”

Pcssimistically, Gritton had learned to live with limited results, only possible through heavy discipline. When Schuster and Benitez-Bordon told him about rapid learning, he was scornful. “Nobody can teach kids flfty or one hundred new science terms in a week, let alone a day, and make them like it.”

Nevertheless he gave rapid learning a try. As his classes learned more easily, rapidly, and successfully, he began to get a kick out of teaching again. “Each group of students has achieved more hecause I have been more encouraged to try even more of the ideas.”

In 1977, with a new group of classes, the mean percentages for the four classcs were: 98.5 percent, 94.0 percent, 97.0 percent and 100.0 percent, with an overall mean percentage of 97.5 percent. “With these kinds of results, the students are highly motivated to work.”

The kids, it seems, wcre elated, and proud of their new-found skills. For many, it was the best they had ever done in their lives. They had a ncw image of themselves and their capabilities. Gritton knew for sure there was something different about rapid learning when kids sent out in the hall for misbehaving didn't cut classes, but hung around his door trying not to miss anything.

“If S.A.L.T. hclps but one, it would be worth it,” says Gritton, "but when you have 115 students at a ninety-seven percent level in four days, teaching is a lot of fun!”

The kids' excitement was contagious. It changed Gritton from a pessimist to an optimist. The ‘illusion’ that people are limited had been dispelled. He tried the same techniques on his wrestling team and coached them to the city championship.

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After a session, have the children do a quiz and check their own results. The quizzes are just feedback to see how they're doing. As they begin to see improvement each day, the quizzes become something to look forward to. Some children found it helped recall to have the music played during the quiz.

A Sample Coaching Section

Iowa teacher Charles Critton tutored two eighth graders, a boy and a girl, who, their teachers and parents agreed, were students with learning disabilities. Unable to do fractions or pereentages, unable to spell, they didn't care about school anymore. Working in their own living room, Gritton spent some time teaching them relaxation and talking about the new learning system. He asked them to take a pretest in spelling and arithmetic. They tried the spelling. Both refused to try the math.

Gritton began with a rapid-learning session of fifty spelling words from their toughest list. The two scored their own papers. They began to look surpnised. On the pretest they'd gotten scores of thirty and twenty. Now each had ninety percent right. Pretty soon, as the tutoring went on, the ‘disabled’ children were telling Gritton, “It's fun to learn; it's easy. There's nothing to it.” They found it was very easy to recall the material if the music was played during the quiz.

He reviewed the math that they'd previously refused even to try. They took off, Gritton says. Their aceeptance of themselves was very high, and they were so excited and pleased about learning. They could work all the problems and had no difficulties.

The next day they did another fifty difficult spelling words. The girl got 100 percent on the quiz. The boy was stunned to discover he'd gotten almost everything correct. His self-image as a person unable to spell was so fixed in his mind that he insisted on erasing correct words and making them wrong.

On another day, they did another fifty spelling words and more math rules. “It's very simple,” the kids said, and asked Gritton to go on with ratios and more difficult things. They remembered math rules, he reports, with “amazing ease.” After four days their attitudes about themselves had completely reversed. Gritton was sürprised too. This was one of his first trials of the system. The approach, he says, “worked beyond any expectation I had had.”

The tutoring scores for the two students looked like this: *Spelling*: pretest 30 percent and 20 percent. First session: 90 percent and 90 percent. Second session: 100 percent and 60 percent (with the boy erasing correct answers). Third session: 100 percent and 60 percent (with erasures). *Math*: pretest 0 and 0. First session: 90 percent and 90 percent. Second session: 100 percent and 90 percent. Third session: 80 percent and 90 percent.

Recap for Supermemory Session

- Ahead of time, make sure the child knows how to relax and do the other learning exercises.
- Go over homework as vividly as possible.
- Have the child relax, affirm his ability to learn and reexperience for a moment the good feeling that comes with successful learning.
- Read the material through at the proper pace while the child follows it, reading silently to himself.
- Read through the same material again, this time over the music while the child, eyes closed and relaxed, simply listens.
- Give a quiz and let the child score results.

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<u>Student Terminal Specifications</u>

Some accelerated learning techniques such as superleaming require audio and video equipment. Provision of such equipment, along with access to the computer system and video network, together comprise the fundamental requirements of a fiber-optic school network student terminal.

As of July 1990, no terminal is presently available on the market which fully meets the requirements of this type of terminal. What follows is a list of requirements and components.

Color Display

Accepts both NTSC video and computer data.

Keyboard

Headphones

Microphone

Video Switch

Switches between input from video cassette playback device and input from mixer. Output goes to video/digital switch.

Video/Digital Switch

Switches between input from video switch and input from cluster computer or Local Area Network (LAN) server. Output goes to color display.

Mixer

Superimposes digital data from LAN server onto video from video network. Output goes to video switch.

Video Cassette Playback Device

Since video recording is not a requirement, to cut cost and physical size, this device would be cabled or attached to the color display and only play back video cassettes. Its output goes to the video switch.

Audio Switchbox

See above. Provision should also be made for a link with an audio channel playing varieties of superleaming music during the entire school session. Thus when a teacher is present in the classroom who is teaching a local class for which the student is currently not scheduled to attend, the superleaming music piped to the headphones will help block out the sounds of the class. In practice, non-attending students will be assigned by the KORBX System to terminals in the back of classrooms.

<u>Consequences of Audio Switchbox Link to Superlearning Music Channel</u>

Heretofore, combining a local class with non-attending students in the same classroom could be an intolerable distraction to the non-attending students. The bottom paragraph of the Student Terminal Specifications suggests linking the audio switchbox to an audio channel continuously playing varieties of superleaming music. When a student is not viewing a recorded or telecasted class, he or she can now study or interact with the computer system while listening to superleaming music and not be distracted.

The uncertainty expressed above with regard to classroom layout is now resolved. Scheduling now appears easily done enough that possibly the KORBX System will no longer be required.

Scheduling individual schools could be given greater emphasis over interrelationships between the schools. Protocols will have to be established as to which schools get to teach which local classes to be telecasted. Ideally, local classes can be rotated to some extent among the different schools.

Video switching would take place only at the master network control center. The computer-controlled video switcher in each school as shown in the Overall System Hardware Configuration Block Diagram (Figure 7) no longer appears necessary.

Assuming that 105 VHF and UHF channels will be sufficient, for 20 schools in a network, only an average of less than six studio classrooms in each school will be needed. An average of 8 or 10 studio

classrooms would be better for handling random fluctuations. Camera outputs would be sent to the master network control center for broadcasting throughout the fiber-optic network.

In case 105 channels is not enough to handle all the courses, a second video switch can be added to the student computer/video terminal to handle a second set of 105 channels.

The last rows of terminals in the back of classrooms could have the option of being turned 180 degrees away from the teacher. Non-attending students would be given preference to these terminals. An even higher preference would be given to those students not scheduled to attend telecasted classes.

Criteria will have to be established to select students who need superlearning music to fill empty seats in video classrooms. Remaining students will be in non-video classrooms and thus may not require superleaming music.

QUESTIONS AND ANSWERS

This chapter was added to clear up possible points of confusion.

Thanks are due to a resident of Foster City, California who had kindly submitted a letter asking many of the questions.

Q. Why did you write such a long proposal? People don't have time for all this reading.

A. It was intended to be a functional specification, to be added to and revised as ideas are generated. very few people are in a position to actually do something about it. Since it would be exceptionally difficult, politically and technically speaking, to implement the first working system, every possible defect has to be anticipated and remedied to overcome the inevitable objections by critics. Ultimately, the school network design has to stand or fall on its own merits, not salespersonship.

Q. Why did you design the system?

A. I was fed-up with the gross inefficiencies of the conventional system, and I couldn't believe that something better was impossible. Computer-Assisted-Instruction (CAI) is not an answer or even relevant to many of the problems associated with the conventional system. I saw education as a classic systems engineering problem, and by following the proven technique of listing my systems design objectives first, I was able to realize nearly all of my goals. Besides, it was a lot of fun!

I ultimately would like to consider a successful design as a gift from our present generation to those who will follow us.

Q. How long did it take you to complete the design?

A. The original design, except for a whole host of improvements during the interim, took a little over two years. But the various technologies to make it all possible didn't arrive until 20 years later. I remember people telling me then that I was ahead of my time. How so right they were!

Q. Why was it so difficult?

A. It was an unusual problem, in the sense that many commonly-held assumptions had to be junked or modified before I could piece together another system to the point where it seems to make some sense and looks like it might work. The fundamental difficulty is that there is no clear path of progression from the present system to the other system; hence, there can be no compromise between the two systems. A few examples are segment tests, series-selecting quotas, credit load units, weekly course progress reports, and skiing vacations in February, which don't make sense in the conventional system. Conversely, semesters or quarters, fixed vacation periods for everyone, and a lack of quality assurance don't make sense in the new system. To top it off, every functional feature in the conventional system must somehow be duplicated in some manner, or the new system may not be accepted.

Q. What goals did you fail to achieve?

A. While the computer system design can be rated as medium in complexity, the user interaction could be simpler. In spite of the impressive new technologies that have been arriving lately, the school networks still could cost too much or be unreliable.

The most unfortunate goal that couldn't be realized is the system's applicability to the typical stand-alone school. In other words, there is no way to make it work right on a small scale.

Q. Were you lucky, or are you a genius?

A. Lucky, without a doubt. I simply started with the simple but novel idea of the segment test, for which a score is not recorded, and worked and juggled to get the classes, examinations for which scores are recorded, and all the other things which constitute the typical educational bureaucracy, back in the system. For example, the simple idea of a credit load unit eluded me for six months after a University of Wisconsin electrical engineering professor, who later on was promoted to assistant dean, pointed out the need for something like it. (It was our informal discussions while I was an electrical engineering student about how schools ought to be operated that was one of the three events that had started me on my school redesign project. He had clarified for me some very fundamental system design objectives.) I had to go through several design iterations, building on what I had done before, to complete the system. I never would have believed that 25 years later, I would still be dreaming up ideas for design improvements in Las Vegas. Working with computers disciplines your thinking, as everyone who has ever worked with them will heartily agree.

Q. Have you ever run across a similar system?

A. Not yet. However, I have experienced something like the spirit, but certainly not the form, of the new system. My high-school advanced algebra class in Drummond, Wisconsin had six students with the usual mixture of abilities. Most of the year, the teacher ran it in the conventional manner. Unlike most school districts, our Easter vacation was only four days long. The weather was cold and rainy so I stayed home and worked all the problems in advance for several chapters in the text. A couple of the students were falling behind anyway, so for the remaining few weeks we all progressed at our own pace. Every so often, the teacher would lecture about the material the slow ones had recently covered, just like the series covering the segment-groups. At the same time, another student and I were racing each other to see who would cover the material in the textbook first. We never did finish, as it was a big book; but we could have if we had started the race at the beginning of the school-year in September.

The text book was so clearly written that I wonder if a CAI system would really have helped that much, but that's my personal opinion, not a scientifically established fact. When I was in electrical engineering school, many times I would contrast my academic struggles with the efficiency and fun of that high-

school algebra class. I had the feeling that I could easily handle two or three extra courses using that method instead of the four or five courses I sat through each semester under the conventional system. But how to re-arrange the conventional system to allow the dual but contradictory conditions of stimulation and bureaucratic efficiency proved to be a very tough nut to crack.

Q. Some students ‘freeze’ when taking a test. Should a grade be based on the results of such a test?

A. Students taking segment tests would not have to ‘quake’ at the thought of failure, since segment test scores would not be recorded. The system simply attempts to ensure that the student has adequately learned the material in the segment before allowing him/her to proceed.

With segment tests behind him/her, he/she should have more self-confidence and be less apt to freeze. Grading for segmented courses could follow the grading scheme for conventional courses, by counting the two one-hour examinations at about 20% apiece, the final examination at about 40%, and the remainder of the grade from homework assignments, papers, laboratory performance, etc.

Q. School is more than academics. The controlling software doesn't take into account the personal or emotional problems a student might encounter through his/her academic life which would influence his/her academic productivity. Might not ‘failure’ in one of these low cycles, especially without human reassurances or understanding, adversely affect the student's psychological well-being?

A. Having had low cycles myself, I agree. One of the really gross inefficiencies of the conventional system is that, when a student is ill or falls behind and has to drop a course or two, he/she must wait until the next quarter or semester before being able to take up a full credit load again. Sometimes students will lose a whole semester, which is very costly. The conventional system allows no way to overcome this problem; in contrast, segmented courses can take such interruptions in stride.

Q. Just how much improvement do you expect over the conventional system?

A. In the case of engineering and scientific studies, about 50% altogether when one includes the losses due to dropping courses in mid-quarter. Of course, there are many variables involved, such as the amount of homework assigned, etc. Fifty percent is not as spectacular as, say, quadrupling, but over the typical sixteen years of schooling from first grade through a bachelor program, the difference can be substantial. Even a 10% increase in efficiency over a long period can be noticeable. Of course, it doesn't compound like interest on a bank account.

Q. It would require hundreds of students per course per year for the system to completely free-wheel. Would you expect a medical school, for example, to be able to use the new system?

