DOCUMENT RESUME

ED 250 499 CE 040 007

AUTHOR	McKinney, Floyd L., Comp.
TITLE	Strengthening Computer Technology Programs. Special Publication Series No. 49.
INSTITUTION	Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY	Office of Vocational and Adult Education (ED), Washington, DC.
PUB DATE	84
CONTRACT	300-83-0159
NOTE	125p.
AVAILABLE FROM	National Center Publications, National Center for Research in Vocational Education, 1960 Kenny Road, Columbus, OH 43210-1090 (Order No. SN49--$10.50).
PUB TYPE	Reports - Descriptive (141) -- Collected Works - General (020)
EDRS PRICE	MF01/PC05 Plus Postage.
DESCRIPTORS	*Black Colleges; Community Colleges; *Computer Literacy; *Computer Science; Developing Institutions; Digital Computers; Faculty Development; Higher Education; Industry; *Microcomputers; *Networks; *Professional Development; Program Descriptions; Program Development; Regional Planning; School Business Relationship; Staff Development; Systems Approach; Teacher Workshops; Two Year Colleges; Vocational Directors; Vocational Education; Vocational Education Teachers
IDENTIFIERS	Corporations; *Local Area Networks

ABSTRACT

Three papers present examples of strategies used by developing institutions and historically black colleges to strengthen computer technology programs. "Promoting Industry Support in Developing a Computer Technology Program" (Albert D. Robinson) describes how the Washtenaw Community College (Ann Arbor, Michigan) Electrical/Electronics Department used industrial support to develop the Digital Equipment Technology Program. It describes these methods to promote industry support: advisory committees, program reviews with industry, and selection of a broad range of laboratory equipment for generic training. A glossary is provided. "Local Area Networks (LANs) of Microcomputers in Education" (Clifford D. Layton) describes a particular implementation and utilization of a LAN of microcomputers at Rogers State College in Claremore, Oklahoma, in 1982. It also discusses, in general, the usefulness, nontechnical theory, selection criteria, and availability of LANs of microcomputers in 1984. "Systems Approach to Computer Literacy for Vocational Educators: A Professional Development Seminar for Faculty and Staff" (Mildred Fitzgerald Johnson) shares with vocational educators and administrators the procedures used in planning, implementing, and evaluating a computer literacy workshop through a systems approach. It describes a successful program for vocational educators conducted by the business education department at Cheyney University of Pennsylvania. Workshop materials and correspondence are appended. References follow each paper. (YLB)

ED250499

Special Publication Series No. 49

STRENGTHENING COMPUTER TECHNOLOGY PROGRAMS

Compiled by

Floyd L. McKinney

The National Center For Research In Vocational Education
The Ohio State University
1960 Kenny Road
Columbus, Ohio 43210

1984

CE040007

ERIC

THE NATIONAL CENTER MISSION STATEMENT

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Providing information for national planning and policy
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

For further information contact:

Program Information Office
National Center for Research
in Vocational Education
The Ohio State University
1960 Kenny Road
Columbus, Ohio 43210

Telephone: (614) 486-3655 or (800) 848-4815
Cable: CTVOCEDOSU/Columbus, Ohio
Telex: 8104821894

FUNDING INFORMATION

Project Title: National Center for Research in Vocational Education, Applied Research and Development

Contract Number: 300830159

Project Number: 051MH30001

Act Under Which Funds Administered: Education Amendments of 1976, P.L. 94-482

Source of Contract: Office of Vocational and Adult Education
U.S. Department of Education
Washington, D.C. 20202

Contractor: The National Center for Research in Vocational Education
The Ohio State University
Columbus, Ohio 43210

Executive Director: Robert E. Taylor

Disclaimer: This publication was prepared pursuant to a contract with the Office of Vocational and Adult Education, U.S. Department of Education. Contractors undertaking such projects under government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official U.S. Department of Education position or policy.

Discrimination Prohibited: Title VI of the Civil Rights Act of 1964 states: "No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." Title IX of the Education Amendments of 1972 states: "No person in the United States shall, on the basis of sex, be excluded from participation in, or be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance." Therefore, the National Center for Research in Vocational Education Project, like every program or activity receiving financial assistance from the U.S. Department of Education, must be operated in compliance with these laws.

TABLE OF CONTENTS

Page

LIST OF TABLES AND FIGURES

Page

Tables

Figures

FOREWORD

Every vocational educator is familiar with the difficulties of bringing computer technology into the classroom and laboratory. How can institutions obtain state-of-the-art computer equipment for hands-on training? How can computer capabilities be used in a cost-effective and timely manner for instructional purposes? How can computer literacy training be provided for the whole range of instructors and administrators who may need it?

Some answers to these questions may be found in developing institutions—Title III institutions of higher education—and in historically black colleges, which are particularly vulnerable to rapidly changing social and economic forces. These institutions are frequently besieged by a series of problems that appear to be insolvable.

However, while many developing institutions and historically black colleges are fighting to survive, there are numerous examples of successful vocational education programs in these institutions. Unfortunately, the characteristics of these successful programs are not generally well known. Through the papers contained in this document, the National Center provides institutional personnel with a description of programs and practices that they can use to improve vocational education programs at their own institutions.

Valuable assistance in selecting the programs and the paper authors was provided by Mr. Rayford L. Harris, Virginia State University; Dr. W. R. Miller, University of Missouri-Columbia; Dr. Delores M. Robinson, Florida State University; Dr. Bernardc Sandoval, Los Angeles Unified School District; and Dr. Steve Van Ausdle, Walla Walla Community College, Washington.

The National Center expresses its appreciation to the paper authors and reviewers. *Promoting Industry Support in Developing a Computer Technology Program* was written by Albert D. Robinson and reviewed by Dr. Martin Parks. Mr. Robinson is Instructional Coordinator, Electrical/Electronic Department, Washtenaw Community College, Ann Arbor, Michigan. Dr. Parks is Associate Dean, Business, Science, and Technology, Chesapeake College, Wye Mills, Maryland.

Local Area Networks of Microcomputers in Education was written by Clifford D. Layton and reviewed by Dr. Roger Lambert. Mr. Layton is Computer Science Coordinator at Rogers State College, Claremore, Oklahoma. Dr. Lambert is Associate Director, Vocational Study Center, University of Wisconsin.

Systems Approach to Computer Literacy for Vocational Educators: A Professional Development Seminar for Faculty and Staff was written by Dr. Mildred Fitzgerald Johnson and reviewed by Dr. Sonja Stone. Dr. Johnson is Chairperson, Business Education Program, Cheyney University of Pennsylvania, Cheyney, Pennsylvania. Dr. Stone is Associate Professor of Afro-American Affairs, University of North Carolina at Chapel Hill.

The National Center is indebted to the staff members who worked on the study. The study was conducted in the Information Systems Division, Dr. Joel Magisos, Associate Director. Dr. Floyd L. McKinney, Senior Research Specialist, served as Project Director and Oscar Potter as Graduate

Research Associate. Dr. McKinney, a former secondary vocational education teacher, holds a Ph.D. in vocational education from Michigan State University. He has served as a university coordinator of graduate vocational education programs and as a division director in a state department of education. Mr. Potter is a doctoral candidate in agricultural education at The Ohio State University and has a M.A. in agricultural education from the University of Florida and a M.A. in administration and supervision from Florida Atlantic University. Patsy Slone served as project secretary and Janet Ray served as word processor operator. Roxi Liming provided technical editing and final editorial review of the papers was provided by Judith Sechler and Christie Durtschi of the National Center's Editorial Services area.

Robert E. Taylor
Executive Director
The National Center for Research
in Vocational Education

EXECUTIVE SUMMARY

Successful strategies to strengthen computer technology programs have been implemented in many developing institutions—Title III institutions of higher education—and historically black colleges. This document presents three examples of such strategies used by developing institutions and historically black colleges.

Part 1. Promoting Industry Support in Developing a Computer Technology Program
by Albert D. Robinson

Industry experts predict that there will be over 50 million electronic keyboard devices—computers, terminals, office systems—in the United States by 1988. In an article in *Fortune Magazine* (16 May 1983) John Roach, chairman of Tandy Corporation, said, "The computer, the calculator, typewriter and telephone will ultimately be one" (p. 62). There is tremendous pressure on community colleges to update their electronic technology programs. However, many colleges find that they are unable to obtain state-of-the-art computer equipment to provide the in-depth hands-on training that is needed.

In 1978 the management of a local computing service company, Automatic Data Processing (ADP) Network Services, visited Washtenaw Community College (WCC) to explore the possibility of using the college to train entry-level computer maintenance technicians. The Electrical/Electronics Department faculty was interested in starting a new program to meet their needs, but the faculty anticipated difficulty in obtaining capital equipment funds for the laboratory equipment. ADP Network Services indicated that they might be willing to donate some equipment to the college to help start the program.

During the 1978-79 school year, WCC organized an advisory committee to plan and implement the program. The program was called the Digital Equipment Technology Program to signify that the training was applicable to a wide range of systems using digital electronics technology. The new program was started in the 1979 fall semester with the introduction of one new course called Digital Computing Systems I. The course, offered to twelve evening students, was taught by a part-time instructor in a temporary classroom using four PDP-8/I minicomputers donated by ADP Network Services. Within three years the program had over three hundred students using the facilities of two dedicated computer laboratories with over $300,000 worth of equipment. By actively encouraging industry support, WCC was able to obtain approximately $290,000 in industry grants and donations to supplement their program development costs of $90,000.

The Digital Equipment Technology Program is one of the most intensive two-year associate degree electronics programs in the state of Michigan. To the best of our knowledge, WCC is the only two-year, or four-year, public college in Michigan to offer computer maintenance training above the microprocessor level. The program is designed around five specialized computer system courses supported by six core courses in basic electronics technology and three electronic device courses.

WCC used an active advisory committee, industry program reviews, and alumni help to encourage industry support. The college received substantial support from Burroughs Corporation, Digital Equipment Corporation (DEC) and ADP Network Services. Burroughs donated a B1865 system and twenty weeks of tuition-free maintenance training for the faculty. DEC donated a PDP-11/60 system, a PDP-11/40 system, thirty weeks of tuition-free training for the faculty, $24,000 worth of audiovisual training material, and a 33 percent discount on all equipment purchased for the program. ADP Network Services donated six PDP-8 computers and ten Dataproducts Model 2410 line printers.

The program provides computer maintenance training to over three hundred students on an open-door admission policy at a tuition cost of twenty-seven dollars per credit hour. The program has produced a 100 percent enrollment increase in the Electrical/Electronics Department and a 300 percent increase in the number of associate degrees awarded. The enrollment of minority and female students has increased dramatically, and graduates of the program are receiving more job offers at higher starting salaries. The program has succeeded in attracting students with better academic training. Approximately 20 percent of the program graduates have a bachelor's degree and about 5 percent have a master's degree before they enter the program.