A. No, unless there were a regional, or even national, network of such specialized schools. It has only been the last few years that such a network would be technically feasible. Microwave and fiber-optic communications, video recordings, etc., are all developing very nicely. Even infrared transmission is a strong possibility. While long-distance telephone costs have decreased, local telephone service costs have been increasing. Perhaps fiber-optics, as a transmission medium, will help reduce the cost. I anticipate that school networks will be practical from grade four through junior college, at least. I am not one to judge its applicability to the wee ones. It doesn't make sense to apply it to a single adult evening course. It only makes sense for mass education over at least several years, as at the high-school level.

Q. How would the new system handle subjective courses, such as drama or music appreciation?

A. Obviously, the system would handle objective courses better, or more appropriately, than subjective courses. Since we wouldn't want to stay with the conventional system if we could help it, we could try to rearrange the pieces of the new system without changing the controlling program. One way is to reverse the prerequisite graph (see Figure 2) so that a single segment test follows several series which have been grouped. CRItical PAth sub-NETworking (CRIPANETing) is another technique that could be modified to fit the needs of musicians, athletes, etc. Once a curriculum designer gets in the swing of manipulating the new system, all sorts of possibilities arise.

Q. Why is there persistent reference to ‘one-hour’ and ‘two-hour’ examinations? The length of a test does not necessarily show its comprehensiveness.

A. I agree with the second part of the question. I refer to the length of the tests because they are so standard in the conventional system. There is nothing in the system to prevent an instructor from giving fractional-hour examinations or classes. There is, however, a serious problem in efficiently managing the students' time and efficient series scheduling. Instructors can be creative with scheduling only up to a point. When an instructor starts demanding too much of the students' time for a given course, the other courses must either lose out or be delayed.

Q. How difficult would be the transition for students transferring into the system? What would happen to those students who had to move to a school outside the network?

A. Transferring into the new system from a school employing the conventional system would be easy. A transfer student would simply confer with his/her academic adviser and determine which segments he/she had not yet covered in his/her old school. The student might want to repeat particular segments more quickly than normal because he/she didn't do well when he/she took the material before.

Transferring out of the new system to a school under the conventional system could present serious timing problems. A high-school student could have a really wild combination, such as beginning a second-year English course, midway through chemistry, two-thirds done with plane geometry, three segments into advanced algebra, and two segments short of completing American History. Imagine transferring into a conventional high school in its junior year in December. The two systems don't even speak the same language when one realizes that ‘grade 11’ in the conventional system doesn't even exist in the new system.

If a student had enough warning, he/she should be able to re-synchronize with the conventional system. It should be noted that the new system would handle the scheduling of children of migratory farm and construction laborers beautifully. California has a classic example of this problem. If all the schools in its Central Valley were combined into one or two huge networks, the education of these children would be more efficient and consistent. The conventional system doesn't really fit the mobile society of today. It is the horse-and-buggy of education.

Q. What about vacations?

A. Having visited over 100 national parks and wilderness areas during all seasons of the year, I can personally testify to our great social need for better balance in the utilization of our recreational resources, as well as the physical facilities of our schools. The conventional school year runs from Labor Day to Memorial Day, with vacations over the Christmas and Easter holidays. The ‘school year’ doesn't exist in the new system. School is always in session with students and teachers taking vacations whenever they please, up to a maximum number of weeks per year. I would expect that this feature will be very popular with both students and teachers.

Q. Will students be able to proceed at their own pace?

A. Not totally, but it should be close enough for all practical purposes.

Q. How much emphasis should be placed on grading versus educational understanding and curiosity? How much room would there be under the new system for curiosity examination of subjects not included in the regular program?

A. One of the features which makes me feel enthusiastic about the new system is that it makes casual study more convenient than the constant grind of the conventional system. I anticipate that students would be expected to carry a certain academic load for most of the year. For the remainder of the year, the students would be on vacation. Sprinkled throughout the year, students and teachers could be scheduled for a half-dozen weeks of half-a-load whenever they feel like it or perhaps are 'burned out'. They could be in school browsing through the library, practicing for musical or athletic events, or out on a nature study trip.

Q. How do you feel about the Russian schools?

A. I saw an interesting report once on the Russian schools. The Communists seem to consider the schools as convenient vehicles for brainwashing and turning out technically qualified people for staffing the 'worker's paradise'. They have completely forgotten what it's like to be a child. Their students get very tired and burned out from excessive academic pressures and six days a week of school. Overemphasis on rote learning and underemphasis on creative thinking can't be conducive to creating a modern society.

I did like very much one objective of their schools that is pursued hardly at all in America. Back in the days of horses and sailing ships, children were often employed around the farm and so forth. Thus when they grew into adults, they already had some first-hand experience with some of the kinds of vocations they could consider taking up.

Carried to its logical absurd extreme end, a child could grow up in modern society with no work experience at all. For instance, chickens are commonly seen only as Colonel Cluck Cluck's Kentucky fried chicken, not as live birds that must be fed and protected from wolves before they are cooked. When I was in electrical engineering school, I myself hungered for some exposure to the working world of engineering rather than just sit through classes all the time. I took the few field trips that were available, but they weren't quite the same as working alongside or at least observing engineers at work.

The Russians diligently work at creating short-term work experiences for their children. I vaguely remember a couple of examples such as having a child do some simple assembly work in a factory for a few hours right alongside the other assemblers, or count sales receipts in a store. It was claimed that the exposure to a non-academic environment, for a change, was very beneficial.

I recommend that the flexibility of school networks be exploited to provide an extensive array of work experiences for students. An organized, massive effort should be made to solicit businesses, nursing homes, hospitals, governmental agencies, etc. in each community to set up situations where students could come in for a few hours and help out. I haven't investigated the possible legal problems; but it should be worth a try.

Q. What part of the system seems to be the most difficult for people to grasp?

A. Most likely, the looseness or dynamicism of the scheduling as opposed to students always being in a class. Just remember that the controlling software actually has many things under far tighter control, where it counts, than in the conventional system, and that the students will sooner or later attend a series of classes.

Q. What would happen if a student failed all of the segment tests on a segment?

A. I do not have a good answer for that. I myself never quite got the hang of optics in college physics so it can happen even to a fairly able student. The course monitor will just have to arrange for tutoring, let him/her proceed with the course, and hope the student will do well enough in other parts of the course to successfully complete it.

Q. Would a student be identified by name or number?

A. The computerized course registration systems I had used at the University of Wisconsin required both a student's name and identification number. Evidently, programmers like to use both because it allows a more compact and reliable data base.

Q. If Student X took a segment test, what assurance is there that Student Y, who took a test on the same segment at a later date, didn't get the answers from Student X?

A. As explained above, it is unlikely segment tests would be the same. Even if they did try to cheat, it would be meaningless as the scores of segment tests would not be recorded. It would be easier to learn the subject matter within a segment than to memorize all the answers in the segment test question repertory. Also, cheaters would be at a serious disadvantage when competing against conscientious students at competitive examination time.

Q. Where will you find public school teachers who will teach on Saturday? How many members of the public are willing to give up their weekend to further their children's education?

A. It is very doubtful classes will be scheduled for Saturdays particularly two-hour final examinations. To avoid scheduling two-hour examinations outside of normal hours, the controlling software would try to schedule them as two adjacent vertical series. The first two or three two-hour classes could be used for review, and the second for the final examination. If a log-jam should occur, and it became necessary to resort to extra-normal scheduling, I suspect most students would prefer to take the examination after-hours rather than on the weekend. Hopefully, this would almost never happen. It is really intended as a last-ditch escape from an otherwise impossible scheduling dilemma.

It is also true that series-scheduling would be done on weekends, mainly to balance the load on computing facilities. The main reason why Figure 9-1 is such a funny-looking schedule is to balance the load on the computers by spreading the workload over the entire week. An otherwise unnecessary peak during just a few hours during the week would increase computing costs. Because of the nature of series scheduling - easily the toughest single software design problem in the entire system - a whole new part-time occupational specialty might be required just for this one task.

Q. Most schools have great difficulty in generating any schedule at all. You are asking them to generate a completely new schedule each week. Isn't that asking too much?

A. I realized almost immediately that conventional scheduling is indeed a difficult problem. The new system does have one decisive advantage over the conventional: Whereas the conventional system must create a perfect schedule for a full quarter or semester or year, the new system can tolerate an imperfect schedule for a week. A series that loses out one week automatically receives a higher priority by virtue of its composite selecting queue substantially increasing in value the following week.

Another advantage of the new system is the fewer classes that need to be scheduled. With more holes, the controlling software would have an easier time scheduling. The fiber-optically-linked video network, which would provide simultaneous access to many series, should be very helpful.

Particularly well-taught series would be available on video tape for review or preview by students who have completed a large number of segment tests and are awaiting scheduling.

As for actually scheduling series by controlling software, I have been told, by two authorities on computerized class scheduling, that it is a manageable situation. A linear programming technique, called the assignment method, is used. The KORBX System, which is licensed by AT&T Bell Laboratories and employs the sophisticated Karmarkar's algorithm, looks very promising. I am anticipating that the network control center's coordinating computer may not do the actual scheduling. Instead, all the data would be accumulated and sent over a high-speed digital link to a service bureau, which would have a super-computer. A super-computer could model quite a few schedule combinations in just a few minutes before arriving at the optimum one.

Modern super-computers are unbelievably fast. For example, Control Data Corporation's liquid nitrogen-cooled ETA10-G, in its full eight-processor configuration, has a peak calculation rate of 10,000,000,000 floating-point operations per second (IEEE Spectrum, Jan. 1988, page 30). So I am not worried about the effectiveness of computerized class scheduling – even for a network of the typical scale of 50,000 students. I would still want a human being in charge, though.

Another interesting possibility is to temporarily link a number of computers from throughout the network into a parallel processing array. Clever programming may allow partitioning the scheduling process among the different computers.

The federal government has selected the university of Nevada-Las Vegas for a $30,000,000 super-computer to be installed 1990. Obviously, a linkup with the CCSD is worth pursuing for scheduling the network.

Q. Do you have any other computer concerns?

A. Yes. The system, on the huge scale it must have to ‘free-wheel’, would require extremely large data storage capacity. All of the segment tests and CAI-type lessons for all segments of all courses must be available on-line at all times. There would be a tremendous amount of overhead involved in keeping track of everything and ensuring that the system ran smoothly. The system places extreme demands on computer technology for user-friendliness, connectivity, reliability, economy, speed, and storage capacity. But technology continues to roll along making fabulous progress. If computer technology can't pass muster now, it should certainly will a decade from now.

Q. Would a student be penalized if a student is taking a not-overly-popular course that has a difficult time filling its quota?

A. This could be taken care of by ‘pacing’ the course (explained above) and networking schools (also explained above).

Q. Do you have any suggestions as to how people could evaluate and compare the new system to the conventional one?

A. Yes. One of the first chapters above includes a fairly comprehensive list of systems design objectives. Assign a number, ranging from zero to one, to each objective. If a system doesn't achieve the objective, give it a zero rating. If the system fully achieves the objective, give it a one rating. If the system fractionally achieves the objective, give it a relative number, such as .3 or .8. Evaluators may want to add their own objectives. I exercised this once and came up with a total rating of 18.4 for the new system and 7.4 for the conventional. In other words, I had rated the new system roughly two-and-one-half times better than the conventional system - not terribly scientific but, nevertheless, indicative.

Q. ‘Minimum student credit load’ is not good enough. A load that might be an adequate challenge for one student might not be challenging enough to another. On the other hand, the maximum load would be different for each student, and would have to be constantly re-evaluated. I question the wisdom of always requiring the minimum of effort when requiring the maximum might encourage more productivity.

A. A very good question. The minimum student credit load is an absolute necessity for colleges which award academic degrees which are highly prized for their financial rewards and social prestige. In the conventional system equivalent of ‘junior high school’, some students don't care about school or are just plain lazy. A minimum credit load would be a perfect excuse for truancy. The question, "Is it the function of schools to baby-sit, or to teach?", has been around for a long time. I would prefer to think that the new system would be more fun, and less of a grind, than the old one. If students enjoy the new system more than the old, then I would expect they would be more inclined to stay in school.

I would recommend that students receive counseling on a monthly basis. Their progress can be reviewed and, at that time, they can be encouraged to carry a heavier load. In practice, I think we would find students constantly shifting speed, depending on their success in mastering the subject matter, sickness, pressure from extra-curricular activities, ambition, family problems, and even the weather. Senior high schools, in particular, might find it profitable to set minimum honors program loads, normal loads, etc. Re-programming the controlling software would be relatively simple.

Q. How would a network degrade if at least some of the teachers go out on strike?

A. If the strike is not inordinately long, a network would be able to recover more quickly than the conventional system. That is, if the students can still attend school, and substitutes and proctors are obtained. Segment testing, CAI, prerecorded video cassettes, and books are still available. Since the students are already accustomed to a greater degree of independence in their studying than in the conventional system, their activity would be more purposeful. While at least some of the series would be suspended for the time being, if the computers are still running, the composite series selecting queues will still be increased every week of the strike. (Notice how useful is the composite series-selecting queue (with quota)).

When the strike is over, the software will choose the series with the greater composite series-selecting queues first. If increased hours are available for a while, the students can catch up on their series, and the teachers will be able to earn back some of their lost pay. After a few weeks or so, the system will catch up with the students and settle back to its normal dynamic equilibrium.

A second level of degradation is where a local school's mainframe, for example, is sabotaged or struck. The students will still have their course study guides and will be able to study with some guidance and purpose. Students who own computers and VCRs will be able to study CAI-taught segments, texts, and videotaped segments, series, and lectures. They can even view normally telecasted series which had been pre-recorded for emergencies such as strikes.

The first few days after the computers start operating again, the students can catch up on segment tests for the segments they have studied. The type of series-selecting queues which counts the number of students eligible for series would dominate the series selecting criteria for the first week or two until the system resumes its normal the dynamic equilibrium.

Q. Would the new system teach students how to THINK? Would they have the ability to verbalize thoughts and write in essay form?

A. Several reviewers of the original version of this document had confused the network with computer-assisted-instruction (CAI). I am reminded of the arguments Alexander Graham Bell had with the communications ‘experts’ of his day. They couldn't understand why the public would want to buy a telephone since it didn't provide a nice, written record of what had been communicated. The telegraph didn't have that terrible handicap.

Other than segment-testing students, the controlling software is mainly concerned with running the system. Of course, there is nothing to prevent offering CAI as an option. It does bring up the question, “What should be done about those portions of subject matter for which it is meaningless to administer segment tests?”. Fortunately, there is an easy way around this, otherwise the new system would have been unacceptable.

Passing a segment test is normally an input datum to several different software routines. Such an input can be replaced by a faculty member entering the fact that a student has satisfactorily completed the requirements for a segment or segment-group from a terminal. In some cases, several series could be combined into a short course where the student would undertake an intensive, in-depth study of some narrow subject and write an essay demonstrating his/her understanding. If not done too often, this could make a nice break in the students' routine. Other segmented courses might be slowed down temporarily, but there would be no disruption in their sequences, and the student would still be maintaining a reasonably constant academic load.

Q. Nevada has an unusual number of students who are really way out in the boonies; consequently, daily bus riding to a school of any appreciable size is not very practical. Could installing networks at Reno and Las Vegas be of any help?

A. I am aware of efforts to use Nevada's only satellite TV channel for beaming classes to local equivalents of one-room schoolhouses. Fiber-optic cable and microwave transmission are probably too expensive. Very recently, I heard about a scheme for transmitting 105 television channels on an infrared beam. Infrared may prove to be a practical means of linking rural schools, no matter how small, to either of the two Nevada networks. Each rural school would then have a cluster computer or two, a combined video receiver/computer monitor for each student or two, and VCRs. Torsion field communications would greatly enhance communications capabilities between cities and rural areas.

Q. what disadvantages do you see with the new system, as compared to the conventional one?

A. The disadvantages are as follows:

The conventional system is so simple that about all a student needs to know to be successful is which chair to keep warm each day. It has been suggested that the new system may be too dynamic for students and teachers to handle. Because the equipment and software can be installed in parallel while an existing conventional course is being taught, converting over a course should go surprisingly smoothly. A course is not fully turned on within a network until the students and teachers are thoroughly trained and accustomed to it while the course is simultaneously running in both modes.

Another problem I see is that, once the system is up and running, it would be difficult to revert to a conventional system as students would have drifted out-of-sync with each other and conventional schools. However, de-synchronization is one of the major objectives of the school network. The time-honored tradition of the 'graduation ceremony' might have to be abolished since it would not be practical and may even lose its meaning, if it ever had any. Monthly network-wide graduation ceremonies might be acceptable.

In spite of the continuing remarkable progress in computer and transmission technology, the system's hardware and software could cost too much to implement. I'm betting it won't.

Teachers could have trouble compiling and validating questions for frequent examinations on top of the segment test repertory.

'Wearing out' a course could conceivably happen.

Let's review briefly what the teachers would be doing on a day-to-day basis. Basically, there would be a wholesale shifting around of their workload. There would be less time spent preparing and giving lectures. There would be more or less time spent compiling, proctoring, and grading examinations, depending on the size of the network. There would be more time spent tutoring, counseling, and on special projects. Some of the teachers would not like it and would be inclined to work at schools still clinging to the conventional system.

They would be able to take vacations at any time of the year, rather than be in locked-step with the holiday and vacation schedules of conventional schools. Substitute teaching would be reduced.

Instead, substitute teachers would be brought into an enlarged pool of qualified teachers that the controlling software would draw on when scheduling series. Some of the teachers would be spending a little time each week monitoring courses at a terminal. Teachers will also be administering non-computer-gradable segment tests.

If a segmented course had been running for at least a half-year, a newly-hired teacher would have to learn the subject matter for the entire course before he/she would be qualified to teach it. They would not have the opportunity to learn the course along with their students. It would be unpredictable as to which course they would be teaching at any one time.

Some students are "workaholics"; their motto is "Thank God, it's Monday!". The conventional system gives them an enforced rest when school is not in session. The temptation is there, in the new system, for them to keep on studying segments when they are supposed to be on vacation. When they return from vacation, they might be able to pass segment tests for several weeks of normal course-work the first day. Now, some people would applaud them, but others would raise vigorous objections out of concern for their mental health.

An interesting case is the mathematical genius who races through his/her math courses for the sheer fun of it, and is no longer shackled by the conventional system. A very bright and energetic student could be studying calculus by the time he/she enters the conventional equivalent of senior high school. I sincerely believe that the students and teachers would prefer the new system to the conventional system. They might even start demanding school networks once the word gets around. A number of people, after having read earlier versions of this proposal, have told me how they would rather have attended school under the new system than the conventional.

The school network requires a very reliable computer system. I don't believe it would survive a shutdown of more than a week. In case of a catastrophic failure, the current series schedules could be ‘frozen’ and changes could be made by hand to reflect the status of the courses. After a week or so, however, pressure would build up for the normal complete re-scheduling. Students would find it very frustrating to study a segment, go to a terminal to take the segment test, and discover the computer to be ‘down’. An airline reservation system, for example, could afford to pay for redundancy to ensure a stable system. The expense of that extra reliability could price the system out of the financial ability of a school district. Again, I am betting that all computer-related problems can be solved.

The students in a conventional course have the problem of catching up if they fall behind. That is not a problem with a completely free-wheeling segmented course. However, there is a potential problem that is the opposite with the segmented course. A segmented course, theoretically, has a certain number of classes, i.e., series, that must be attended. There probably wouldn't be as many as in a conventional course, but there would be some. The ambitious student, zipping through his/her segmented course, could become eligible for quite a few series. The system could then fall behind the student. The student could be allowed to substitute video cassettes from the library for at least some of the series.

One minor question I have been unable to resolve is, ‘What do you do with students who can't demonstrate adequate understanding of a segment, even with the aid of tutoring and CAI?’.

The superlearning technique has been repeatedly demonstrated to bring ‘slow’ students up to par with other ‘average’ and even bright students.

I don't believe the new system is suitable for kindergarten. Not even the conventional system is suitable for the little rascals. So when should a child be turned loose? How about the ones who are not mature yet? Bad feelings could arise when Johnny sees Sandra whisked off to ‘computer-land’ while he remains under the firm thumb of Mrs. Jones.

Q. Do you have any suggestions for comparing the costs of the new system to the conventional system?

A. Yes. My favorite tool for analyzing social and economic problems is ‘external vs. internal cost accounting’, and the method's corollary, the 1000-year cost. It is easier to illustrate the power and elegance of ‘external vs. internal cost accounting’ with examples than it is to explain it. I arrive at the 1000-year cost this way: After another 100 years of progress, we probably will have a few non-renewable resources left in the ground. We are unlikely to have any non-renewable resources left in 1000 years. Ten thousand years is a little too long to worry about.

For example, let's consider garbage. Is it desirable to continue dumping garbage in San Francisco Bay until it is a plateau 3000 feet high from the Diablo Range to the Santa Cruz Mountains? Clearly, the answer is ‘no’; but the Bay is still being filled. The answer ultimately has to be an internalizing of the external costs involved with garbage until the mechanism of price alters the current scheme of things. A simple, and just, method is to judiciously apply a consumption tax on products in the market place to

reflect the external costs of their manufacture, disposal and pollution. Consumption taxes could be compensated for by reductions in income taxes.

I saw a spectacular demonstration once with respect to automobiles. In today's dollars, the conclusion arrived at was that driving a car to work in San Francisco costs over two dollars a mile! (Curious readers can find the calculation in pages 318-324 of the Handbook of the San Francisco Region by Robert H. Dreisbach.) It should be obvious that internalizing the cost of automobile driving from the beginning of the twentieth century would have resulted in a different, possibly more pleasant, lifestyle in greater harmony with Mama Nature.

Fully calculating the costs and benefits of course networking would have to wait until the machinery has been running for a few months. In the meantime, it wouldn't hurt to do a little forecasting. Some anticipated benefits are more of a hope than a determination. Some internal benefits are fairly easy to calculate.

The physical plant of our schools would be more efficiently utilized by not shutting them down every summer. An interesting benefit of television networks is that busing to facilitate racial desegregation would become pointless and irrelevant. That would save vast amounts of time, money, and fuel.

Students in wheelchairs or on crutches could stay in their cubicle and attend televised classes rather than struggle from classroom to classroom.

External benefits can be more difficult to calculate. How does one calculate less crowding of favorite vacation spots, such as Yosemite and Yellowstone National Parks, during the summer months? If the new system would result in reduced illiteracy and more satisfaction with less resentment among students, how does one measure the benefits of a hopefully reduced crime rate?

The additional machinery would certainly result in higher electric bills for the schools. The external and internal costs of increased generating and transmission capacity should certainly be factored in.

I am anticipating that each network would need an electronics technician to maintain the computing and television equipment. Each master network control center might find it necessary to establish a technical support center. The number of teachers required for the new system would be highly dependent on the economic constraints placed on each series, such as the different kinds of quotas.

Currently, children are required by law to attend school from kindergarten through age 14-16. In the future, if a child starts playing with a home computer at the age of three and is reading, typing and doing math at the age of four, school boards may find themselves being asked to accept four- as well as five-year-olds in kindergarten, and that would certainly increase costs. This might be unwise in the conventional system but very easily facilitated in the new system. I am keenly interested in seeing how students would respond to a free-wheeling environment instead of the locked-step pace of the conventional system.

Q. Since series containing examinations would not be scheduled as often as the smaller series, students could occasionally be waiting an excessively long time for mid-course or final examinations. Isn't that a severe disadvantage for the new system?

A. Consider, first, what sometimes happens under the conventional system. I personally have had to take final examinations in mid-January on material I had studied the previous September, and that was when I was still finishing regular course-work and had to take final examinations in four or five courses in a

week's time. Since this was an accepted practice, then it should be acceptable to take an occasional examination on segmented course material that was studied maybe eight months previously. Don't forget that students will sometimes interrupt segmented courses for vacation or illness. It can also be argued that students should be tested on how well they can retain subject matter in addition to how well they had learned it in the first place.

The new system offers at least three advantages over the conventional system with regard to competitive examinations:

Provided the content of the course allows it, segments can sometimes be studied in parallel, rather than in sequence. A series containing an examination, or double-series (vertical stack of two series) for two-hour examinations, would allow for one or two review classes.

There is less waste of classroom space which is often not used during examinations and between semesters and quarters.

There is much less chance of many examinations being given at the same time. If the course monitors discover an inadvertent pile-up of series containing examinations, they can postpone one or two series.

Q. Have you considered other cycles, such as daily, semi-weekly, or bi-weekly, rather than the uni-weekly cycle used in Figure 6?

A. Yes. I think with the daily cycle, there would be too much commotion, and teachers would find it difficult to assign homework.

Semi-weekly cycles would reduce the time-lag between passing segment tests and attending series, which is an advantage. Students would be able to receive homework assignments. But the controlling software would have only Tuesday night to select, schedule, and publicize series for Wednesday noon through Friday afternoon. That would be cutting things a bit close when it comes to reliability. Of course, if the computer should fail, then it probably wouldn't very much matter to ‘freeze’ the schedule and repeat it for the second half of the week.

Another disadvantage of semi-weekly cycles is that it would require twice as many students to enable all-year free-wheeling. Bi-weekly is too slow and ponderous. I feel the most comfortable with the one-week cycle. It provides a psychologically very necessary sense of routine. It has some tolerance for computer down-time at the crucial scheduling-time. It allows teachers and students to plan ahead. It allows them some time to respectively compile and study for examinations. The only other possibility I can think of is to alternate between full- and half-weeks, but that would be very confusing.

Q. Why are you being so very thorough in specifying the functional details of the system?

A. To minimize, as much as possible, the cost of developing the controlling program. Some years ago, I ran a very small project where, among other things, I had to direct a computer programmer what I wanted done. I learned a hard lesson when the programmer had to restart almost at the beginning because of a ‘small detail’ I had overlooked.

Q. How do you feel students who have difficulty keeping up with the system, and who may even be semi-literate, should be handled?

A. Students having difficulty following the system could be literally ‘walked around’ by more mature students they could be paired with. From the student's point of view, I do not believe the system is unduly complex. Normally they would be doing what they were told to do, although it is tempting to be cynical about this when parents have difficulty persuading their children to take out the garbage!

Unusual attention to user-friendliness to both students and teachers will be required when writing the software. Obviously, the menu-driven approach is the way to go.

Q. Will all teachers be required to operate computer terminals?

A. No. Only teachers selected as course monitors would need to be fully trained to operate the computer terminals. Other teachers would continue lecturing, grading homework, etc. These other teachers would be provided minimal computer training and access to a subset of the full set of course monitoring menus. All the teachers would be furnished a weekly schedule, along with the students.