Converting a typical community college electronics program from its current status to a state-of-the-art computer maintenance program is a major undertaking. The electronics faculty must be committed to develop the hardware, software and training resources needed to shift from traditional circuit and device courses to computer system courses. It will be very difficult to hire full-time instructors with computer maintenance experience, so the administration must be prepared to support a long-term staff development program. If the college is unable to obtain support from industry, it will cost approximately $40,000 to train two instructors and over $200,000 for equipment and facilities to start a typical program.

Part 2. Local Area Networks of Microcomputers in Education
by Clifford D. Layton

Developing institutions and historically black colleges involved in vocational education are faced with the problem of providing computer capabilities for instructional purposes in a cost-effective and timely manner. A solution to this problem is the installation of local area networks of microcomputers.

Local area networks (LAN) of microcomputers are interconnected sets of microcomputers and microcomputer-related devices located in a relatively small space, such as a room, building, or campus. Local area networks of microcomputers are appropriate to both present and future, and are cost-effective, responsive, resourceful, transportable, reconfigurable, and robust. Local area networks can be used for instructional and noninstructional purposes and can facilitate educational program development.

The selection process for local area networks of microcomputers requires consideration of initial and future costs, expandability, multivendor connectivity, ease of installation, and security needs. Knowledge of topologies, interconnection media, data transmission rates, and access techniques is also required.

Wh[illegible] the selection process for local are[illegible]tworks of microcomputers can be complex, educators o[illegible] students the opportunity to become familiar with what will probably be the most common co[illegible]ter workstation of the future, the microcomputer. Students should also be given the

opportunity to become familiar with what will probably be the most widely pervasive configuration of computer workstations of the future, the LAN of microcomputers.

Part 3. Systems Approach to Computer Litera., or Vocational Educators: A Professional Development Seminar for Faculty and Staff
by Mildred Fitzgerald Johnson

The purpose of this paper is to share with vocational educators and administrators the procedures utilized in planning, implementing, and evaluating a computer literacy workshop through a systems approach. This report discusses a successful computer literacy program for vocational educators that was conducted by the Business Education Department at Cheyney University of Pennsylvania. The goals of this paper are to—

- provide an understanding of a practical systems model,
- indicate how a well thought-out system benefits the participants and workshop presenter(s),
- identify and define production aspects such as implementation and evaluation.

The systems model discussed in this report consists of the following eleven procedural steps:

1. Conduct client needs assessment.
2. Identify and classify basic computer literacy competencies.
3. Develop workshop brochure, application, evaluation, and resource materials.
4. Write cognitive, affective, and psychomotor performance goals.
5. Pretest participants for competency level.
6. Utilize multimedia teaching-learning strategies.
7. Evaluate achievement.
8. Revise and modify teaching strategies.
9. Teach programming concepts/logic.
10. Evaluate achievement.
11. Revise and modify teaching strategies.

The systems model was successfully utilized in a workshop conducted for non-data processing professional educators and administrators. The workshop content included an introduction to fundamental data processing concepts and trends. It also provided practical logic exercises and short BASIC language programming activities. Sixty-five percent of the participants rated the overall effectiveness of the workshop as "superior-excellent."

The overall performance goal for participants was to raise their level of computer literacy through participation in a one-day computer workshop. This goal was achieved as evidenced by an oral postassessment. Although pretests were administered and scored, time did not permit formal scoring of posttests or a comparative analysis between pre- and posttest scores to determine level of achievement.

An oral test was administe ed at the workshop by the workshop leader, who clarified any misconceptions that were noted. Many of the participants requested additional workshops and indicated a desire to take computer science courses. It was quite evident that the participants were knowledgeable about computers and how computers work as problem-solving tools. During the postassessment period, the participants demonstrated verbal competence in discussing basic computer concepts with the workshop staff and computer personnel—they had unraveled the mystery surrounding the computer! In order to assist vocational educators and administrators in replicating this workshop, recommendations are as follows:

- Workshop leaders and educators should further test the systems model to refine it.
- Workshop period should be extended to three to five days to allow for documentation of pre- and posttest results that can be utilized to validate achievement.
- Workshop leaders should utilize a multimedia teaching-learning approach which is, without a doubt, most vital to increasing levels of computer literacy.
- Workshop leaders should be resourceful and willing to prepare transparencies of basic concepts; compile the latest reference materials, workshop notebook of data processing fundamentals, "how-to" workshop exercises; arrange tours of computer center; etc.
- Workshop leaders should utilize a highly qualified workshop staff consisting of an education-industry mix. The staff should consist of persons who are committed to computer education and who can clearly and concisely express points of view and information in written and oral formats.

PART 1

PROMOTING INDUSTRY SUPPORT IN DEVELOPING A COMPUTER TECHNOLOGY PROGRAM

Albert D. Robinson
Washtenaw Community College

CHAPTER 1

DIGITAL EQUIPMENT TECHNOLOGY PROGRAM DESCRIPTION

Introduction

The Digital Equipment Technology Program was started at Washtenaw Community College (WCC) in the 1979 fall term with the introduction of one new course called Digital Computing Systems I. The course was offered as an evening class only and consisted of twelve students taught by a part-time instructor. The laboratory, located in a temporary classroom, was equipped with four PDP-8/I minicomputers donated by Automatic Data Processing (ADP) Network Services of Ann Arbor.

By the 1982 fall semester the program enrolled more than three hundred students. Two dedicated computer laboratories were equipped with more than $300,000 worth of new equipment. All of this new equipment, except for five PDP-11/40 systems purchased for only $50,000, was donated to the college for use in the program.

During this three-year period, the enrollment in the Electrical/Electronics (E/E) Department increased over 100 percent and the number of graduates increased 300 percent. During the same period the overall college student-credit hour generation increased approximately 2 percent. The development of this program allowed the E/E Department to offer better technical education at a lower cost per student. Furthermore, the graduates of this program have been able to obtain more job offers and higher starting salaries than at any time since WCC was founded in 1966.

The purpose of the paper is to describe how the WCC Electrical/Electronics Department utilized industrial support to develop the Digital Equipment Technology Program and to describe techniques that other colleges may find helpful to encourage industry support.

General Description of Washtenaw Community College

In addition to a large academic community, the Washtenaw Community College district contains a mixed urban and agricultural population. The eastern half of Washtenaw County is primarily industrial with a large number of automotive plants. The people of this region are primarily plant employees, and many are minorities with low socioeconomic status. The western half of Washtenaw County is generally rural. People of this area are at medium-income levels and the minority population is small.

Washtenaw Community College was founded in Ann Arbor, Michigan, in 1966. The city of Ann Arbor is an affluent academic community placing a high priority on traditional academic education.

The WCC campus is located near the border of the twin cities of Ann Arbor and Ypsilanti, Michigan. The University of Michigan campus is located five miles west of the WCC campus, and Eastern Michigan University is five miles east.

The Michigan Employment Security Commission (1980) reports the 1979 employment data for the Ann Arbor-Ypsilanti area as 38 percent employed in manufacturing, 36 percent in nonmanufacturing, and 31 percent in government or public education.

Washtenaw Community College offers instruction in occupational education, general education, college transfer courses, developmental education, continuing education and community services. The college provides counseling, financial aid, job placement and other supportive services to assist students from a wide variety of educational backgrounds.

The college offers instruction from 8 a.m. to 11 p.m., and the full-time faculty has the responsibility for teaching both day and evening classes. During the 1982-83 school year, WCC employed 110 full-time instructors and approximately 300 part-time instructors.

WCC has over eight thousand students, but only 25 percent are enrolled on a full-time basis. Approximately 50 percent are enrolled in occupational education courses. Except for the health science programs, approximately 50 percent of occupational education students attend only evening classes. Table 1 summarizes the principal student data for the 1983 Fall Semester.

The WCC Electrical/Electronics Department provides both day and evening instruction to a wide spectrum of students in support of WCC's open-door admissions policy. The students range in age from eighteen to over sixty-five and in educational achievement from high school diploma to a master's degree in science of engineering. A typical student is twenty-seven years old, married, has a family and has completed one or two years of postsecondary education prior to enrolling in any electrical/electronic courses.

Approximately four hundred students are enrolled in all of the E/E Department programs. Most are enrolled on a part-time basis and average eight credit hours per semester. Approximately 50 percent of the students are enrolled in evening courses.

TABLE 1

STUDENT DATA FOR 1983 FALL SEMESTER

Enrollment Categories	No. of Students
Total students registered	8,418
In-district	6,964
Out-district	1,329
Out-state/county	125
New students	2,690
Readmit students	1,259
Continuing students	4,469
Female	4,435
Male	3,983
Full-time	1,977
Part-time	6,441

The E/E Department has eight full-time instructors and an average of eighteen part-time instructors. Approximately sixty sections of eighteen different courses are offered by the department each semester. The E/E Department has four general-purpose electronics laboratories with approximately fifteen hundred square feet of floor space in each lab and two specialized computer labs with a total of three thousand square feet of floor space.

Curriculum

The Digital Equipment Technology Program is one of the most intensive two-year associate degree electronics programs in the state of Michigan. To the best of our knowledge, WCC is the only two-year, or four-year, public institution in Michigan that offers an occupational electronics program in computer maintenance above the microcomputer level. The program curriculum, as illustrated in figure 1, includes a two-semester sequence in math for electronics, a two-semester sequence in electrical circuits, a four-semester sequence in computer systems, and three courses in electronic devices.

The first two semesters in the program include introductory courses in electrical circuits, basic electronics, and applied mathematics that are found in many community college electronics programs. The first semester also includes a course in digital logic that covers numbers systems, Boolean algebra, logic gates, combinational logic, flip-flops, and sequential logic circuits. The second semester includes the first of three computing system courses. The first course, Computer Systems I, teaches basic central processor operation, instruction sets, addressing techniques, bus principles, computer arithmetic, peripheral devices, organization of file information, input/output techniques, and software operating systems. The laboratory activities stress hands-on training in assembly language programming, detailed CPU operation, and CPU troubleshooting on PDP-8 minicomputers. The PDP-8/I is a 12-bit processor that was designed in 1968 using small-scale and medium-scale TTL logic circuits.

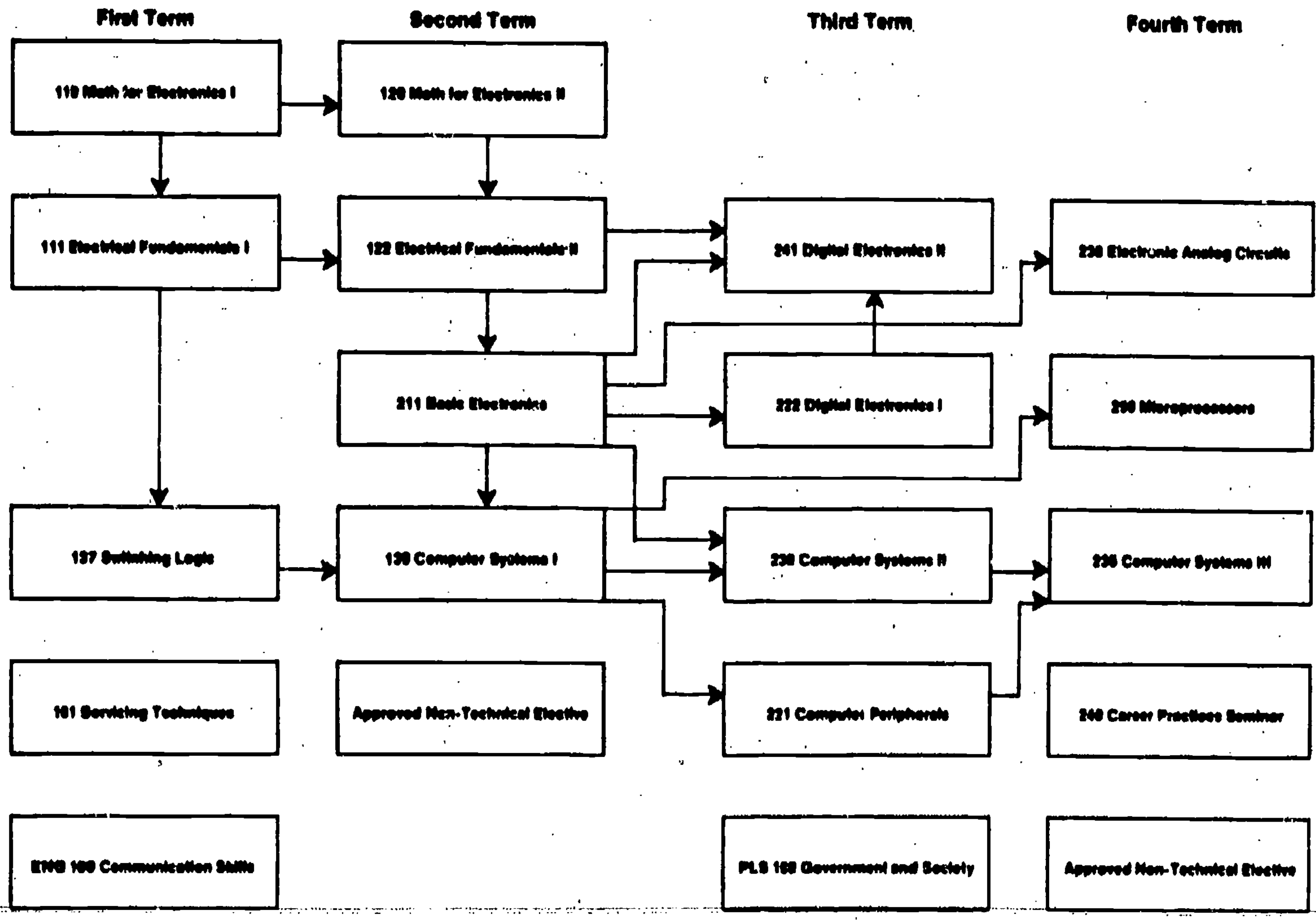

Figure 1. Digital equipment technology program curriculum

In the third semester, students take two specialized computer courses: Computer Systems II and Peripherals. Computer Systems II includes the PDP-11 system characteristics, instruction sets, addressing modes, bus operation, main memory organization, input/output techniques, and a detailed study of the PDP-11/40 central processor (KD11-A). The PDP-11/40 is a 16-bit processor that was designed in 1974 using medium-scale integrated TTL logic circuits. A comparison of the PDP-8/I and PDP-11 processor features is shown in table 2. Laboratory experiments are conducted on the PDP-11/40 computer systems and include the following: assembly language programming, the operation of hardware traps, bus operation, data transfers, interrupts, the power supply system, and CPU troubleshooting. The Computer Peripherals course includes three major units of study: magnetic recording techniques for mass storage devices and basic operating principles of both magnetic disk and magnetic tape recorders.

TABLE 2

COMPARISON OF PDP-8/I AND PDP-11/40 PROCESSORS

Features	**PDP-11/40**	**PDP-8/I**
Word size	16-Bits	12-Bit
Memory size	64K Bytes	4K
Maximum addressable memory size (words)	128K*	32K
Memory access time	980 NSEC	1500 NSEC
Memory type	Core	Core
Number of general purpose registers	8	None
Number of special purpose registers	12	7
CPU control	Synchronous Microprogram	Asynchronous time state pulses
System control	Asynchronous	Asynchronous
Addressing format	Single operand Double operand address	Single operand address
Addressing modes	12	2
Processing modes	Word or byte	Word
Number of hardware stacks	2*	None
Number of hardware interrupt levels	4	1

*with memory management

Students take two specialized computer courses in the fourth semester: Computer Systems III and Microprocessors. Computer Systems III includes a study of software-operating systems, diagnostic programs, the RK06 magnetic disk drive, the RK611 disk drive controller, and memory management. The laboratory activities stress hands-on, system-level troubleshooting using diagnostic program and system documentation. The microprocessor course teaches the operation of the Intel 8080 microprocessor and interfacing techniques.

Laboratory Facilities and Equipment

The E/E Department has two specialized computer laboratories to support system-level courses. One laboratory, equipped with PDP-8 computers, is used for the laboratory activities in the Computer Systems I course. Although the PDP-8 is a relatively old processor, it is an excellent machine for an introductory course. It has a small instruction set, relatively simple architecture, and the internal data and control signals are easily accessible. This same laboratory also contains line printers, teleprinters, video terminals, and disk drives for use in computer peripheral courses.

The second laboratory is the minicomputer systems lab. It contains one PDP-11/60 system and seven PDP-11/40 systems. Each PDP-11/40 system has a central processor with 32K of core memory, a disk drive, and a teleprinter.

Table 3 summarizes the special laboratory equipment used in the Digital Equipment Technology Program at WCC.

TABLE 3

DIGITAL EQUIPMENT TECHNOLOGY PROGRAM EQUIPMENT

Equipment	Quantity
B1865 computer systems	
Processor and operator's console	1
Disk drive and controller	1
Tape drive and controller	1
Line printer	1
Card reader	1
Video terminals	3
PDP-11/60 computer system	
Processor and operator's console	1
Disk drives and controller	2
Video terminals	12
Teleprinters	11
PDP-11/40 computer system	
Processor and operator's console	7
Disk drives and controller	9
Line printer	1
Teleprinter	5
Magnetic tape unit	1
PDP-11/20 computer system	1
PDP-11/05 computer system	1
PDP-8/I computer systems	4
PDP-8/E computer systems	4
Pertec magnetic tape recorders	2

CHAPTER 2

PROGRAM DEVELOPMENT

When WCC was founded in 1966, the electronics technician program was designed to support the electronics research and development activity existing in Ann Arbor in the 1960s. By 1978 two things had happened. First, almost all of the electronics research and development activity in Ann Arbor was gone, and the new electronics companies in the area were manufacturing computer-related equipment. Second, the WCC electronics technician program had not been revised to keep pace with technological changes that had occurred during the 1970s.

In 1978, the management of Automatic Data Processing (ADP) Network Services in Ann Arbor visited WCC to explore the possibility of using WCC to train entry-level computer maintenance technicians. At that time ADP was planning a major expansion in the local division and anticipated difficulty in finding technicians to support the planned expansion. The WCC Electronics Department was interested in responding to this request, but the faculty knew it would be difficult to get capital equipment funds needed for the laboratory equipment. ADP said they might be willing to donate some equipment to WCC to help get the program started.

The WCC E/E Department organized an advisory committee during the 1978-79 school year to explore the need and feasibility of establishing a computer maintenance technology program. Approximately ten different companies and institutions were represented on the advisory committee. In some cases, two or three people representing different levels of management from the same company served on the committee. This broad spectrum of technical and management experience gave the committee a total corporate viewpoint that produced a program designed to meet a broader range of entry-level job skills.

The advisory committee recommended that the purpose of this new program be to train electronics technicians for entry-level positions for the manufacture, testing, installation, service, and maintenance of digital computer systems. The committee also recommended that the program be designated as the Digital Equipment Technology Program. This name was selected to indicate that the training is directly applicable to a wide range of electronics systems using digital electronics technology.

The three principal companies represented on the committee were Automatic Network Services Incorporated (ADP), Digital Equipment Corporation (DEC), and Xycom, a small industrial process control company. These three companies shared two common characteristics. All three were entrepreneur-managed computer companies experiencing rapid growth. All placed a high value on the contribution and importance of the individual employee. The three principal companies recognized that their growth was being constrained by a shortage of competent technical personnel. Their corporate attitudes and optimism encouraged the WCC E/E Department to take more than normal academic risks in starting and planning the program.

The E/E Department had but six full-time instructors in 1979, and none had prior professional experience in computer maintenance. However, two instructors had extensive experience in the development of state-of-the-art electronics systems and were accustomed to managing difficult technical projects with stringent schedule requirements.

One of the first tasks assumed by the Digital Equipment Technology Program advisory committee was to aid in the definition and documentation of the basic training goals of the program. These goals emphasized the necessity of providing a digital computer laboratory environment representative of the equipment used in industrial and commercial computer facilities.

The strategic program goals of the Digital Equipment Technology Program at Washtenaw Community College are as follows:

- Train technicians who can function successfully in digital equipment manufacturing, quality control, service, or technical support
- Meet the digital equipment technician needs of the manufacturers, users, and service organizations operating in the area served by Washtenaw Community College
- Provide a viable educational program for both full-time and part-time students attending day or evening classes so that a full-time student can complete the requirements for an associate degree within twenty-one months and a student attending on a half-time basis can complete an associate degree within forty-four months
- Actively recruit and encourage women, minority, and handicapped students
- Graduate at least twenty students per school year

Graduates of this program will be competent in the following ways:

- Work effectively as a member of a technical team in an open and objective manner
- Communicate effectively with programmers, engineers, other technicians, managers, and customers using acceptable oral and written English
- Trace the cause of a digital system hardware discrepancy to the subsystem or board level
- Use the system documentation, diagnostic aids, and test equipment to troubleshoot system problems effectively after completing an on-the-job training program at students' place of employment
- Apply basic electrical, electronics, electro-mechanical and information-processing principles to the solution of practical servicing, maintenance, and test problems
- Perform work in an ethical and professional manner
- Observe and apply the principles of electrical safety to protect personnel, test equipment, and system components from injury or damage
- Adapt to the pace of constantly changing digital equipment technology by using the manufacturer's technical information and the vendor's training programs in order to maintain technical competence

- Be knowledgeable about where, how, and why digital equipment techniques are used for increased awareness of ethical, social, and economic implications

- Have the training, experience, maturity, and self-confidence to succeed at entry-level jobs calling for work with large computing systems

This requirement made it clear that the college could not meet industry's needs by using only microprocessor trainers to simulate industrial equipment or environments.