Q. How would using the new system affect local school boards?

A. I have long admired the democratic aspect of local control of our schools. Thus it is with a feeling of sadness that I expect local school boards would have to give way to network-wide school boards. The schools in a cooperative network would have to be managed in such tight inter-relationships that local administration is not likely to remain practical.

Q. An important premise of the new system is that the series are taught independently of the students' place in the segmented course. Segment tests are taken before students attend series where teachers do the actual lecturing. Does this make sense?

A. Yes. It is assumed that CAI, better textbooks, video tapes and study session instructors available to answer on-the-spot questions would make the difference. Qualified teachers would be available to answer questions either locally or on the television network. Note that the system allows the reversal of the prerequisite graph when the course content dictates that it is better for students to attend series before studying segments. A real advantage of having several qualified teachers available on the network is that students could avail themselves of several points of view on a question.

Q. Now that the design of the system apparently no longer contains any major problem areas, how do you foresee the actual development of the system?

A. The standard Silicon Valley routine of obtaining venture capital and starting up a new company doesn't seem to be appropriate in this case. The major problem with that approach is that it represents a financial investment with expected financial return at some future date. Because of the severe political problems involved in drastically re-organizing our school systems, the last thing we would want is a product prematurely rushed to market simply because someone wants to ‘make a buck’.

For the time being, it should be handled as a university research project. We could take our time shopping for the best equipment, piecing together the system, and writing good, reliable software. Once the system is running in the laboratory, move it to a model school, scale-up the system by adding peripheral gear, and teach a few courses to volunteer students. After gaining experience and debugging the system as much as possible, demonstrate it to the professional educational community. Then the most important decision must be made: Is it really a better design than the conventional system? If the answer is ‘yes’, then we could let up on the brakes and have the system standardized and marketed by private industry. If the answer is ‘no’, then the system should make an interesting exhibit at the Foothills Electronics Museum.

Q. When I walk into a classroom, what would I see?

A. I think there would be four different types of classrooms. One type would be a television studio classroom where local series would be held and broadcast. One operating mode, which is sometimes used by the Stanford Instructional Television Network, has the instructor seated at a desk. One camera is focused on the teacher, while another is focused on an area of the desk, much in the manner of an overhead viewer. The teacher would place diagrams and written material on this spot.

The other mode of the studio classroom requires a camera operator.

A television studio classroom could be equipped to operate either with or without a camera operator. The teacher should have some sort of computer-linked video console or teleprompter with a variety of functions such as were described above.

When studio classrooms are not being used for a series, the facilities could be used by teachers tutoring students in other schools or answering student questions. The camera mounted over the teacher's desk can be used to show diagrams, etc.

The second type, the ‘computer classroom’, would be laid out more like an office bullpen. Each cubicle would contain a microphone, headphones, student computer or, more likely, student terminal which is on-line to either the computer network, the video network, or a video cassette playback device.

A variation of the computer classroom would be used solely for confining disruptive students and isolating them from the main student body. Really obnoxious behavior cases would even have enclosed cubicles so they can't be heard and have no eye contact with other students. But such students can still study and attend telecasted series. They also may benefit by being removed from the interpersonal stresses of the typical classroom.

The third type of classroom would be the laboratory. The current status of equipment bench places would be available, and facilities could be allocated on request from on-line terminals.

The fourth type of classroom would be the examination room. Network-wide examinations would be proctored here.

Another type, which I have seen used but don't recommend for school networks, could be termed a ‘video receiver classroom’. Television monitors would be placed around the room, mounted on the walls. Each seat would be equipped with a headphone and a microphone. In most areas of the room, more than one monitor could be viewed. A local programmable audio switcher would configure the headphones so students would listen to the audio channel for the series on the monitor for which he/she is scheduled. If the series is a local video tape, the microphone would not be activated. If the series is carried over the network from another node, the microphone would be enabled to carry voice feedback to the lecturer.

The video receiver classroom is less advantageous than the computer classroom. The logistics would be much simpler if every student has his/her own combined computer monitor/video receiver and video cassette playback device.

Students would be switching between a classroom envrionment, studying, and an office environment. Both video receiver, if used, and computer classrooms would each contain a desk and terminal for teachers.

It would be cumbersome and not likely to work very successfully, but classrooms could also be divided with movable partitions. The controlling software would schedule series of similar size for consecutive hours, if possible.

Q. It was rather generous of you to take the time to design a new educational system. Do you think you might someday design a third system?

A. I have thought of starting over again on a radically new system. While it would be nice to believe that a radically new system could be possible to design, it is discouraging to note the instances of duality between the conventional system and the school network. Duality implies that other possibilities are excluded.

The conventional system teaches in serial format; the school network would teach in parallel format.

Vacation periods are fixed under the conventional system; the school network would allow vacations at any time for both students and teachers.

The conventional system is haphazard with respect to quality control; the school network would ensure quality control with segment tests.

The conventional system measures academic loads with credits; the school network would measure academic loads with credit load units.

The conventional system groups students into grades kindergarten through twelfth, undergraduates and graduates; the school network would group students into student interest groups, when they are grouped at all.

The conventional system schedules students into courses at the beginning of each semester; the school network would use a totally unrelated series selection and scheduling scheme.

The conventional system forces a constant, unrelenting workload on teachers and students alike for fixed periods of several months at a time; the school network allows variable loads for unrestricted periods of time.

In the conventional system, the teacher has the primary responsibility for education. In the new system, without meaning to downgrade the teachers, the network has the primary responsibility for education.

The conventional system offers a simple method for keeping chairs warm; the school network is a constant game of musical chairs except there had better be enough chairs when the music stops!

Q. And what if there are not enough chairs when the music stops?

A. In the conventional system, when scheduling an overcrowded school, there is time for school officials to set up mobile classrooms, add more chairs to existing classrooms, and so forth. Thus the school at least has a chair for each student to keep warm until the end of the semester or school year. A school network with weekly scheduling has to pretty much operate like the proverbial mechanical clock with many interlocking pieces.

One likely source of fatal trouble for the school network design lies in the rather formidable logistics of scheduling terminal usage and studio classrooms every week – even with AT&T Bell Laboratories' powerful KORBX System. Having students not attend series of classes every single week should make it easier for the KORBX System to schedule the network.

It may also help the KORBX System schedule the network if each school had an overflow classroom with terminals connected to the computer system and video disk or cassette players, but NOT to the computer-controlled audio- and video-channel switchers. The need for such an overflow classroom is another of several network design problems which can be solved probably only by applying operations research techniques.

Q. Recent newspaper reports have warned of serious future teacher shortages. Do you see where school networks might be able to mitigate such a shortage?

A. It is likely that the school network would make teaching a more attractive profession. Teachers would be able to take vacations at any time. Their workload would be more varied and less of a bore. Since the school network features built-in quality assurance and mutual support from many other teachers in the network, they would feel less pressure and anxiety as to their teaching ability. It would be undesirable, as there is a qualitative difference between the presence of a flesh-and-blood teacher in a classroom and a televised image, but, if a network were short of teachers, the only choice would be to rely more heavily on more machinery, video tapes, and larger television audiences. A key advantage of the new system is that it would be far easier to recruit teachers for a number of one-week series of two or three classes than for one-year courses.

Q. Do you have any hope of reducing truancy?

A. Yes. Students are apt to become emotionally involved with their student interest group(s). So that they can stay in step with their student interest group, they would be motivated to keep up. Other students within the group may occasionally spend a little time helping them (and themselves) learn the material so that they can stay within the group.

Q. How could the networks handle disruptive students?

A. Separate them from the other students and teach them entirely, with some supervision, with TV and computers. When they tire of ‘solitary confinement’, they then can think about rejoining society.

Q. (From a database analysis supervisor) What I suggest is revisiting the content to decide if you want it exactly as is, or should you rewrite the proposal based on new technology. I say this because your original proposal for a fiber optic school network is now very simply online classes. My second thought is that 20 years ago, learning outside of a traditional classroom was a radical concept. Today, universities offer class formats that range from 100% in a classroom, to 50/50 blended, to 100% online.

To revisit your central idea, have you considered differentiating the benefits of learning through computer hosted courses from the technology used to host courses? As an example, the classes I teach at Keller Graduate School have a course shell where students participate in online discussion threads, submit homework, take exams, and share files. I also remember an article from several years ago where Harvard University posted the content of most of their vaunted Harvard MBA program online for free. If you reread your proposal, my guess is that you will quickly find areas where the benefits of computer aided study and more specifically the CRIPNETS are still there, but the technology to deliver computer guided classrooms has come a long way.

A. If anyone doubts that the school network makes any sense or is even now obsolete, all I have to do is point to the chaos in the schools and compare.

Some years ago I read about a high school in east Las Vegas that has a turnover of students of 40% to 60% each school year. The school network offers the advantage of dividing up the courses into segments and teaching them in parallel all year around. If a student transfers into a school network, he or she simply can start with the appropriate segment in a segmented course and continue rather than be out of sequence.

If a student or teacher get sick or wants to take a vacation anytime during the school year, no problem.

I still think the school network is worth spending some money on to see how far it can be expanded and utilized.

Q. Shouldn't you be hesitant about specifying things that should be the specific province of those with Ph.D's in Education?

A. Not at all. I feel quite comfortable engineering the system since I have had considerable experience with both computer and television systems far more complicated than this. It is true that I have no business telling professional educators how to use this new tool. It would be like my directing an actor how to perform before a television camera. I do have an electrical engineering education, which probably gave me better training for systems engineering than the training teachers typically receive.

My father was a highly regarded high-school teacher and superintendent for many years so I have the greatest respect for the demanding profession of teaching. I have tried to design the best possible educational system which must satisfy many sometimes conflicting requirements. I personally can not use the system, but I would be happy to help build it. The professional educational community must make the final decision as to whether to use the system as I have designed it, or with modifications.

CCSD FIBER OPTIC NETWORK QUESTIONAIRE

The Clark County School District (CCSD) is based in Las Vegas, Nevada. The CCSD Fiber Optic Network Design Project, a group of volunteers, is pleased to offer a vision of how to substantially improve our schools by fully utilizing today's powerful new technologies. The school network would provide a framework for addressing the issues of information dissemination efficiency and effectiveness in the face of increasing student population and demands for improved performance. However, the subject matter taught within the framework would still be determined by the teachers and administrators of the school district.

The school network is largely a computer-video interactive network. All of the junior and senior high schools in the CCSD would be linked into a single audio, video, and computer network with fiber optic cables. The CCSD network would be a pilot project. The technology is now available to permit system development and installation by 1995.

The school network provides quality control while allowing students to progress faster or slower through material as permitted by their abilities and circumstances. The teachers are freed from routine clerical work so as to provide more time for student interaction. The administrators are provided with solid data on student performance on a weekly basis. The fiber optic cables eliminate long-distance busing for racial desegregation since the students are all provided equal access to instructional resources. Schools are not wastefully shut down for fixed periods of vacation.

The conventional system teaches courses in serial sequence. In contrast, the school network would divide the courses into segments of a week or so in length, and then teach all of the segments in parallel all year long. Whenever a student is successfully tested on a non-graded basis by computer as having learned a segment, he or she may immediately advance to the next segment in the course without waiting for the other students. If a student fails a segment test, he or she goes back and studies the segment again before taking another segment test. Thus the teachers can monitor student progress and provide either help or further enrichment as needed. Also, the students can be absent due to illness or vacations at any time of the year and pick up where they left off without missing any material. Transfer students are able to enter any course at any point at any time of the year.

At the same time, classes and graded examinations are frequently held throughout the twelve months of the year so as to dovetail in various ways with the segments. In addition, modified versions of two sophisticated management tools, Programmed Evaluation and Review Technique (PERT) and the Critical Path Method (CPM), enable the teachers to administer and teach the segmented courses with a multitude of previously unavailable features and options.

To help the students and teachers efficiently handle the moderate bookkeeping, a three-layer computer hierarchy is integrated with the fiber optically-linked audio and video network. At the top layer, an on-line network computer coordinates the entire network. This network coordinating computer also controls the audio and video channel switchers at the network control center so that audio and video signals are routed through the fiber optic cables to the correctly addressed schools. The entire network of students, teachers, classes, and equipment is rescheduled every week all year long with an off-line KORBX System made by AT&T Bell Laboratories.

At the middle layer is the administrative computer in each school. The administrative computer controls the audio and video channel routing switchers within the school with commands received from the network coordinating computer. The administrative computer also tracks student attendance with bar code readers which read student identification cards. During a class, the administrative computer provides the teacher via computer-controlled teleprompter several types of status information concerning the telecasted class. An assortment of system administrative services are also provided with the aid of cluster computers.

At the bottom layer is a large number of cluster computers with access to the administrative computer, a printer, and either magnetic or optical disk storage. Each cluster computer services 8, 16, or 32 on-line faculty and student terminals. Each terminal can either receive computer data or video. The computer software supports approximately 75 different input/output functions for the teachers, and approximately 25 input/output functions for the students – only one of which is computer-assisted instruction.

Students may begin any course at any time of the year. Simultaneously, a student can be starting a course, finishing a second course, and be halfway through a couple more courses. While attending each course, students can be exposed to a variety of teachers from throughout the network. When not prerecorded, classes can be either local, televised to other schools, or both.

Thus classes will have enough students from throughout the network on the average to be cost-effective even when repetitively taught all year long. Now semester-length courses can be taught only twice a year, and even a quarter-length course can be economically taught only four times a year if a single school can attract enough students to the course. But, with a video network of many schools, week-long segments of courses may be taught economically and repetitively all year long.

Examinations are graded and recorded in the same manner as in the conventional courses. Academic standards are maintained by the computer system which continually keeps track of student workloads by totaling and then averaging over the past few months fractional credit load units assigned to completed course segments.

The segmented courses can be shut off for occasional lengths of time to permit bunching up of students into groups which can then be paced to a certain extent. Grouping can thus reduce the number of students, and still retain a high student-to-teacher ratio to hold down costs. Otherwise, the practical scale of a school network is so large that the only foreseeable application lies in junior and senior high schools within districts of at least 50,000 students.

Students may also voluntarily organize themselves, with the aid of the computer software, into student interest groups for sharing common interests and local classes (which would usually still be televised). These student interest groups can, when desired, provide most of the social functions currently associated with ‘grades’ such as ‘class reunions’. Yearly ‘class graduation’ ceremonies at a single school would be replaced with monthly network-wide graduation ceremonies.

Note that the conventional system happens to be a small-scale, static version of the full-scale, dynamic version of the school network. Thus many of the school network concepts such as classes and examinations are still very familiar. The more unfamiliar concepts would include quality control of the students' education, automated class attendance listing, student interest groups, the elaborate scheduling procedures, fiber optic networking, and nearly unlimited self-paced learning.

Any of 187 validated accelerated learning systems could easily be incorporated into a school network. The school network's extreme flexibility would allow much more effective use of such accelerated learning techniques since students will be able to learn as fast or as slow as their abilities and circumstances allow, continue to enjoy interesting discussion classes and the social functions of student interest groups, and be assured of quality control of their learning.

Copies of the school network design are available at www.padrak.com/vesperman. Suggestions for design improvements are most welcome!

Please mail completed questionaires to:

Gary Vesperman
588 Lake Huron Lane
Boulder City, NV 89005-1018

1. In the conventional system, students are arbitrarily grouped into grades K through 12. The school network organizes students, on a voluntary basis, into student interest groups which may meet for local classes. Should students be grouped on the basis of their age, or interests and abilities?

Age _____ Interests and Abilities _____

2. Do you agree with the school network's objective of easing the transfer of students from other schools into the Clark County School District so that they don't have to cope with gaps and duplications in subject matter?

Yes _____ No _____

3. Should the relative competence of students be measured with graded course examinations?

Yes _____ No _____

4. Should academic standards be maintained by measuring student credit loads and ensuring that the students don't dip below a minimum rate of progress without penalty? (For example, most schools require that students attend a fixed number of hours of classes per week per semester or quarter.)

Yes _____ No _____

5. Should routine teaching of fundamentals as quickly and easily as possible be clearly separated from in-depth teaching which inspires and challenges students to think?

Yes _____ No _____

6. Should final examinations be spread out as allowed by the school network rather than concentrailed into one week or less at the end of each semester?

Yes _____ No _____

7. The school network could provide better instruction by making possible continuous and sustained small improvements. For example, the school network would offer more recorded lectures and fewer discussion classes than the conventional system. Should the school network be allowed to increase the proportion of the things constituting an educational system that can be stored piecemeal over that of the conventional system?

Yes _____ No _____

8. Is it efficient and cost-effective to have school buildings and equipment shut down all summer as necessitated by the conventional system?

Yes _____ No _____

9. Or should schools be open and fully utilized all year long as required by the school network?

Yes _____ No _____

10. The conventional system provides quality control by forcing students who have failed a course to wait all summer before starting the course over again the following fall. The school network assures quality control by giving each student a short quiz after the completion of a segment of a course. If the student passes, the student may immediately move on to the next segment in the course. If the student fails, he or she studies the segment again, without having to keep up with other students as in a conventional course, before attempting to pass a similar quiz on the same segment. Do you prefer the conventional system's method of quality control, or the school network's?

Conventional System _____ School Network _____

11. Should students be able to proceed at their own pace as much as possible?

Yes _____ No _____

12. One of 187 validated accelerated learning techniques, the 20-year-old Bulgarian-developed super learning technique enables efficient learning of factual subject matter in short intensive periods of a few weeks in length. For example, students have reportedly learned easily and quickly up to 1000 words of a foreign language per day with 96% or better retention after three months. Should the conventional system be replaced with the flexibility of the school network so as to allow more effective use of accelerated learning techniques?

Yes _____ No _____

13. Would it be beneficial to allow both students and teachers to schedule vacations of any length at any time of the year, up to a maximum number of weeks per year, as permitted by the school network?

Yes _____ No _____

14. The conventional system forces sick students to miss classes. The school network allows students to continue a course where they left off when they return to school. Do you prefer the conventional system or the school network in this situation?

Conventional System _____ School Network _____

15. Is it beneficial to provide quick implementation when revising course subject matter and improving learning methods?

Yes _____ No _____

16. Would a school network's wide variety of teachers be preferable to a single school's limited !;election of just a few teachers?

Yes _____ No _____

17. Manufacturing companies frequently employ elaborate procedures to assure consistently high quality in their products. Similarly, the school network provides separate, non-graded testing to ensure thorough understanding of fundamentals and thereby reserve the major course examinations for the purpose of grading students. Would this method improve academic performance?

Yes _____ No _____

18. Would you prefer the fixed schedule of the conventional system, or the scheduling flexibility of the school network?

Conventional System _____ School Network _____

19. Should the school network be allowed to provide for the optimum number of classes rather than a fixed number of classes for each course as required by the conventional system?

Yes _____ No _____

20. Would it be helpful for students to be able to start, interrupt, and finish courses at any time of the year?

Yes _____ No _____

21. Should the school network be completely compatible with the conventional system? (Courses can be scheduled in a school network just like conventional courses when desired.)

Yes _____ No _____

22. Is the conventional system's busing to facilitate racial desegregation preferable to the school network's electronic racial desegregation?

Yes _____ No _____

23. Should the schools fully exploit all technological advances such as fiber optics, video transmission and recording, computers, and accelerated learning techniques?

Yes _____ No _____

25. The annual per student cost to run the conventional system in the CCSD is approximately $3500. Please circle the largest of the following increases which you think would justify replacing the conventional system with a school network.

$0/year $50/year $100/year $200/year $350/year

$500/year $750/year $1000/year $1500/year

PROPOSAL TO NORTH AMERICAN SCHOOLS DEVELOPMENT CORPORATION

From the early 1960's until about 1990 when I added possibly the last piece of the puzzle, I had a hobby designing a high-technology educational system.

During the winter of 1992, with the backing of the Clark County School District, I submitted to the New American Schools Development Corporation (NASDC) a proposal for developing a prototype fiber-optic school network to be installed in six junior and senior high schools for approximately $12 million. Judi K. Steele acted as liaison with the school district. The NASDC was an off-shoot of President Bush's America 2000 program. Funded mainly by donations from large corporations, the NASDC was a private company chartered to fund the development of radically different schools.

We did not win a grant. There were 685 other competitors for 11 awards. Afterwards we received short descriptions of the winning proposals. None of them appeared to be as advanced as my design. Sometime afterwards, the Las Vegas Review-Journal newspaper had an article that raised the suspicion that one reason for our not winning was that Nevada was not important to President Bush's re-election!

Yet I have been authoritatively told more than once, although not recently, that no other design is close to mine, and may be the only one that has a genuine chance to break the organizational logjam hampering our schools. All the other designs I have ever come across have flaws that my design doesn't have. In fact

a few years ago I came across an article claiming that educational computer experts have come to a dead end trying to make computers more useful in the schools. The basic systems engineering obstacle, which I believe I have surmounted, is that the answer lies in a completely different, complicated system which can not be arrived at in piecemeal fashion. There seems to be much more that could be done than just throwing a bunch of PCs into a school.

The proposal (about 180 pages) included a development schedule which was tailored to the requirements as set forth by the NASDC. But I had felt uncomfortable with their schedule. It was just too fast. It would have skipped first spending a year or so doing several preliminary research projects which would examine the design from different angles. My intention was that since building a full-scale school network for a metropolitan area would cost well over $100,000,000, once the small projects were finished, we would all then have a better understanding of the costs, capabilities, and limitations of the design.

Assuming that equipment costs continued to come down, and that the pilot program worked well, the next step was to expand the pilot network into a prototype full-scale version. The engineering was to be done during the third year of the pilot program. It would then take at least a year to build, and another two years to fully make the conversion from the conventional system in all networked schools.

At the end of the project a cadre of experts would have been built up in the Las Vegas area well-versed in all aspects of engineering and operating fiber-optic school networks. A potentially multibillion-dollar business could then be spun off to market, configure, install, and maintain school networks around the world, each network averaging $100 million.

Some time ago the Las Vegas Weekly had an article on ‘five classroom problems’. The one statement that caught my attention was "... the district's east region sees, for example, a 40 to 60 percent rate of students changing schools in a given year...". I had no idea that Las Vegas schools are this chaotic. The school network, with its flexibility, built-in quality control, and previously unavailable features and options, in total may offer more advantages than the rigid Labor Day-to-Memorial Day schedule of conventional courses.

Below is a summary of the school network design:

A fiber optic cable-linked school network's three-layer computer system would comprise of a network coordinating and scheduling computer as the top layer, an administrative computer in each school as the middle layer, and personal computers as the bottom layer. The network's customized software would include network management and coordinating functions for the system manager, two layers of software for the teachers to support 100 different functions, and 25 different functions for the students, only one of which is computer-assisted instruction. Each personal computer would have a monitor capable of also displaying telecast or recorded classes — hopefully in three-dimensional holographic television.

All computers and television cameras and monitors would be linked via fiber optic cables. The typically huge scale of a school network would economically justify the simultaneous teaching in parallel of all week-long segments of each course year round with no seasonal constraints. Continued reduction of communication costs may allow school networks to be extended outside large cities. The school network's average cost may exceed $100,000,000.

Segmented courses would still include the standard features of conventional courses such as classes, graded examinations, and academic load standards. Short quizzes on each segment with pass/fail grading would provide quality control. Other nonstandard features of segmented courses include modified versions of the project management tools Programmed Evaluation and Review Technique (PERT) and

Critical Path Method (CPM), unique statistical techniques for selecting series of two or three local/televised classes for weekly scheduling, nearly unlimited self-pacing, student interest groups for replacing personal self-identification of students with artificial groupings into “grades 1 through 12”, and optimum utilization of the superlearning technique.

Perhaps the most difficult aspect of the school network to understand is that it is a dynamic system, fully controlled by teachers acting as system administrators or course monitors. The school network is projected to compare favorably with static, partly uncontrolled conventionally taught courses.

Proposal
to
New American Schools Development Corporation
for a Prototype

Fiber-Optic Network of Computer-Based Segmented Courses

Las Vegas, Nevada

SUMMARY

FIBER-OPTIC NETWORK OF COMPUTER-BASED SEGMENTED COURSES Gary C. Vesperman, Vice President and Chief Operating Officer, Film Funding, Inc., 1700 East Desert Inn Road Suite 100, Las Vegas, NV 89109 (702) 735-1922 FAX: (702) 735-0094

(Film Funding, Inc., a Nevada corporation, no longer exists.)

One dozen to four dozen junior and senior high schools in each large metropolitan area are to be linked with fiber-optic cables into a single network with an average cost of $100,000,000. The Clark County School District is proposed to be the site of a small-scale prototype network of three junior high schools and three senior high schools with a budget of $11,897,400. Younger students would be transported from nearby elementary schools for experimental classes in order to research their capabilities for interacting with the increased complexity of the school network.

The network's three-layer computer system would comprise of a network coordinating and scheduling computer as the top layer, an administrative computer in each school as the middle layer, and personal computers as the bottom layer. The network's customized software would include network management and coordinating functions for the system manager, two layers of software for the teachers to support 100 different functions, and 25 different functions for the students, only one of which is CAI. Each personal computer would have a monitor capable of also displaying telecasted or recorded classes.

The typically huge scale of a school network would economically justify the simultaneous teaching in parallel of all week-long segments of each course year round with no seasonal constraints. Segmented courses would still include the standard features of conventional courses such as classes, graded examinations, and academic load standards. Short quizzes on each segment with pass/fail grading would provide quality control. Other nonstandard features of segmented courses include modified versions of the project management tools PERT and CPM, unique statistical techniques for selecting series of two or

three local/televised classes for weekly scheduling, nearly unlimited self-pacing, student interest groups, and optimum utilization of the superlearning technique.