After the strategic goals were completed, the advisory committee was asked to recommend a curriculum based on three boundary conditions:

1. The program had to maximize utilization of the core courses being offered in the current E/E programs.

2. The program should not exceed sixty-eight semester credit hours.

3. The E/E Department would need the committee's help in obtaining any specialized laboratory equipment because of the small capital equipment budget available.

The first condition was required for two reasons. First, enrollment in the existing core courses was typically twelve to fifteen students in 1979. It was essential that the Digital Equipment Technology Program increase, rather than decrease, the small enrollment in those courses. Second, the small full-time E/E Department faculty would not be able to develop and teach many new courses.

The second boundary condition stemmed from two faculty concerns. First, the WCC faculty anticipated difficulty in meeting industry's training needs with a four-semester program. Furthermore, most electronics technology programs require two or three laboratory courses each semester, and the faculty wanted to design a program with a maximum of seventeen credit hours per semester, if possible.

The original curriculum for the Digital Equipment Technology Program is illustrated in figure 2. The two new courses required to start the program are highlighted by the heavy black borders.

ADP Network Services donated the PDP-8/I minicomputers that were used to support the first new course in the program, EE-138 Digital Computing Systems I. When the advisory committee started discussing the need, scope, and content of the second computer systems course, the E/E Department faculty raised the issue of laboratory equipment. The advisory committee agreed that additional laboratory equipment would be required. ADP Network Service donated ten Dataproducts Model 2410 line printers to help support the second course. Using the line printers for laboratory activities, the second computer systems course was offered during the 1980 winter term. Offered as an evening course only, this course was taught by a part-time instructor with extensive printer maintenance experience.

During the 1080-81 school year, both day and evening sections of the two new computer systems courses were offered. The day sections were taught by full-time faculty, and the evening sections were taught by part-time staff. The enrollment in these two courses increased over 100 percent during the second year, and overall E/E Department enrollment increased 43 percent.

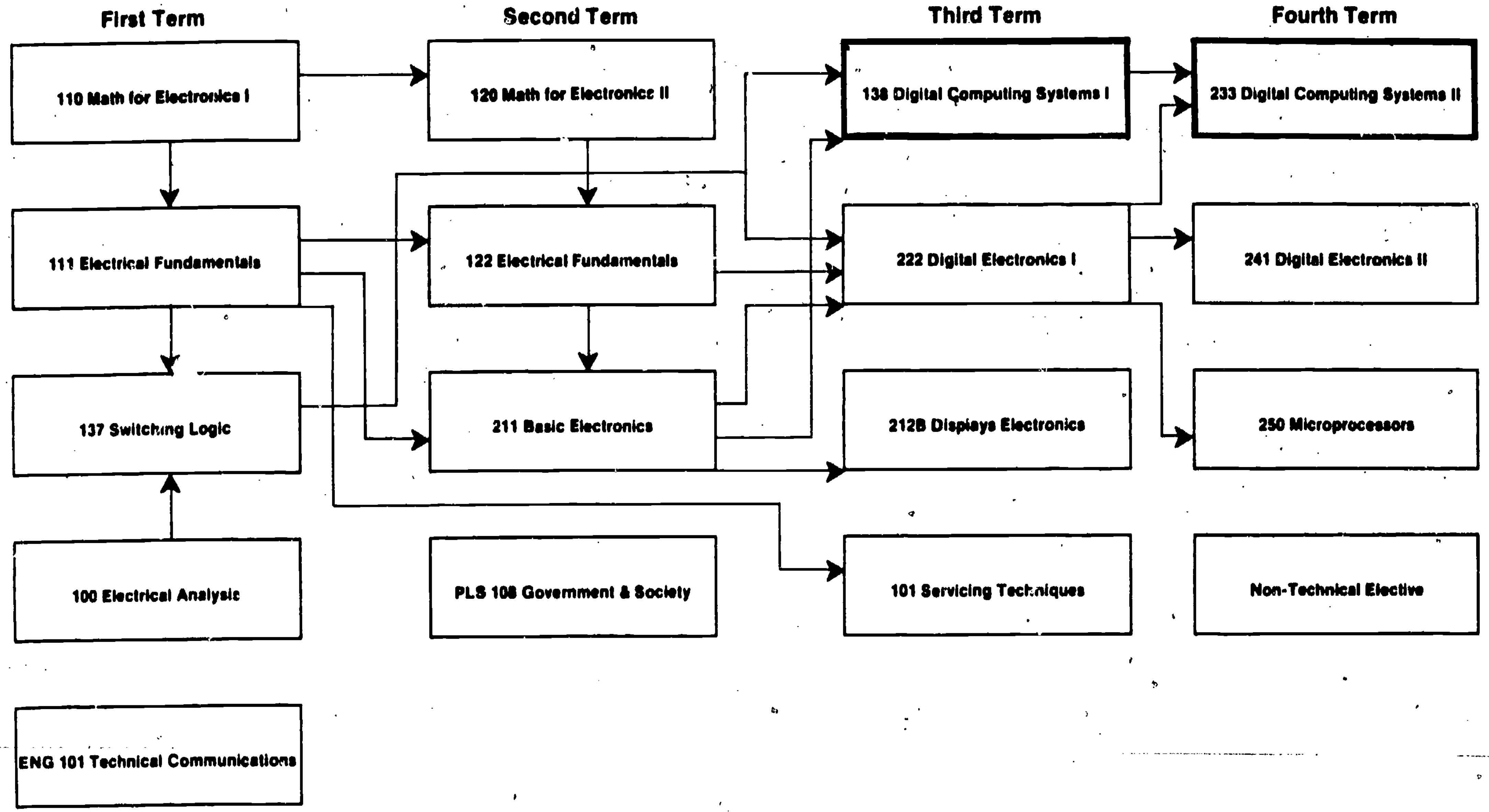

Figure 2. Original digital equipment technology program curriculum

In September 1980, one of the most significant events in the development of the Digital Equipment Technology Program occurred when Digital Equipment Corporation (DEC) agreed to support WCC through its corporate Minicomputer Technology Program. It is important to note that commitment from DEC made many resources available to the program. DEC agreed to the following:

1. assist in training the college faculty by providing thirty weeks of tuition-free training at DEC field engineering schools

2. donate the following audiovisual courses to the college:

   Introduction to Minicomputers
   Introduction to the PDP-11
   Introduction to Digital Logic
   Magnetic Recording Techniques
   Magnetic Tape Principles
   Magnetic Disk Principles
   Introduction to Digital Communications

3. give a 33 percent discount on equipment purchased to support the computer maintenance technician program

4. provide summer internships at the local field service office so that E/E Department instructors could obtain practical experience

5. provide technical training literature and technical documentation at reduced cost for use in the classroom and laboratory

6. coordinate workshops and seminars with other colleges in the DEC Minicomputer Technology Program so that the faculties could share ideas and information

Furthermore, the local DEC office established a goal to make job offers to 50 percent of the WCC program graduates. This commitment was one of the most important program assets. DEC has hired over thirty WCC graduates during the past two years and has placed them in a variety of assignments. DEC has carefully monitored the job knowledge and performance of the WCC graduates in order to assist in evaluating the WCC training program and to suggest specific program changes.

In 1980, the college administration decided to purchase a Burroughs B6800 mainframe computer for the college's administrative data processing center and to support data processing and computer science instruction. During contract negotiations with Burroughs, it was mentioned that another company had donated equipment to the WCC electronics department for use in the computer technology program. As a result of this discussion, Burroughs agreed to donate a B1865 computer with a magnetic disk unit, a magnetic tape unit, line printer, card reader, three video terminals, and the applicable software to the WCC electronics department. The B1865 computer system was delivered and installed in the fall of 1981.

Burroughs also donated twenty weeks of tuition-free training at a Burroughs training center so that the E/E faculty would be able to maintain the system. During the summer of 1981, two members of the E/E staff completed ten weeks of hardware maintenance training on the central processor, magnetic tape drive, and disk drive.

The total enrollment in the E/E Department increased another 30 percent during the 1981-82 school year as a result of the Digital Equipment Technology Program. The advisory committee recommended that WCC procure PDP-11/40 systems for the program and that a peripheral course and an analog circuit (op amp) course be added to the program. The PDP-11/40 was chosen because the architecture was closer to the state of the art, was well designed for training purposes, and was available at a low cost. The program curriculum, as shown in figure 1, was formalized and approved during the 1981-82 school year. During the summer of 1982, the WCC administration agreed to purchase the PDP-11/40 systems.

The economic recession in Michigan forced the college to postpone and reduce expenditures during the 1982-83 school year. As a result, the five PDP-11/40 systems were not ordered until October 1982. Therefore, the laboratory equipment needed for EE-230 Computer Systems II was not available for the 1982 fall term, forcing cancellation of the course. Three sections of EE-230 were scheduled for the 1982 winter term on the assumption that the PDP-11/40 lab would be ready. However, it became apparent in December of 1981 that the equipment would not be available the following January. WCC could not risk canceling the class again without jeopardizing the graduation of many students and seriously damaging the reputation of the program. The faculty asked the Digital Equipment Technology Program's advisory committee for suggestions and help in solving this problem. DEC donated a PDP-11/40 system (with four RK05 disk cartridge subsystems, a line printer, and a teleprinter), a PDP-11/23 and a PDP-11/05. ADP loaned the college a PDP-11/34 to help start the course. There were seventy-five students enrolled in the three sections of EE-230 during the 1982 winter term.

In February 1982, DEC donated a PDP-11/60 system to WCC. The system had 156K bytes of main memory, two RK05 disk cartridge subsystems, twelve video terminals, and five DEC writers. Of the five PDP-11/40 systems ordered in October 1982, two were delivered in February 1983 and the other three were delivered in March 1983. EE-235 Computer Systems III was offered for the first time during the 1983 fall term. This milestone represented the culmination of a four-year effort to implement the Digital Equipment Technology Progra[illegible] WCC.

The cost of establishing the Digital Equipment Technology Program at WCC is summarized in table 4.