Gary C. Vesperman, Inventor and Project Director (see above for address)
Judi K. Steele, Manager of Development and Educational Improvement, Clark County School District, 2832 Flamingo Road, Las Vegas, NV 89121 (702) 799-1042
Software developer and systems integrator to be determined
CENTEL, (local telephone company – fiber-optic cable right-of-way engineering), 330 S. Valley View Boulevard, Las Vegas, NV 89107 (702) 877-7171
Kevin Convoy, (video equipment sales representative), Perspective Measurements, 2501 N. Green Valley Parkway, Henderson, NV 89014 (702) 456-5594
Jim Mendoza and Dan Zuran, (video teleconferencing experts), NEC, 1411 West 190 Street Suite 800, Gardena, CA 90248 (213) 719-2462 FAX: (213) 719-2401
Mrs. John (Elaine) Holt, superlearning consultant, Parowan, Utah
Albert Zopp, National Sales Manager, (fiber-optic cables and interfaces), CATEL, Fremont, California (800) 827-2722

ACKNOWLEDGEMENTS

Proposal Writing and Copying Donated by Gary C. Vesperman
IBM Personal System/2 Model 50 Loaned by Computerland
Compaq Personal Computer Loaned by Film Funding, Inc.
Proposal Experience and Editing Donated by Al Lacklen, Business Development Manager, Computerland
Proposal Binding Donated by Film Funding, Inc.
Fiber-Optic Cable and Interface Equipment Information Provided by Albert M. Zopp, National Sales Manager, CATEL
Video Information Provided by Kevin Conboy, Perspective Measurements, and John Hill, General Manager, Las Vegas PBS Channel 10
School District Information Provided by Many Clark County School District Employees
Keying of Original Design Document Donated by Cyrus N. Wells, Jr., EG&G
The Enthusiastic Support of Many Friends

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AN AFFIRMATIVE ACTION
EQUAL OPPORTUNITY EMPLOYER

CLARK COUNTY SCHOOL DISTRICT

2832 EAST FLAMINGO ROAD LAS VEGAS, NEVADA 89121 TELEPHONE (702) 799-5011
FAX 799-5063

February 12, 1992

TO WHOM IT MAY CONCERN:

Please be advised that we support Gary Vesperman's efforts to investigate the applicability of optic fiber telecommunications as it relates to classroom education.

Further, if this project is funded, it is our intent to explore the feasibility of piloting the project in several of our schools.

Brian Cram
Superintendent of Schools

1 ABSTRACT

A private inventor proposes to engineer, build, and test a prototype computer-based fiber-optic school network. His subsequent unfunded requirements analysis of his local school district resulted in this request to the New American Schools Development Corporation to fund a pilot program for approximately $11,897,400. Since the program will also help accommodate future growth, top district officials have informally expressed high confidence that a development contract will be accepted.

This particular configuration of audio, video, computer, and communications equipments would simultaneously teach all week-long segments of each course in parallel all year. Thus the pattern of conventional courses taught with fixed lengths and starting times would be successfully broken with more flexible schedules and also permit more precise quality control. The advantages of this approach are significant in providing students continuous access to all parts of courses without seasonal constraints.

All technical questions should be directed to Gary C. Vesperman, 3123 Trueno Road, Henderson, NV 89014-3142 (702) 435-7947. Acting as America 2000 liaison for the Clark County School District is Judi K. Steele, Manager of Development and Educational Improvement, Clark County School District, 2832 Flamingo Road, Las Vegas, NV 89121 (702) 799-1042.

2 EXECUTIVE SUMMARY

A private inventor is pleased to propose to the New American Schools Development Corporation the engineering and test of a prototype fiber-optic school network. By fully utilizing today's powerful new technologies, the fiber-optic school network would forcefully “break the mold” of American secondary schools, and probably also the higher elementary grades.

The inventor's submittal of his design to his local school district generated much excitement about the network's possibilities. The Clark County School District (CCSD) includes all metropolitan Las Vegas area schools. The pilot program proposed to be funded by the New American Schools Development Corporation includes provision for the construction of additional classrooms. These additional

classrooms offer the rapidly growing CCSD an incentive to accept a pilot program and to implement the radical changes required by the fiber-optic network.

It is unfortunate that the fiber-optic school network may not be simple enough to allow operation by students in grades six and lower as called for by the RFP. It is also unfortunate that rural communities without access to fiber-optic trunk lines would have no opportunity to participate in fiber-optic school networks. Otherwise, national implementation of fiber-optic school networks in all large metropolitan areas should achieve a significant proportion of the America 2000 program goals. Future design upgrades are refinements are possible which will achieve the remaining goals.

The design of the fiber-optic school network would be based on a paper written by the inventor, Gary C. Vesperman, titled “Towards a Prototype Fiber-Optic Network of Computer-Based Segmented Courses” (see Appendix B). Appendix A contains a summary and questionnaire that should be answered before reading Appendix B. Appendix C describes the proven superlearning technique, which Mr. Vesperman has added on to the fiber-optic school network design.

The fiber-optic school network is largely computer/video interactive. This type of network's key distinction from all other such electronic configurations as implemented in the schools is its serial-to-parallel conversion of courses while still providing for classes and examinations. Using uniquely developed statistical techniques, the network's computer software will be designed to schedule students into local classes instead of televised classes as much as possible.

A full-scale version would link most, if not all, of the junior and senior high schools in the Las Vegas metropolitan area into a single audio, video, and computer network with fiber-optic cables. The New American Schools Development Corporation is being asked to fund the detailed design and development of a prototype version which would be smaller than the full-scale version. Yet the prototype version would be large enough to test all the features of the design. The major difference between the prototype and full-scale versions is that the prototype would cost more to operate, per student, due to the much smaller average size of the classes.

The CCSD's existing computer and television facilities are substantial and competently staffed as to be expected of the 14th largest public school district in the nation. Since these facilities do not begin to match the demanding technological requirements of the fiber-optic network, it was decided to have outside contractors engineer and build an entirely new system which would incorporate state-of-the-art equipment.

Three senior high schools and three junior high schools in Henderson and Boulder City, which are located adjacent to Las Vegas proper, have been selected for the prototype fiber-optic network. These six selected high schools' existing buildings are already full of students and have no room for additional equipment. To house as well as incidentally better protect the fiber-optic network's expensive electronic equipments, one wing of six classrooms would be built and a total of nineteen portable classrooms would be installed, all with security alarm systems.

Project management, teaching, and engineering staff would be located in off-campus office space. Thus the fiber-optic network's equipment and customized computer software could be developed, installed, and tested without interfering with the conventional academic programs in the high schools' main buildings. This would also provide early-on comparison of teaching methodologies and student achievement rates. It is understood that one of the goals of the New American Schools Development Corporation is to educate all students from kindergarten through grade 12. Additional funding could be provided for extending the network to nearby elementary schools. It is recommended that the prototype fiber-optic

network be limited to the junior and senior high schools, and instead bus the younger students from the nearby elementary schools to their network classes. Then when the design team provides technical support to other New American Schools during the fourth and fifth years of the program, solidly-based decisions can be made as to how far down into the elementary grades it would be practical to implement fiber-optic school networks.

3 DESIGN TEAM

Only a few specific types of equipment have been found which seem to be ideally suited to the fiber-optic school network. Other types of equipment such as video routing switchers and computer mainframes have not yet been identified. Not even the most appropriate computer language has been determined with which to write the network's fairly large amount of customized software.

For the first few months of the first-year detailed design phase of the program, it has been decided to award up to ten preliminary study contracts to promising computer/video system integrators. These study contracts would be in several phases and start out small and short so as to quickly focus in on those systems integrators more suited to engineering fiber-optic networks.

This weeding out process should produce two useful results: A prime contractor would be selected with the interest and engineering qualifications to build a reliable and cost-effective school network. And New American Schools Development Corporation will be assured that the design is feasible enough to continue pursuing.

Separate contracts may be awarded for examining alternative transmission media other than optical fibers such as infrared, determining optimum fiber-optic cable layouts, individual standalone equipments such as microphones and cameras, and to research the difficult problem of scheduling which is unique to the fiber-optic school network.

Seven obvious candidates for systems integrators are Apple, AT&T, Computerland, DEC, EG&G, IBM, and UNISYS. Computer Sciences Corporation (CSC) already has a strong presence in the Las Vegas as a software developer and systems integrator.

CENTEL, 330 S. Valley View Boulevard, Las Vegas, NV 89107 (702) 877-7171 is the local telephone company. They can provide right-of-way engineering for laying the fiber-optic cables.

Kevin Conboy of Perspective Measurements, 2501 N. Green Valley Parkway, Henderson, NV 89014 (702) 456-5594 is a very knowledgeable sales representative for a complete line of twelve video equipment manufacturers. He has been supportive of the fiber-optic school network design effort, and will continue to be a strong local source of video expertise.

Mr. Conboy recommended NEC, 1411 West 190 Street Suite 800, Gardena, CA 90248 (213) 719-2462 (FAX # is (213) 719-2401). NEC is a large company which is one of very few with both computer and video engineering expertise. In particular, NEC has a highly competent team in Jim Mendoza and Dan Zuran. They specialize in applying video teleconferencing equipment and techniques to colleges and schools. Even if NEC doesn't win the prime systems integration contract, Mr. Mendoza and Mr. Zuran should be excellent candidates as video teleconferencing subcontractors.

Elaine Holt of Parowan, Utah has offered to provide part-time consulting in the superlearning technique. Her degree is in psychology with an emphasis on motivation and behavior. Mrs. Holt was trained in the

superlearning technique by Richard E. Ewing, the founder of Ultimate Adventure International, Salem, Oregon.

Mr. Ewing's contribution, after twelve years of experimenting and development, is the innovation of combining video pictures with superlearning music produced with an electronic frequency synthesizer. Mr. Ewing may be available for consultations.

Numerous phone conversations have shown Albert Zopp, National Sales Manager, CATEL, Fremont, California (800-827-2722), to be extremely helpful and knowledgeable about fiber-optic cables and interfaces, and their applications in schools. He will be able to provide at no charge all selection and configuring of the fiber-optic interface equipment.

The formats of network courses would be radically changed from those of conventionally taught courses. To fully take advantage of the fiber-optic school network's new features and capabilities, experienced high school teachers will be hired immediately to begin re-organizing courses to fit the network's requirements. Once the network becomes operational during the second phase of the contract, these teachers will already be trained in teaching, monitoring, and supervising other teachers in segmented courses within their areas of expertise.

Immediately after the design team is funded for the second phase of the program, additional experienced elementary school teachers will be hired to re-organize elementary courses. By the time the network has reached operational status, and the high school teachers have had some experience using the network, the elementary school teachers will be ready to try out the network on elementary students.

The Project Director will be Gary C. Vesperman, 3123 Trueno Road, Henderson, Nevada 89014-3142 (702-435-7947). Mr. Vesperman brings a wealth of systems engineering experience to the project. He holds a BS degree in Electrical Engineering from the University of Wisconsin. In addition to being the designer of the fiber-optic school network, he brings 15 years of technical writing experience at 18 Silicon Valley electronic companies, and over five years with EG&G Special Projects in Las Vegas. The Silicon Valley companies have included Hewlett-Packard, Amdahl, Moore Systems, Mohawk Data Sciences, Timex, Ampex, Verbatim, Ford Aerospace, and Control Data Corporation.

He has written software user's guides and theory of operation/maintenance manuals for a radar system, vehicle electronics testing system for a GM luxury car assembly line, broadcast video camera, and a wide variety of computer hardware including disk drives, tape drives, I/O channel interfaces and switches, power control and distribution systems, and mainframe modifications.

In addition to providing overall project direction, the Project Director will select contractors, award them grants, supervise their work, and ensure that their reports and other products meet the requirements of the network. Taking advantage of his technical writing expertise, Mr. Vesperman will also document the electronic equipment configurations and write project reports and user guides. Other tasks will include hiring and supervising network teachers and engineering consultants as needed.

4 BASIC DESIGN

4.1 Introduction. Appendix B contains an extensively detailed discussion of the generic design and ramifications of the fiber-optic school network. This chapter contains a brief description of the design and is followed by two scenarios starring Johnny and his new dog Panther. The chapter ends with a rudimentary example demonstrating the dynamics of fiber-optic school networks.

4.2 Design Description. The school network provides quality control while allowing students to progress faster or slower through material as permitted by their abilities and circumstances. The teachers are more free from clerical work so as to provide more time for student interaction. The administrators are provided with solid data on student performance on a weekly basis. The network eliminates long-distance busing for racial desegregation since the students are all provided equal access to instructional resources. Schools are not wastefully shut down for fixed periods of vacation.

The conventional system teaches courses in serial sequences. In contrast, the network would divide the courses into basic weekly segments and then teach all of the segments in parallel all year long. Whenever a student is successfully tested on a non-graded basis by computer as having learned a segment, he or she may immediately advance to the next segment in the course without waiting for the other students.

If a student fails a segment test, he or she goes back and studies the segment again before taking another segment test. Thus the teachers can monitor student progress and provide either help or further enrichment as needed. Also, the students can be absent due to illness, vacations, or family problems at any time of the year and pick up where they left off without missing any material. At any time of the year, transfer students are able to enter any course at any point of the course.

At the same time, classes and graded examinations are frequently held throughout the twelve months of the year so as to dovetail in various ways with the segments. In addition, modified versions of two sophisticated management tools, Programmed Evaluation and Review Technique (PERT), and the Critical Path Method (CPM), enable the teachers to administer and teach the segmented courses with a multitude of previously unavailable features and options.

To streamline the administrative work of keeping track of students, coordinating classes, and providing other computer-related functions, a three-layer computer hierarchy is integrated with the fiber-optically linked audio and video network. (Figure 7 above shows a generic hardware block diagram of the network.)

At the top layer, an on-line network computer coordinates the entire network. This network coordinating computer also controls the audio and video channel switchers at the network control center so that audio and video signals are routed through the fiber-optic cables to the correctly addressed schools. The entire network of students, teachers, classes, and equipment is rescheduled every week all year long, possibly with an off-line KORBX System made by AT&T Bell Laboratories.

At the middle layer is the administrative computer in each school. The administrative computer controls the audio and video channel routing switchers within the school with commands received from the network coordinating computer. The administrative computer also tracks student attendance with bar code readers which read student identification cards. During a class, the administrative computer provides the teacher via computer-controlled teleprompter several types of status information concerning the telecasted class. A wide assortment of system administrative services are also provided with the aid of cluster computers.

At the bottom layer is a large number of cluster computers, sometimes known as Local-Area Network (LAN) file servers, with online access to the administrative computer, a printer, and either magnetic or optical disk storage. Each cluster computer would service in the neighborhood of a dozen or so on-line faculty and student terminals or personal computers. Each terminal or personal computer must include a display capable of combining the functions of a video receiver and a computer monitor.

Software would be customized for the network which would provide one set of menus for the network's system manager, two sets of menus for the teachers, and a completely different set of menus for the students. Approximately 100 input/output functions for the teachers are described above. Also described above are approximately 25 input/output functions for the students, only one of which is computer-assisted instruction.

The software for the system manager and teachers is broken down into a three-layer hierarchy. The top layer of the software is accessible only to the network's system manager who would have access to all software and switching equipment. The software's middle layer is accessible to the teacher assigned as the monitor of each segmented course. Only the software's bottom layer is accessible to all other teachers who have not been trained and assigned to monitoring segmented courses.

Students may begin any course at any time of the year. Simultaneously, a student can be starting a course, finishing a second course, and be halfway through a couple of more courses. While attending each course, students can be exposed to a variety of teachers from throughout the network. When not prerecorded, classes can be either local, televised to other schools within the network, or both.

Thus classes will have enough students from throughout a full-scale network on the average to be cost-effective even when repetitively taught all year long. Now semester-length courses can be repetitively taught only two or three times a year.Even a quarter-length course can be economically taught only four times a year if a single school can attract enough students to the course. But, with a video network of many schools, week-long segments of courses may be taught economically and repetitively all year long. Examinations are graded and recorded in the same manner as in the conventional courses. Academic standards are maintained by the computer system which continually keeps track of student workloads by totaling and then averaging over the past few months credit load units assigned to completed course segments.

The segmented courses can be shut off for occasional lengths of time to permit bunching up of students into groups which can then be paced to a certain extent. Though with a loss of scheduling flexibility, such groupings can thus reduce the number of students, and still retain a high student-to-teacher ratio to hold down costs. Otherwise, the practical scale of a fiber-optic school network is so large that the only foreseeable application lies in junior and senior high schools within districts of at least 50,000 students. It is still to be determined how far down into the elementary grades younger students would have sufficient maturity to successfully handle attending networked courses.

Students may also voluntarily organize themselves, with the aid of computer software, into student interest groups for sharing common interests and local classes (which would usually still be televised to other schools). These student interest groups can, when desired, provide most of the social functions currently associated with “grades” such as “class reunions”. Yearly “class graduation” ceremonies at each single school would be replaced with monthly network-wide graduation ceremonies.

Notice that the conventional system happens to be a small-scale, static version of the full-scale, dynamic version of the school network. Thus many of the school network concepts such as classes and examinations are still very familiar. The more unfamiliar concepts would include quality control of the students' education, automated class attendance listing, student interest groups, the elaborate scheduling procedures, fiber-optic networking, and nearly unlimited self-paced learning.

At least most of 187 validated accelerated learning systems could easily be incorporated into a fiber-optic school network. The fiber-optic school network's extreme flexibility would allow much more effective use of such accelerated learning techniques since students will be able to learn as fast or as slow as their

abilities and circumstances allow, continue to enjoy interesting discussion groups, and be assured of quality control of their learning.

The potentially productive synergism of the fiber-optic school network with the accelerated learning technique known as “superlearning” (see above) should allow learning subject matter fundamentals with much higher rates, efficiency, and retention than conventional classroom teaching techniques. The superlearning technique requires audio and sometimes even video electronics, which happen to be built into the network's hardware. With superlearning, the likelihood would be enhanced that a properly engineered fiber-optic network will meet most, if not all, of the goals of the New American Schools Development Corporation.

4.3 Johnny Learns How to Wash His Dog. To illustrate how a student would actually attend a fiber-optic school network, we shall follow Johnny as he takes a hypothetical course in dog washing. But first let's see how he would take a conventionally taught course in dog washing during the fall semester at little Mellen High School in Wisconsin's North Woods.

Johnny's parents give him a male labrador puppy in May at the end of his ninth grade. Johnny immediately falls in love with his new companion and names him Panther. After a while, Panther begins to smell, and Johnny, not knowing how to wash a dog, tries to get by with throwing Panther in a nearby lake. As the summer drags on and warms up, and the dog grows in size, Johnny decides he needs to take a course in dog washing so he could learn how to clean Panther.

Now Mellen HS offers a 15-week semester-length conventional course in dog washing, but it won't start until after Labor Day. So both Johnny and Panther suffer as Panther stinks and catches infections all summer long.

At long last, school begins in September, and Johnny begins learning how to wash dogs. But by then, Panther now weighs 25 pounds, and during the first five weeks, the dog washing course teaches how to wash only dogs under 20 pounds in size. Johnny gets a B in his first examination at the end of five weeks, but he still has to wait until October when in the course's second five weeks, Johnny will be able to learn how to wash medium-sized dogs between 20 and 60 pounds. Until then, poor Panther's smell becomes almost unbearable.

Deer hunting season rolls around during the week of Thanksgiving, and by then Johnny is learning how to wash very large dogs.

However, Johnny has trouble getting his deer, and elects to miss one class on how to wash a St. Bernard. And guess what? Santa Claus gives Johnny for Christmas a St. Bernard!

Now let's re-enact this scenario in Boulder City where Johnny has access to a fiber-optic school network. Johnny is given the puppy in late April. There is no such thing as “ninth grade”. At this time, Johnny is finishing Algebra I, starting Government, writing an essay for the fifth segment in English I, and studying for the second graded midterm examination in Biology.

Thanks to superlearning, Johnny is learning his fundamentals with a very high rate of retention. However, he has failed the non-graded test on two chapters (segments) in Algebra I. After additional instruction on the two segments, the computer system administers another non-graded test on each of the two segments. Johnny passes, thus ensuring quality control in Johnny's math studies.

Johnny and his parents had just enjoyed a two-week vacation in San Jose, California where the wild-flowers had been at their peak, and the grass in the Bay hills were green. Johnny had not miss any classes or examinations in his networked courses. When Johnny had come back to school, he had picked up where he had left off in his segmented courses.

Johnny notices Panther is starting to stink, and throws him in Lake Mead. Panther crawls out and bathes Johnny as he shakes his fur. Johnny decides there must be a better way to wash a dog.

Johnny immediately registers for an elective networked course in dog washing, after receiving permission from his counselor and the teacher in charge of monitoring the course. Johnny brings up on his screen an introduction to the course. The structure and prerequisite graph of the course is laid out, computer and video-related instructions are provided for taking the course, and other such information is shown.

To help Johnny and his fellow classmates schedule their work, shown are lists of students, immediate past schedules of week-long series of classes and graded examinations, possible future schedules of future classes and graded examinations, and a current course status report.

Johnny spies a group of segments on washing small dogs. He traces the course's prerequisite graph and determines he won't be eligible until he attends an earlier group of segments on dog soap. He plots a strategy where he will stop for a while in his Government course, finish Algebra I, finish his English I essay, and continue studying for the upcoming second mid-term examination in Biology.

While plotting his courseware, Johnny carefully ensures that he will stay above the minimum academic load of 1.2 credits per week. If at any time he slows up due to laziness or other problems, and dips below the minimum academic credit load, the computer system's software will report Johnny's lack of progress to his counselor. Otherwise, all leftover time is to be given priority to his dog washing studies. For Johnny is very anxious to learn how to wash Panther.

Johnny immediately runs through the first of several prerecorded videotapes on dog soap. The tapes are accompanied by superlearning music so that he will be able to remember 95% of the material months later. He reads the chapters on dog soap in his dog washing textbook. He occasionally asks questions over the phone to the dog washing teacher who is in another school.

After he finishes his studies on each segment, Johnny has the network's computer system give him a non-graded quiz on the segment. Each non-graded segment test is usually unique since the computer software draws questions at random from its repertory of questions. But on Segment 3, Johnny barely fails the non-graded segment test. After additional corrective instruction, two days later, Johnny tries again and passes a different non-graded segment test on Segment 3.

Since he started the dog washing course, Johnny has been checking every day the Dog Washing I status report. It is now Monday, and he sees that if he passes the non-graded segment test on Segment 2 by Wednesday, he will become eligible for a vertical stack of two series of classes on the dog soap segment group at the next scheduling.

Johnny continues throwing Panther in Lake Mead every few days, and races through his dog washing course segments as fast as he can, but with the assurance of the quality control built into the fiber-optic school network. Sometimes he even chooses dog washing over his other courses just so he can more quickly reach the part of the course on washing labradors. Thanks to the flexibility and simultaneous parallel teaching of all parts of the segmented dog washing course, Johnny learns how to wash Panther just in time for Las Vegas' really hot summer weather.

4.4 Network Dynamics. To illustrate the dynamics of a fiber-optic school network, assume that a network contains ten schools. Everything being equal such as the number of students attending a course in each school, and the students evenly spread out through the course at any one time, the statistical probability of each student attending a local class in his or her own school with a live teacher present would only be 10%.

Students have two options for increasing the probability of attending local classes at their schools. By periodically checking the status report on his or her segmented courses, a student can then pace his or her work accordingly but on a voluntary basis and at his or her own convenience. The other option is to take advantage of the system software by organizing student interest groups with other local students.

5 IMPLEMENTATION

5.1 Additional Classrooms. The CCSD is currently the fastest growing of the large public school district in the nation. To illustrate, a record eighteen new schools were opened in 1991. Rather than purchase and install network equipment in existing buildings, and then try to schedule network classes in conjunction with conventional classes, it is proposed that portable classrooms be purchased and installed on the grounds of selected existing high schools.

These additional portable classrooms would be dedicated to the network and used completely independently of the conventional programs in the main buildings on each high school campus linked to the network. Network equipment would be installed and cabled together, also independently of existing video and computer facilities. To more fully take advantage of the network's many features and capabilities, network courseware as well as customized software would be developed independently of existing programs.

Once the software and at least some of the courseware are fully debugged, and all the equipment is up and running without problems, students would be brought out from the main buildings to these dedicated network classrooms. Priority would be given to students who happen to be out of synchronization with conventional courses due to vacation, illness, family problems, out-of-town transfer, or other reasons.

Three types of portable classrooms are currently available. The smaller type contains one classroom, sized 28 feet square, and costs $26,000. The larger type is 24' wide and 60' long and comes in two versions. One version contains two classrooms and costs $50,000. The other version costs $70,000 and contains 1 restroom, 1 office, 2 classrooms, and large windows. These costs include moving and installation.

To run a telephone line out to each classroom from the school's main telephone switch panel costs an average of $200. Due to the portability and abundance of expensive equipment such as computers, cameras, and fiber-optic receivers, a monitored security alarm system for each network classroom should be budgeted. Security systems range from $100 to $500 for each portable classroom, depending on the number of doors, windows, etc.

5.2 Combined Video Receiver/Computer Monitor. A key equipment is a display which combines the functions of a video receiver and computer monitor. The product which currently seems to most nearly satisfy all the requirements of the fiber-optic school network is the Vision/1 TV adapter for the IBM PS/1 personal computer, made by Tecmar, Inc., 6225 Cochran Road, Solon, Ohio 44139-3377. Their sales representative is Chuck Hutchinson (800-624-8560 x231). Mr. Hutchinson quoted a suggested retail price of $395 and around $325 in large quantities.

The Vision/1 TV adapter allows superimposing a video image on computer-generated information displayed on the PS/1 monitor, without disturbing the computer information. The video image can be easily zoomed larger or smaller, moved around the screen, or even occupy the full screen. Vision/1's own software menu provides for displaying the channels available for reception; selection of channel, video source, and audio source; and adjustment of volume, color, tint, brightness, contrast, size, and picture-in-picture location. The Vision/1 software program is installed with Microsoft Windows 3.0 or OS/2.

Without presenting additional demands on computer resources such as memory, the Vision/1 TV adapter thus transforms the IBM PS/1 into a true multimedia system. By displaying full-motion color video in VGA resolution on the PS/1 monitor, Vision/1 allows combining PS/1 computing power with the versatility of standard broadcast, cable TV, VCR, laser disc player, or video camera input.

5.3 Fiber-Optic Cables and Interfaces. The project's first-year detailed design phase will address the specifics of optimum configurations and costs of the fiber-optic cables and interfaces. Alternative types of linkages between networked schools will also be examined for potential cost reductions. Examples of alternative types of linkages are microwave transmission, infrared transmission, and tie-ins with the local cable TV company.

To illustrate the types and costs of fiber-optic cables and interfaces, Albert Zopp, National Sales Manager, CATEL, Fremont, California (800-827-2722), has kindly provided the following information: When cable TV companies install fiber, they normally have 80 channels per fiber. For a system transmitting ten TV channels from one school to another, CATEL can provide for $57,275 the following:

* Five dual-channel modulators, $5775 each, totalling $28,875
* One electrical-to-optical converter (transmitter) $7450
* One fiber-optic receiver $3450
* One chassis with power supply $2500
* Chassis holds seven plug-in demodulator cards, $1300 each, totalling $9100
* Second chassis with power supply $2000
* Second chassis holds three plug-in demodulator cards, $1300 each, totalling $3900

Fiber-optic cable sells for $2 per meter for a six-fiber cable. Each additional fiber costs $.05 per meter. Fiber-optic cable comes in numbers of fibers per cable in the following increments: 2, 4, 6, 8, 10, 20, 30, ..., N x 10. Each spool typically contains 2 kilometers of cable and is 8 feet in diameter. The Bell companies normally lay cables with a minimum of 20 fibers.