TABLE 4

COST OF ESTABLISHING DIGITAL EQUIPMENT TECHNOLOGY PROGRAM

Laboratory Equipment	WCC Cost	Industry Support
B1865 system	$--	$150,000
PDP-11/60 system	--	50,000
PDP-11/40 system	--	20,000
Dataproducts line printers	--	40,000
PDP-8 processors	--	10,000
PDP-11/20	--	1,000
PDP-11/05	--	1,000
PDP-1140 systems	50,000	25,000
	50,000	$297,000
Facilities		
Remodeling	1,000	
Halon fire protection system	10,000	
	11,000	
Faculty Training		
B1865 training	10,000	20,000
PDP-11 training	1,000	2,500
Disk drive training	1,000	2,500
Diagnostic training	500	1,000
	12,500	26,000
Audiovisual Training Courses		
Introduction to Minicomputers	--	4,150
Introduction to the PDP-11	-	5,200
Introduction to Digital Logic	--	3,450
Introduction to Data Communication	--	2,800
Magnetic Recording Techniques	--	2,800
Magnetic Tape Principles	--	2,800
Magnetic Disk Principles	--	2,800
Small Systems Course	--	350
		24,350
Special test equipment		
Logic card tester	5,650	
Alignment packs	2,500	
Disk drive fi ld test box	6,400	
Disk drive run box	265	
Disk drive alignment meter	345	
Disk drive tools and fixtures	1,800	
	16,960	5,600
TOTALS	90,490	352,950

CHAPTER 3

PROMOTING INDUSTRY SUPPORT

DEC Minicomputer Technology Program

Shortly after the WCC E/E Department started recruiting advisory committee members for the proposed program, Digital Equipment Corporation placed an advertisement in the *Ann Arbor News* for computer maintenance technicians. The E/E Department faculty telephoned the DEC district field service manager who had placed the ad and asked him to support the advisory committee. When the representative from the local DEC office attended the first advisory committee meeting, he informed the WCC faculty that DEC had a corporate program to encourage public and nonprofit colleges and technical institutes to train computer maintenance technicians. This program is called the Minicomputer Technology Program (MTP).

At that time, ex-military technicians were the principal source of new maintenance technicians in the computer industry. The number of electronics technicians leaving military service was not adequate to support the needs of the computer industry. DEC recognized that human resource development is critical to the sustained growth of the computer industry. Furthermore, DEC recognized that additional sources of trained technicians were needed to sustain their corporate growth rate. DEC started the Minicomputer Technology Program to enable the community colleges, technical institutes, and DEC to pool their resources and talent.

The E/E Department faculty were excited about the possibility of participating in the DEC Minicomputer Technology Program (MTP) and invited the DEC midwestern region MTP manager to visit WCC. Several discussions were held with the DEC MTP managers during the 1978-79 school year regarding WCC's participation. DEC's principal reason for providing support through the Minicomputer Technology Program would be to provide a source of trained technicians for the local field service offices. However, in June 1979, DEC decided not to support WCC through the MTP program for two reasons. First, the managers believed that the WCC computer maintenance program had not developed to the point at which DEC corporate investment was commensurate with the risk. Second, DEC corporate personnel recognized that WCC and the local DEC district office had not developed a close working relationship.

The WCC E/E Department faculty renewed their effort to strengthen the computer maintenance curriculum during the 1979-80 school year. Several advisory committee meetings were held for the specific purpose of reviewing curriculum issues, and the program curriculum, as shown in figure 2, was developed for the 1981-82 school year. The WCC E/E Department faculty also worked more closely with the local DEC district staff during the 1979-80 school year. Three managers from the local DEC office served on the advisory committee that year, making major contributions to the committee's effort. The DEC Minicomputer Technology Program corporate managers visited WCC again during September 1980 to review the status of the program. After the review, DEC agreed to support the WCC program.

Advisory Committee Support

The most important requirement in developing an active and supportive advisory committee is to recruit members from companies that are hiring graduates of the program. If the company is not hiring graduates, the member will tend to have only an academic interest.

Presently, five companies represented on the WCC Digital Equipment Technology Program advisory committee are hiring graduates of the program. All of these companies have a strong interest in the program and are continually looking for ways to help. These companies provide program improvement suggestions based on the performance of former students and new technology developments.

At every advisory meeting, one of the principal agenda topics is a discussion of how to recruit new companies. The committee members are encouraged to recruit new members through their business, professional, and social contacts. The committee has established a goal of recruiting at least one new company per year to help support the program. Committee members seek individuals or companies that may be interested in hiring graduates or donating equipment or members who will expand the technical expertise of the committee.

Committee members are also encouraged to find equipment donations. The committee has been very successful in this task, and during the past year, WCC has been in the fortunate position of declining many offers for equipment donations because of inadequate laboratory space to accommodate them.

Program Reviews with Industry

Alvin Toffler (1974) wrote that "All education springs from some image of the future" (p. 3). Virtually all instructors hold to yesterday's traditions in preparing today's students. That is, their image of a student's training needs tends to be only a minor adaptation of what they received in school. However, the present computer industry is not a minor adaptation of the electronics technology that most community college instructors learned or practiced in industry. It is very difficult for instructors to evaluate objectively their own occupational courses and programs or to foresee the new training requirements for the immediate future.

One feature of the DEC Minicomputer Technology Program (MTP) is an annual program review at each participating college. The agenda for the review is prepared by DEC and the college. The corporate manager of the MTP and two or three engineering managers from the local DEC office participate in the review. WCC's vice-president of instruction, the dean of occupational education and three or four members of the E/E Department represent the college during the program review. The meetings include a critical review of curriculum, status of faculty training, laboratory facilities, test equipment, enrollment statistics (with particular emphasis on minority and female enrollment), and any program problems. DEC also interviews three or four students enrolled in the program. The students are asked about their perception of the program, advantages, disadvantages, and faculty support. They are also encouraged to recommend areas for improvement. The review is conducted in a spirit of cooperation for the purpose of mutual problem solving to improve the program. The E/E faculty tries to listen carefully to all suggestions and questions. The faculty respectfully and throughtfully considers each recommendation.

Many colleges and faculty might be uncomfortable about industry representatives conducting a critical review of their technical programs. The WCC E/E faculty believes industry program

reviews are invaluable and produce a better program. The WCC program reviews have added credibility to the faculty effort with the college administration. The administration sensed that E/E faculty must be doing something correct if a company was willing to invest the time and expense to participate in the program reviews on a regularly scheduled basis.

The academic and technical challenges of these meetings were beneficial to the professional development of the E/E faculty. The annual reviews have increased not only the mutual respect between the two organizations, but also the awareness of the problems confronting each institution. It is also important to note that these industry meetings have not been restricted to a review of the technical curriculum. They have been equally concerned with the general educational skills of the students. Industry reviews have stressed the importance of speaking, writing, and interpersonal skills essential for success in industry.

The WCC E/E Department has a policy of inviting each company that is hiring graduates of the program to attend an annual luncheon meeting at WCC. The purpose of this luncheon is to permit companies to conduct an informal program review. Although these meetings are not so formal or intensive as the Minicomputer Technology Program reviews conducted with DEC, the meetings provide valuable support. The company is reassured that the college is interested in its recommendations and assistance.

Program reviews with industry helped the college obtain badly needed equipment. Occasionally, industry representatives would recommend additional instruction in a special technical area. The E/E faculty would often agree, but point out that the college was not currently teaching that topic because the necessary laboratory equipment was not available. On several occasions a company was able to locate equipment that was then donated to the program. The industry reviews also identified sources of special technical expertise in preparing technical material or training experience to help the college.

Contribution of Former Students

The E/E faculty located four graduates of the electronics technician program who were working in the computer industry and asked them to serve on the advisory committee. One of these graduates had completed a bachelor's degree program in computer engineering at the University of Michigan and was employed as a design engineer for a local manufacturer of intelligent terminals. He had firsthand knowledge of the WCC E/E courses and knew what additional training was needed to make WCC graduates employable at his company.

These four graduates agreed to serve on a curriculum subcommittee to recommend several innovative program changes. For example, in order to generate student interest in the computer maintenance program, the subcommittee recommended that WCC teach digital logic during the first rather than the third semester. They recognized that the new program would be competing with the older and more established electronics technician program. As a result of their suggestion, WCC became one of the first community colleges in the country to teach digital logic during the first semester.

Former WCC students were also able to solicit equipment donations for the college. One student learned that Michigan Bell Telephone was going to replace two magnetic tape records in a suburban Detroit office and made arrangements for this equipment to be donated to WCC.

Selection of Laboratory Equipment

The selection of laboratory equipment for an occupational training program, particularly in a systems laboratory, can often help establish a strong industry interest. Although the PDP-11/40 systems were selected for the WCC computer systems laboratory primarily to meet the basic training needs recommended by the advisory committee, there were a large number of PDP-11/40 installations in the college district. They were being used in standard data processing facilities, in medical applications, in scientific computing, and in the testing of automatic transmissions for automobiles.

Schools must provide generic training that is applicable to a broad range of equipment. In most occupational education laboratories, it is technically and financially feasible to have equipment manufactured by several different companies. On the other hand, there are several important reasons for selecting a single computer model for a computer systems laboratory, if possible. First, during a two-year program, it is difficult to teach one system thoroughly. If a student has a sound understanding of one system, normally the student can apply that training on the job to learn a second system. Second, a single model will reduce the quantity of spare parts, documentation, and special test equipment needed. It is less expensive to buy a spare system than it is to buy spare parts. If there are no failures, the spare system can be used as a laborat[illegible] station. When a failure occurs, the required spare part can be removed from the spare s[illegible] quickly. Furthermore, the spare system provides an efficient and compact method of sto[illegible] spare parts.

It is recommended that a college establishing a computer maintenance pro[illegible]m conduct a survey to determine the types of computers used in local industry. If possible, the college should consider selecting a computer system most frequently used in the college district. Graduates of the program will probably have more job opportunities because industry will be eager to reduce their training costs. Furthermore, companies may be willing to donate their equipment to the college when it is time to replace computer systems. The survey may identify companies planning new computer procurements in the near future. This information will give the college an opportunity to ask for company support of the new program in the form of an equipment donation.

Search for Industry Help

ADP Network Services had an average growth rate of 27 percent per year during the period of 1974 to 1979. During the period 1979 through 1983, DEC's gross income increased from $1.8 billion to $4.2 billion, an average growth rate of 24 percent per year. Companies growing at these rates experience tremendous pressure to find an adequate supply of skilled technical personnel and are more interested in technical skills than academic credentials. The companies are willing to take more risks to sustain their rapid corporate growth.

WCC faculty believes that growth companies in the high-technology industries are the most promising partners for a cooperative industry-college vocational training program. It is recommended that colleges considering linkages with industry contact companies that are achieving growth rates of 20 percent or more per year.

CHAPTER 4

PROGRAM RESULTS

At a very modest cost to the taxpayers of the college district, the development of the WCC Digital Equipment Technology Program has made available a state-of-the-art computer maintenance and electronic technology program to both day and evening classes. Two dedicated computer laboratories were remodeled and equipped for less than $70,000. The program is providing quality technical education to over four hundred students per year. Using an open-door policy that imposes no admission requirements, the tuition cost is only $27 per credit hour. Although the primary intent of the program is to train computer maintenance technicians, many of the courses meet the continuing education needs of techicians and engineers in local industry.

The program also has provided an opportunity to develop an industry-college partnership that has been mutually beneficial. The local computer industry has found a source of competent entry-level technicians who require less on-the-job training, and they are convinced that the college is interested in meeting their future needs. The college has found a means of obtaining technical consulting services, planning assistance, program evaluation support, and equipment grants crucial for maintaining quality occupational education. The real beneficiaries in this partnership are the students who receive a quality education in a highly competitive technical field and the taxpayer/consumers who ultimately pay the bills.

At WCC an important result of the Digital Equipment Technology Program has been the transformation of the E/E Department. Prior to the start of the program, primary instructional emphasis had been on basic electrical circuits and basic electronic components (transistors). System-level courses were taught only as part of a radio and television repair program. The department provided little instruction in integrated circuit devices. The professional development required of faculty to implement the program has created a strong commitment to technical excellence. The department views the present status of the digital program as a beginning rather than an end. This emerging attitude has allowed the department to make long-overdue decisions on goals and priorities. For example, in 1981, the E/E Department recommended that the college discontinue the radio and television service program because it was an expensive program with a relatively small enrollment. Additionally, in 1983, the department recommended that the Electronics Engineering Technician Program be discontinued so that limited resources could be used more effectively.

WCC has not advertised or marketed the Digital Equipment Technology Program. Yet, as a result of the faculty and administration's commitment, the success of the program has spread by word of mouth with the following results:

1. Enrollment has increased 100 percent within three years. The E/E department generated [illegible]3 student credit hours during the 1978-79 school year and 9,270 student credit hours 1982-83.

2. The number of students completing an associate degree in the electronics occupational programs increased by approximately 300 percent. Prior to 1980, WCC awarded about twelve associate degrees per year in E/E programs. During 1982, WCC awarded thirty-two associate degrees to graduates of the Digital Equipment Technology Program alone.

3. The enrollment of minority and female students has increased dramatically. Only two minority students and two female students graduated from WCC E/E programs between 1966 and 1979. From 1980 to 1982, ten minority and twelve female students graduated from the Digital Equipment Technology Program.

4. Graduates of the program have received more job offers and higher starting salaries. Students have been able to gain employment with companies not previously hiring WCC graduates.

5. Students have transferred from other Michigan community colleges to enroll in the Digital Equipment Technology Program. Most of these students live close to their former colleges but have elected to commute to WCC to enhance their job prospects.

6. The technical skills and experience of the E/E faculty have improved. Despite a hiring freeze in all other departments, the WCC administration has allowed the E/E Department to hire two additional instructors in response to the large increase in students. The success of the program has enabled the college to attract more qualified applicants for E/E Department faculty positions.

7. The program is attracting students with better academic training. The typical student has at least one year of postsecondary training. Approximately 20 percent of the program graduates have a bachelor degree and approximately 5 percent have a master's degree.

8. Department efficiency has increased. The average class size is larger. The department offers approximately fifty-six sections in the fall and winter semesters and approximately forty sections are filled to capacity.

Some of the courses in the Digital Equipment Technology Program also serve students majoring in other occupational education programs and provide a foundation for other high-technology programs. For example, WCC started a robotics technician program in 1982, and over 50 percent of the courses in the robotics program are digital electronics courses. It would have been more difficult to start the robotics program without the prior development of the Digital Equipment Technology Program. WCC expects the Digital Equipment Technology Program to form a base for other high-technology programs in the future. The E/E Department is planning to implement a telecommunications program during the 1984-85 school year as an extension of the digital program.

Significance to Vocational Education

The WCC Digital Equipment Technology Program is a typical example of what can be accomplished in a relatively short period of time as a result of close cooperation between industry and a college. This program demonstrates that the computer industry is willing to assist colleges in the development of their most valuable resource—competent technical workers. Many of the computer and computer-related companies have an enlightened attitude toward education and are willing to make long-term investments that will contribute to the success of their industry. If college administrators and faculty are willing to listen to industry's needs and to respond to the challenge facing the computer industry, they will find a generous, creative, and enthusiastic partner.

The WCC program was developed during the most severe economic recession in Michigan since the Great Depression. It would have been impossible to develop all of the new courses and laboratory facilities without generous support from industry. A different, and probably less successful, program would have evolved if the program curriculum had been developed by the E/E faculty without regard to recommendations from industry. The faculty would have been more conservative in making curriculum changes, and the program development would have undoubtedly taken much longer without the encouragement, support, and challenges provided by industry.

The program has also confirmed that there is demand for graduates of a digital electronics program. Students have been offered jobs to repair computer terminals, install minicomputer systems, service computer systems, test and repair robotics equipment, service microcomputers, repair medical electronics, service electronics test equipment, and sell computers.

Although southeastern Michigan has some computer and computer-related manufacturing industry, none of the WCC graduates have been employed in manufacturing. All of the graduates have been employed in servicing or computer sales. The rapid development of digital electronics systems, such as office equipment, security systems, digital telecommunications, flexible automated manufacturing equipment, CAD/CAM equipment, and medical systems will create a demand for digital electronics service technicians in almost every community. Many of the techniques used by WCC to encourage industry support can be used in other communities.

CHAPTER 5

ESTABLISHING A COMPUTER TECHNOLOGY PROGRAM

Faculty Commitment

The most important requirement in starting a successful computer maintenance program is faculty commitment. Before embarking on a major change in existing electronics technology programs, a self-evaluation should be conducted to determine the faculty dedication to starting and maintaining a computer technology program. The electronics faculty should recognize that the emphasis will shift from traditional circuit and device courses to system operation, including the interaction of hardware and software. This transition will require intensive staff development. As John Naisbiett (1982) suggests,

> If you want to move a company or some other kind of institution in a new direction, people within that institution must have a sense of direction. . . . For best results, the people in that institution must have ownership of the new vision. (p. 95)

A computer maintenance program requires a broader range of technical expertise among the E/E faculty than a traditional electronics technology program. The E/E faculty must be able to teach computer system courses, peripheral devices, and software concepts in addition to electrical circuits and electronic devices. The department will need to offer a greater variety of courses. Normally, because a technical instructor can teach four to six different courses per school year, a larger E/E faculty may be required.

The E/E faculty will find that there is a shortage of training material. This will be a source of concern. Although there is an abundance of textbooks and laboratory experiment manuals for the traditional electronics courses, very little is available for computer maintenance courses. The E/E faculty must be prepared to create and write training materials of all types. This course development will require the preparation of study guides, study questions, homework problems, laboratory experiments, and training aids.

It is much more difficult for instructors to teach advanced courses than beginning courses in a computer maintenance program for three reasons. First, instructors must learn the detailed operation, design, and documentation of the equipment. This requires many hours of self-study and/or attending special training courses offered by the manufacturers. Second, instructors must prepare all of the training materials. Third, equipment malfunctions or failures will occur during the course, and instructors often are expected to repair these equipment failures in their spare time. The administration should provide some incentive for electronics instructors to develop advanced-level courses to implement a successful computer maintenance program. WCC faculty members spent over thirty person-weeks attending special computer training courses during the two year period between 1980 and 1982, mostly during the summers and on their own time. For professional development, most electronics instructors will attend one or two courses on their own time, but few are

willing to do this every year. Unfortunately, faculty training is never completed in a computer maintenance program. Thus, it 's essential that the faculty and administration develop a long-range plan and commitment fo. sustaining faculty expertise.

Faculty must be interested in—and willing to devote the extra time and effort needed for—developing a close working relationship with industry. A tremendous amount of time and effort is required to develop and maintain a successful industry-academic partnership. The administration and faculty should evaluate each E/E faculty member's capability of performing this task successfully. Not all electronics instructors have the industrial experience, personality, technical skill, or interest to perform this activity. Some instructors are primarily course oriented, and their goal is to become a master teacher in two or three technical courses. They have no interest in developing a series of courses that is systematic and consistent in terms of content and technical level in order to meet the overall training goals. The E/E faculty should have at least one person who has experience as an electronics systems engineer and who is interested in the development of new occupational programs.

Administrative Commitment

What can the college administration do to encourage the development of a successful high technology program? First, it should recognize that academic processes in the community college tend to encourage the status quo. There is often little incentive for a department to introduce a rapidly changing high-technology program. If a technical department continues to teach traditional courses, there is no need to change the textbooks, purchase new laboratory equipment, plan new laboratories, develop new courses, organize new advisory committees, revise the course catalog, or change the class schedule.

Second, the administration should recognize that converting a typical community college electronics program from the traditional to the innovative is a major undertaking. The technical faculty will need extensive fiscal support for faculty development, industry liaison, program reviews, course development, laboratory development, and equipment procurement. Although soliciting equipment donations reduces the capital equipment expense to the college, it may also increase the work load for the instructors by demanding completely new or significantly revised training materials and procedures.

The administration and faculty need to encourage the participation of occupational advisory committees in the development and implementation of new programs. The administration can help in this activity by recruiting from local industry the managers who make the hiring decisions. The administration and faculty must convince the advisory committee that the school is sincerely interested in its advice and is able and willing to incorporate its recommendations. Developing and maintaining a successful high-technology occupational program is difficult without an active advisory committee.

Colleges also need to encourage program reviews by industry. This activity can be implemented as part of the advisory committee activity. However, having separate reviews with individual companies has several advantages. First, the company representatives feel freer to discuss corporate business, technical, and personnel plans when other companies, and possible competitors, are not present. Second, a small review team may be more productive and creative. Small review teams are frequently more relaxed, less formal, friendlier, and less threatening to the faculty than larger, more formal reviews. Few organizations or individuals enjoy an in-depth evaluation, and most members of the faculty tend to be defensive when being evaluated. A smaller review team is often more conducive to constructive criticism.