The upper limit of the cost of digging trenches, drawing cable through ducts or pipes, labor, permits, materials, etc. is in the neighborhood of $25 per foot. The actual configuration of a prototype network connecting three junior and three senior high schools will be determined during the first-year detailed design phase of the project, possibly by using sophisticated operations research techniques. To understand better the full-scale version without actually building it, the configuration of fiber-optic cables and certain other equipment should be studied also.

If the Las Vegas area high schools are visualized as the shape of a pear, the Boulder City and Henderson high schools are located in the stem area of the pear. Since high schools will not be built to either side of the pear's stem area for the foreseeable future, it is proposed that these schools should be linked together for the prototype network.

Approximately ten miles separate the senior high school in Boulder City) from one of the two senior high schools in Henderson, and approximately seven miles separate Henderson's two senior high schools.

A preliminary survey determined that a corridor of undeveloped sandy desert comprises most of the distances separating these three schools. So the actual cost of laying fiber-optic cable is likely to be somewhat less than $25/foot. Assuming a worst-case figure of $20/foot, the cost of the cable between the two schools would be in the neighborhood of $20/foot times 5280 feet/mile times 17 miles or approximately $2,000,000.

The network is designed to be so flexible that ambitious students could conceivably advance through both the conventional system's junior and senior high schools in five or even four years, and still satisfy the fiber-optic network's quality control standards. Three junior high schools, one in Boulder City and two in Henderson, will be fiber-optically cabled to the three senior high schools at little extra cost since at most a few blocks separate the junior high schools from nearby senior high schools.

Thus the desirability of gifted junior high school students prematurely crossing over into networked senior high school courses can be fully tested. Linking the three junior high schools into the prototype network would also more fully test the fiber-optic network's capabilities and applicability to a wider age range of students.

The proposed prototype network of the six high schools in Boulder City and Henderson will offer courses in the new segmented format with segments of a week or so in length. In order to fully test the network's features and capabilities, the classes could frequently have very few students. Thus an excessive number of substitute teachers will also be required. Funding could be provided for additional portable classrooms, fiber-optic cables, and equipment for a larger network. The more schools connected into the fiber-optic network, the greater would be the average number of students per class, and the lower the cost per student.

5.4 Scheduling. Scheduling a fiber-optic school network promises to be a particularly tricky problem. Study contracts are planned to be awarded to Stanford University and AT&T Bell Laboratories. Stanford University has a group which has researched computerized scholastic scheduling for many years. Bell Laboratories has been marketing its KORBX System for some years. In conjunction with their study of fiber-optic school network scheduling, a computer simulation of the prototype network may be programmed to help optimize equipment and cable configurations using operations research techniques.

5.5 Targeted Student Populations. All students in the conventional grades 7-12, except those with some type of relevant handicap such as blindness, are expected to possess sufficient maturity for attending school via the fiber-optic network. Tests will be conducted during the second two-year implementation phase of the program to determine the percentage of students in each of the lower grades which have sufficient maturity to handle attending the network. Then when the project provides technical support to other schools around the nation during the fourth and fifth years of the program, it will be determined by then which lower elementary grades should be connected into fiber-optic school networks.

5.6 Busing. Since the fiber-optic network would be operating all year long versus the conventional system's fixed sessions and vacation periods, the need for additional busing during the conventional system's vacation periods will be studied during the first-year detailed design phase.

5.7 Courseware Development. Re-organizing courses for the fiber-optic school network would not be as simple as it may appear. Portions of each course would have to be allocated to videotape, superlearning, discussion classes, review classes, segments, non-graded segment tests, graded examinations, and so forth. An advantage of the fiber-optic school network over the conventional system is that while a higher percentage of the course material and presentation must be thought out in advance, all the pieces of each

segmented course would be taught or otherwise be available simultaneously in a full-scale network, and less simultaneously in the proposed prototype network.

Once a segmented course becomes available through a fiber-optic school network, specific improvements to the various pieces of the segmented course can be implemented either immediately or within a few weeks at most. Thus the quality of the segmented course's material and presentation would benefit from continuous and sustained upgrading.

5.8 Construction Schedule. The second phase of the contract, which comprises of its second and third years, will initially be devoted to laying the fiber-optic cables, purchasing and installing the portable classrooms, and building a new wing for one of the Junior High Schools. Some computer and switching equipment will be temporarily installed in the project office to facilitate writing and testing customized software. The selected systems integration contractor may elect to perform all engineering and programming functions at its own facilities.

The second half-year of the second phase will see all construction completed, all electronic equipment installed and cabled together, and at least most software in operation. Much of the courseware should be ready by this time. During this period, students can begin to be brought out from the main building, trained in operating network software, and begin taking pieces of courses as needed.

The second year of the second phase will be devoted to developing courseware, adding on students, and training other teachers. Elementary students will also be brought on board to determine the percentage in each age bracket which can successfully handle attending networked segmented courses.

Documentation will be developed to allow other New American Schools to implement duplicate fiber-optic school networks during the third phase of the program. Additional programming, engineering, and teaching personnel may be hired and trained during the second year of the second phase so that they will be ready to provide technical support for the program's third phase.

6 BUDGET

It is anticipated that the one-time research and development costs of the prototype fiber-optic school network will be substantial. It is possible that even with today's advanced technology, the cost will still be prohibitive. If so, it is likely that by the end of New American Schools Development Corporation's five-year program, the cost-effectiveness of new equipment not currently on the market may be sufficient to allow widespread implementation of the fiber-optic school network.

Certain portions of the budget were relatively straightforward to determine. Other portions of the budget are by necessity wild guesses either due to the continuing rapid improvement of electronic equipment, or to the research character of the program. However, the RFP does encourage submitting proposals with vague cost estimates. New American Schools Development Corporation is understood to be somewhat tolerant of vagueness since its goal is to aggressively seek out radical new school designs.

Part of the budget is for construction of additional classrooms. New American Schools Development Corporation may wish to save money by implementing a prototype network in another city with excess classrooms.

FIRST YEAR
Staff:
Project Director

45 weeks at $1400/week (no fringe benefits) $63,000
Six teachers (Math, science (two), English, history, geography) 45 weeks at $800/week (with fringe benefits) $216,000
Computer consultant 10 weeks at $1500/week (no fringe benefits) $15,000
Superlearning consultant 4 weeks at $800/week (no fringe benefits) $3200
Total salaries $297,200

Study Contracts:
AT&T for KORBX System study $100,000
Stanford University for computerized network scheduling study $100,000
Prime Cable (local cable TV company) for study of cable TV alternative to fiber-optic cable $10,000
President George Bush's son's company for study of infrared alternative to fiber-optic cable $10,000
Ten companies for two-month systems integration studies – first phase at $30,000 each $300,000
Three companies for four-month systems integration studies – second phase at $60,000 each $180,000
One company for final five-month systems integration design $150,000
Miscellaneous (travel, office rent, computers for staff, additional consultants, additional study contracts, liaison time for CCSD, illustrations, secretarial, etc.) $200,000
Total $1,347,200

SECOND YEAR
Staff:
Project Director
45 weeks at $1400/week (no fringe benefits) $63,000
Ten teachers (Math, science (two), English, history, geography, elementary (4)) 52 weeks at $800/week (with fringe benefits) $416,000
Superlearning consultant 4 weeks at $800/week (no fringe benefits) $3200
Total salaries $482,200

Fiber-optic cables between three junior high schools and three senior high schools $2,000,000
Construction:

<u>Senior High School A</u>
Three large portable classrooms at $50,000 each $150,000
One large portable classroom with restroom $70,000
Four security alarm systems $1000
One telephone extension $200
Subtotal $221,200

<u>Senior High School B</u>
Three large portable classrooms at $50,000 each $150,000
Two large portable classrooms with restroom at $70,000 each $140,000
Five security alarm systems $1300
Two telephone extensions $400
Subtotal $291,700

<u>Senior High School C</u>
Three large portable classrooms at $50,000 each $150,000
One large portable classroom with restroom $70,000
Four security alarm systems $1000
One telephone extension $200

Subtotal $221,200

Junior High School A
One large portable classroom $50,000
One large portable classroom with restroom $70,000
Two security alarm systems $500
One telephone extension $200
Fire hydrant (cost is wild guess) $5000
Subtotal $125,700

Junior High School B
Three large portable classrooms at $50,000 each $150,000
One large portable classroom with restroom $70,000
Four security alarm systems $1000
One telephone extension $200
Subtotal $221,200

Equipment cost:
Item costs and notes -
High-resolution camera with tripod and lens - $50,000
IBM PS/1 with 40-MB fixed-disk storage, color display, and TECMAR Vision/1 TV adapter - $1600
CCSD allocates 36 square feet per computer.
Portable classroom without restroom and office is 24' x 60 and has room for roughly 40 personal computers.
Portable classroom with restroom and office has about 1200 square feet of classroom space and has room for roughly 30 personal computers.
At least two cameras in each school.

Senior High School A
Three cameras
Three large portable classrooms without restrooms contain 120 personal computers
One large portable classroom with restroom contains 30 personal computers

Senior High School B
Three cameras
Three large portable classrooms without restroom contain 120 personal computers
Two large portable classrooms with restroom contain 60 personal computers

Senior High School C
Three cameras
Three large portable classrooms without restroom contain 120 personal computers
One large portable classroom with restroom contains 30 personal computers

Junior High School A
Two cameras
One large portable classroom without restroom contains 40 personal computers
One large portable classroom with restroom contains 30 personal computers

Junior High School B
Three cameras

Three large portable classrooms without restroom contain 120 personal computers
One large portable classroom with restroom contains 30 personal computers

Junior High School C
Four cameras
New wing of six classrooms contains average of 30 personal computers per classroom or
total of 180 personal computers
Total number of cameras plus one spare - 19
Total cost of cameras at $50,000 each is $950,000
Total number of personal computers plus 20 spares - 900
Total cost of personal computers at $1600 each is $1,440,000

Determining the total cost of cameras and personal computers alone to be in the range of $2,400,000 is a useful exercise. However, two years of technological improvements from the time of writing this proposal to the time of purchase should see substantial reductions. In particular, technologies are on the horizon that could replace the costly and bulky CRT type of display with much cheaper high-resolution flat-panel displays.

While fiber-optic interface equipment unit costs are available (see above), their total cost can not be determined at this time because of complex configuration considerations. The costs of computer-controlled audio and video routing switchers, cabling, miscellaneous video equipments, administrative computers, and network control center equipment remain to be determined during the detailed design phase. In particular, software development cost estimates are notoriously unreliable.

The total equipment cost of the prototype network, excluding the fiber-optic cables, appears to be in the ballpark of $4 million.

Project salaries $482,200
Construction $1,461,000
Fiber-optic cables $2,000,000
Equipment and software $4,000,000
Total second-year cost $7,943,200

THIRD YEAR
Staff:
Project Director
45 weeks at $1400/week (no fringe benefits) $63,000
Ten teachers (Math, science (two), English, history, geography, elementary (4))
52 weeks at $800/week (with fringe benefits) $416,000
Substitute teachers $200,000
Video technician (with fringe benefits) $40,000
Computer programmer (with fringe benefits) $50,000
Total salaries $769.000
Miscellaneous (travel, consultants, insurance,
materials, office space, etc.) $100,000
Total third-year cost $869,000

Ten teachers (Math, science (two), English, history, geography, elementary (4))
52 weeks at $800/week (with fringe benefits) $416,000
Substitute teachers $200,000

Video technician (with fringe benefits) $40,000
Computer programmer (with fringe benefits)$50,000
Total salaries $769.000
Miscellaneous (travel, consultants, insurance,
materials, office space, etc.) $100,000
Total fourth-year cost $869,000
Technical support and travel expenses depend on number of fiber-optic school networks funded in other cities.

FIFTH YEAR
Staff:
Project Director
45 weeks at $1400/week (no fringe benefits) $63, 000
Ten teachers (Math, science (two), English, history, geography, elementary (4))
52 weeks at $800/week (with fringe benefits) $416,000
Substitute teachers $200,000
Video technician (with fringe benefits) $40,000
Computer programmer (with fringe benefits)$50,000
Total salaries $769.000
Miscellaneous (travel, consultants, insurance,
materials, office space, etc.) $100, 000
Total fifth-year cost $869, 000
Technical support and travel expenses depend on number of fiber-optic school networks funded in other cities.
Total program cost $11,897,400

DISCLAIMER: Inclusion of any invention or technology described in this detailed design of a torsion field school network does not in any way imply its suitability for investment of any kind. All investors contemplating any investments in these devices and technologies should first consult with a licensed financial professional. Prospective investors should exhaustively perform their own investigation of pertinent facts and allegations of facts. Investors should also ensure thorough compliance with regulations of the federal Securities and Exchange Commission and appropriate state securities divisions. For more information, see http://www.zpenergy.com/modules.php?name=News&file=article&sid=1655.