Pratzner (1983) cautioned against promoting industry involvement in vocational education. Public institutions, he argued, must provide generic training applicable to a broad spectrum of equipment and should not become a training school for any one company (p. 13). However, community colleges can avoid this criticism by conducting program reviews with several companies. Only after proposed changes have been reviewed and approved by the advisory committee should changes be incorporated. Very few community colleges have the faculty technical expertise to develop state-of-the-art vocational programs without close cooperation with industry. In many respects, teaching computer technology courses is a lonely job. A typical instructor has little technical or business contact with industry and feels isolated from the mainstream of technical activity. Instructors are continually wondering how they can get ready to teach the courses required next year when the state of the art is changing so fast. Such technical faculty members need periodic contact with industry to maintain a sense of direction.

Equipment Costs

The cost of developing a computer maintenance program will vary widely depending on the quality of the faculty, facilities, and laboratories of the current electronics technology programs. If a school has an electronics program that includes courses in integrated circuit devices such as TTL logic, op amps, and microprocessors, then a computer maintenance program could be started by adding two or more computer system courses and one or more peripheral courses.

Laboratory equipment required for the computer system and peripheral courses will depend on the number of students in each laboratory section and the equipment selected for each course. WCC elected to design its laboratories to accommodate a maximum of twelve students per section for two reasons. First, only six computer systems could be installed in the room assigned to the E/E Department for a computer systems laboratory because of the room size. Second, the WCC training program is based on the philosophy that a maximum of three students should perform any lab activity on a system. It was determined that adequate hands-on experience needed to meet training requirements could not be provided if more than three students were working on a single system.

Depending upon the system configuration, the equipment for a computer systems laboratory with six computer systems consisting of a central processor, 32K of main memory, a disk drive, a teleprinter, and documentation and diagnostic programs can be purchased for from $91,000 to $145,000. Typical equipment costs for a computer systems laboratory are summarized in table 5. It will be necessary to purchase special test equipment and spare parts to maintain the systems or to purchase a maintenance agreement. A maintenance service contract on a system of this size is normally between $1,200 and $1,500 per month. However, most computer companies will charge a premium if students are performing laboratory experiments on the equipment. One computer company refused to provide a service contract to WCC at any price if the computer system was to be used for student training.

Normally, equipment for the computer peripheral laboratory will consist of video terminals, teleprinters, line printers, disk drives and magnetic tape records. The equipment cost will depend upon the number of students in each laboratory section and the types of peripheral devices taught. Equipment for a peripheral laboratory including six disk drive subsystems, six line printers, and six video terminals will cost from $37,000 to $98,000 plus test equipment and documentation. Typical costs for computer peripheral devices needed to support a computer maintenance program are shown in table 6.

TABLE 5

TYPICAL EQUIPMENT COSTS FOR A COMPUTER SYSTEMS LABORATORY

Equipment	Unit Cost
Central processor and main memory	$10,000 — $15,000
Hard disk drive and controller	$ 4,000 — $ 7,000
Teleprinter terminal	$ 800 — $ 1,200
Diagnostic pack and documentation library	$ 500 — $ 1,000
Total cost per system	$15,300 — $24,200

TABLE 6

TYPICAL COSTS OF COMPUTER PERIPHERALS

Equipment	Unit Costs
Video terminals	$ 400 — $ 1,300
Teleprinters	$ 1,200 — $ 3,000
Line printers	$ 1,800 — $ 8,000
Floppy disk drive	$ 200 — $ 2,000
Magnetic tape drive	$10,000 — $12,000
Hard disk drive	$ 4,000 — $ 7,000
Total	$ 7,600 — $21,300

The special test equipment will include such items as disk drive field-test boxes, alignment packs, logic module testers, skew tapes, and special tools for aligning disk drives and tape decks. One set of special test equipment and tools will cost from $11,000 to $17,000. The number of sets needed will depend upon the variety of peripheral devices to be maintained and the number of work stations to be equipped for instructional purposes. Typical costs of special test equipment and tools are summarized in table 7.

TABLE 7

TYPICAL COSTS OF SPECIAL TEST EQUIPMENT

Equipment	Unit Costs
Printed circuit modul tes.er	\$ 4,000 — \$ 6,000
Disk drive field test box	\$ 4,500 — \$ 6,500
Alignment pack	\$ 1,100 — \$ 1,400
Logic dard extender	\$ 50 — \$ 300
Disk drive alignment tools and fixtures	\$ 1,500 — \$ 3,000
Total	\$11,150 — \$17,200

WCC recommends that the peripheral curriculum include maintenance instruction on video terminals, line printers, and disk drives as a minimum. Since the peripheral devices used in the system laboratory must be functioning correctly at all times for students trying to perform the system experiments, WCC also recommends that these peripherial devices not be used for peripheral maintenance training. Every effort must be made to ensure the integrity of the equipment in the systems laboratory. Maintaining a reliable systems laboratory is difficult if students are disassembling and adjusting the peripheral devices.

Facility Costs

The costs of a new or remodeled computer facility also vary widely. As mentioned earlier, the first WCC computer maintenance laboratory was located in a temporary classroom building. The present WCC E/E Department computer laboratory is located in a room built for the college's data processing center. The room has a raised floor and additional air conditioning, having been remodeled for the computer maintenance program at a cost of \$11,000, which included the installation of a Halon fire protection system. Prior to the remodeling, the room had an overhead water sprinkler system. The computer equipment would have suffered serious water damage if the sprinklers had been activated, either due to fire or accident. It will cost from \$30,000 to \$40,000 to remodel an existing facility if a raised floor, air conditioning, and a Halon fire protection system are installed.

Faculty Training

It is very difficult to hire instructors with computer maintenance experience, so most colleges must provide faculty training. Typically, the primary source of specific hardware training is the equipment manufacturers. The tuition for these courses can be as much as \$1,500 per week. However, some companies provide tuition training credits as part of the equipment purchase agreement. The length of each manufacturer's hardware maintenance course depends on the type and complexity of the equipment. Typical duration of company training courses is as follows:

- Central processors and memory — 15 to 25 days
- Disk drives — 10 to 15 days
- Tape drives — 10 to 15 days
- Line printers — 3 to 5 days
- Video terminals — 3 to 5 days
- Teleprinters — 3 to 5 days

A set of courses will require from eight to twelve weeks for training, and it is recommended that two instructors be trained. The tuition for this training will be approximately $8,000 to $12,000 per instructor. Such equipment manufacturers assume that students taking their courses have extensive field training experience, the courses are generally very intensive. For maximum benefit, the college instructor should teach the material learned in a specialized course shortly after completing the course. For these reasons, it is recommended that an instructor take only two or three courses per school year. Hence, the total hardware training sequence of nine weeks may extend over two calendar years.

The instructors also may need special training in the use of diagnostic programs and operating systems. Typical software courses and their duration are:

- Software Concepts — 3 to 5 days
- Diagnostic Programs — 5 to 10 days
- Introduction to Operating Systems — 5 to 10 days

WCC recommends that the same two hardware instructors also receive the software training. A set of courses will require from two to five weeks of training. The tuition for the software training will be approximately $2,000 to $5,000 per instructor. Travel costs for each course will depend on the training site location. Assuming a travel cost of $500 per week for the hardware and software training yields an additional expense of $6,000 per instructor.

The costs of establishing a computer maintenance program in a college with an existing electronics technology program are summarized in table 8. The total cost to develop the program will depend upon the type and quantity of equipment selected, number of faculty to be trained, maintenance and logistics plan, and the availability of laboratory facilities.

TABLE 8

COSTS OF ESTABLISHING A COMPUTER MAINTENANCE PROGRAM

Expense Items	Cost
Equipment for computer systems lab (6 systems)	\$ 91,000 — \$145,000
Equipment for peripheral lab (6 sets)	\$ 37,000 — \$ 98,000
Special test equipment (per set)	\$ 11,150 — \$ 17,200
Faculty training for one instructor	\$ 15,000 — \$ 25,000
Laboratory facilities	\$ 0 — \$ 40,000
Totals	\$154,150 — \$325,200

CHAPTER 6

PROGRAM IMPROVEMENTS

WCC has revised the Digital Equipment Technology Program every year since it was founded in 1979 becaus... new equipment has become available. The faculty and advisory committee are conducting a cu...iculum review again this year, and additional changes probably will be incorporated in the 1984 fall term. WCC is trying to anticipate the changing requirements of the computer industry so that necessary curriculum changes are incorporated as needed.

WCC is considering possible curriculum changes for the Digital Equipment Technology Program. There is a definite need for a second, and possibly a third, computer peripheral course. A separate course on the theory of operation and maintenance of disk drives and controllers should be added. Most computer installations have one or more disk drives. Furthermore, the diagnostic program and operating system software are normally stored on disk packs. WCC is currently not teaching a separate course on disk drive maintenance because the only disk drives available are part of the PDP-11/40 system. EE-235 Computer Systems III includes the theory of operation and the use of diagnostic programs for troubleshooting the disk drive subsystem. However, students do not have the opportunity to replace read/write heads, to perform head alignment, or to perform the other maintenance adjustments. WCC also is considering a new peripheral course on the operation and maintenance of video display terminals.

The demarcation between hardware and software functions is changing rapidly as the cost of read/write memory and read only memory decreases, and more complex systems are developed. The field service engineer often must perform system maintenance while the operating system is running. Many diagnostic programs now run on-line under the control of the operating system. Therefore, the student must understand the functions, organization, commands, file specifications, device control, file organization, job control, utilities, editor, and sort features of the operating systems. The student also must (1) know how to log onto and communicate with the operating system and (2) how to communicate with the customer about how a possible hardware problem impacts the operation of the software.

The student must have the skill to use the operating system as a tool in the maintenance of the hardware system. WCC contemplates adding two or more specialized software courses to the Digital Equipment Technology Program. The first course will probably be an introductory course on the characteristics of an operating system, the functions of an advanced operating system, and the structure of a general-purpose time-sharing/resource-sharing system. The second course will teach the student how to communicate with a specific operating system, run device exercisers, analyze the output for system fault diagnosis, retrieve and analyze error logging, interpret relevant information on the system generation for system fault diagnosis, and determine which software tools and techniques are appropriate for a given troubleshooting situation.

All of the computer equipment used in the WCC computer maintenance laboratories was designed approximately eight years ago and is implemented with TTL logic. To improve performance and reduce costs, the new equipment designs use large-scale, integrated circuits to a greater extent. The WCC E/E faculty recognizes that one or more new electronics device courses must be implemented in the near future, including courses in MOS logic and ECL devices.

The E/E faculty is concerned about the general English writing skills of the Digital Equipment Technology Program students. WCC is seriously considering requiring a second technical writing course in the curriculum. Not only do the field service engineers prepare frequent reports, but also their opportunity for promotion is severely limited if they do not possess above-average communication skills.

GLOSSARY

Assembly Language. The set of rules, symbols, and punctuation for the programmer to obey in writing assembly language programs.

Assembly Language Program. A source program written according to the rules of an assembly language.

Assembly Language Programming. Writing program instructions in a language which facilitates the translation of programs into binary code by making use of mnemonic conventions.

Asynchronous Computer. A computer in which completion of one operation triggers the start of the next one, rather than depending on a clock to "time" the operation.

Binary Digit. One of two possible digits (0 and 1) in binary notation. A binary digit, usually abbreviated as "bit," is the smallest unit of information that can be used in a digital computer.

Bit. See **Binary Digit.**

Bus. A flat, flexible cable containing many individual transmission lines or wires. Used to interconnect computer system components and provide communication paths for addresses, data, and control information to be transferred between components. Each line (or group of lines) is designed to carry a specific type of information.

Byte. A group of bits considered as a unit, usually a subdivision of a word. Bytes are normally one-half or one-fourth the length of a word and are typically 6 or 8 bits in length. A byte is the smallest unit of information that can be addressed.

Central Processor. The major control, logical, and mathematical unit in a computer system.

Chip. A piece of semiconductor material containing a microscopic integrated circuit.

Controller. See **Interface.**

Core. A ferrite ring used to store a bit of information; core is a medium of main memory. Also a slang word for main memory.

CPU. Central processing unit.

Device. A computer component or related equipment.

Device Handler. A collection of routines that connect the operating system and the user program with the input/output devices. There is one device handler for each type of peripheral device in the hardware configuration.

Diagnostic. Pertaining to the detection and isolation of a malfunction or mistake; usually used in the form "diagnostic programming."

Digital. Pertaining to discrete units.

Direct Memory Access. Transfer of data between a peripheral and main memory without intervention of the CPU. In a multiple-bus configuration, DMA transfers are accomplished by using the DMA Bus.

Disk. A mass-storage device. Basic unit is a disk on which data are magnetically recorded. Data can be accessed randomly, and access time is faster than with a magnetic tape because required search time is significantly less. Most disks can store considerably greater amounts of data than core memories.

Display Terminal. A terminal consisting of a television-like screen and a keyboard.

Executive. The central component of an operating system. It coordinates and controls all other programs in the operating system. (See **Supervisor.**)

General Purpose Register. A register in the central processor that is used for different functions such as addressing operands, storing operands, and holding the results of computations. Usually abbreviated GPR.

Hardware. The physical equipment that makes up a computer system.

Instruction [illegible] series of bits (usually one word) that tells the computer what elementary operation to [illegible]n next and, if necessary, where to find the data to be operated upon.

Instruction Mnemonic. A three or four letter abbreviation that programmers use in place of the binary op code. Instruction mnemonics suggest the meaning of each instruction and, therefore, are easier to remember.

Instruction Set. A group of instructions that are interpreted and executed by a specific computer. Instruction sets can vary significantly from one computer manufacturer and model to the next.

Interface. A unit that serves as a translator between a specific peripheral device and the computer system to ensure that transfers of information conform to system characteristics. Use of an interface permits devices to use a common bus.

Interrupt Handler. The component of an operating system that is responsible for selecting the proper routine to service an interrupt request and for saving the status of the interrupted process.

Interrupt Request. A signal sent out by an interface to the CPU, indicating that the interface needs intervention by the program.

Machine Language. The actual language used by the computer in performing operations. This language usually refers to either binary or octal codes and is also often used to refer to assembler language coding.

Machine Language Programming. Writing a program in binary or octal notation, or converting from a symbolic program to a binary program.

Mainframe. The central processor and main memory of a computer system.

Main Memory. The high-speed storage area of a computer. Usually used for storing current instructions and data.

Mass Storage Device. A bulk storage device, such as a disk.

Medium. (1) The part of main memory that physically holds bits of data during storage. (2) The part of a peripheral device that physically holds bits of data and moves into or out of the device during input and output.

Memorv. The storage in the system; pertaining to a device in which data can be retrieved. See also **core memory** and **read only memory**.

Memory Page. A segment of main memory that contains a fixed number of storage locations. The page size is selected so that any storage location within a page can be directly addressed using the available bits in the operand field of the instruction.

Mnemonic Symbol. A symbol chosen to assist the human memory; a memory aid. For example, the abbreviation MPY for the word multiply.

Operating System. A set of programs that manages computer resources to provide efficient computer operation.

Peripheral Device. Any part of a computer system other than the CPU and the main memory. Input/output units and auxiliary storage devices are included in this category.

PDP. Programmable data processor.

PDP-11. A family of minicomputers, manufactured by the Digital Equipment Corporation, featuring a 16-bit word length, byte or word addressing, 8 general purpose registers, 12 addressing modes and a single system bus.

PDP-8. A family of minicomputers, manufactured by the Digital Equipment Corporation, featuring a 12-bit word length, page addressing, and direct and indirect addressing modes.

Processor. A unit of a computing system that includes the circuits controlling the interpretation and execution of instructions. The processor does not include the bus, core memory, interface, or peripheral devices. The term main frame is sometimes used but this term refers to all components (processor, memory, power supply) in the basic mounting box.

Program. A complete sequence of instructions for solving a particular problem on a computer.

Read Only Memory. A random access memory containing components that permanently assume a specific state so that data can be read from memory but cannot be erased, changed, or added.

Service Routine. A program used for general support of the user. For example, I/O routines, diagnostics, and other utility routines.

Software. The collection of programs, procedures, rules, and related documentation associated with operation of a specific computer. For example, compiler, editors, utility programs, and related documentation and run procedures.

Synchronous. All changes occurring simultaneously or in a definite, timed sequence.

Synchronous Computer. A computer that relies on an internal clock to synchronize the actions with the CPU.

Teleprinter. A printing device that combines a keyboard and a printer.

Terminal. A device in a system through which data can either enter or leave.

Trap. An unprogrammed jump to a known location, automatically activated by the hardware if certain predetermined conditions occur, such as illegal instructions, errors, etc.

Word. A basic unit of data that consists of a predetermined number of bits that are treated as an entity.

Word Length. The size of a word as measured by the number of binary digits (bits) that it contains. The most common word lengths used by minicomputers are 12, 16, and 18 bits per word.

REFERENCES

"Computer Systems and Services for Business, Industry and the Home." *Fortune*, 16 May 1983, p. 62.

Michigan Employment Security Commission. "Occupational Supply Demand for Ann Arbor-Ypsilanti SMSA." A report prepared by the Michigan Employment Security Commission. Ann Arbor: MESC, 1980.

Naisbiett, John. *Megatrends: Ten New Directions Transforming Our Lives*. New York: Warner Books, 1982.

Pratzner, Frank C. "Look before You Leap Aboard the Industry/Education Bandwagon." *Vocational Education* 58, no. 7 (October 1983): 13-14.

Toffler, Alvin. *Learning for Tomorrow: The Role of the Future in Education*. New York: Random House, 1974.

PART 2

LOCAL AREA NETWORKS OF MICROCOMPUTERS IN EDUCATION

Clifford D. Layton
Rogers State College

CHAPTER 7

INTRODUCTION

The "computer revolution" is upon us; in our businesses and industries, in our schools and in our homes. It is advertised and accelerated through our media, both directly and indirectly. And the field that is accelerating most rapidly is the personal computer or microcomputer field.

A microcomputer is a desk-top size or smaller computer based on a thumb-sized chip called a microprocessor. In order for a microcomputer to be useful, it must be part of a microcomputer system, consisting of an input unit such as a keyboard, a microcomputer unit for processing, an output unit such as a CRT or a printer, and, possibly, a secondary storage unit such as a floppy disk drive or a hard disk drive. Throughout this paper, the word "microcomputer" will be used in the place of the words "microcomputer system."

Microcomputers are inexpensive, yet powerful enough for all computer science and data processing purposes, except those involving the processing of large files or large numbers of calculations in short periods of time. Microcomputers are cost-effective and appropriate for most computer-related instructional educational purposes and some computer-related noninstructional educational purposes. According to studies reported by John King (1983), microcomputers are also easier to use and more responsive than other types of computer systems.

When two or more stand-alone microcomputers are located within one thousand feet of each other, the cost-effectiveness, productivity, and responsiveness of the total system of microcomputers may be significantly increased by interconnecting the microcomputers within a local area

network. The main purposes of a local area network of microcomputers are the sharing of expensive hardware, software, and data resources; and the increasing of the intercommunication of networked devices.

A local area network (LAN) of microcomputers is an interconnected set of microcomputers and microcomputer-related devices located in a relatively small space such as a room, building, campus, business, or industrial installation. In understanding this definition, it should be possible to make a distinction between the interconnective structure of the network, and the computers and computer-related devices embedded in the structure and served by it. Many network authorities consider the network to consist of the interconnective structure, including hardware and software for network control; and the attached computers and computer-related devices as a separate network-related category. At the very least, the interconnective structure, both hardware and software, should be considered the most constant aspect of a network. The computers and computer-related devices should be considered as a quite variable aspect in comparison.

Based on a frequency count of topics of articles in recent computer publications, local area networks (LANs) of microcomputers is the most frequent of all topics treated. Katherine Hafner's (1983) report of the results of a survey taken at the tenth International Management Exposition and Conference, in New York City, in October 1983, indicated that seven out of ten people surveyed had installed or would soon install a LAN. This represents a 90 percent increase over the results of a similar survey done in 1982.

The two main purposes of this paper are to describe a particular implementation and utilization of a LAN of microcomputers at Rogers State College in Claremore, Oklahoma, in 1982; and to discuss in general, the usefulness, nontechnical theory, selection criteria, and availability of LANs of microcomputers in 1984.

Because of the extreme variability in the costs of different kinds of microcomputers and printers, and the way in which network vendors present the costs of their products, throughout this paper LAN cost comparison information will not consider microcomputer and printer costs. The cost of a networkable microcomputer varies between three hundred and ten thousand dollars. The cost of an appropriate microcomputer-network printer varies between four hundred and three thousand dollars.

CHAPTER 8

A LOCAL AREA NETWORK OF MICROCOMPUTERS AT ROGERS STATE COLLEGE

Background

In January 1980, Rogers State College (RSC), in Claremore, Oklahoma, began to participate in "the computer revolution." Rogers State College purchased and installed a DEC PDP 11/70 time-sharing minicomputer system for administrative data processing and computer science instruction. Initially, there were eight user terminals in the system: four terminals for administrative data processing purposes and four terminals for the use of twenty students enrolled in three computer science classes.

By the spring of 1982, the PDP 11/70 had thirty-four user terminals in the system: eighteen terminals for administrative data processing and sixteen terminals for the use of three hundred students in sixteen computer science classes. The administrative users and students were constantly competing for computer time on an overburdened and unresponsive system. Increasing numbers of new computer users from Administration and Counseling, the Mathematics and Science Division, the Business Division, the library, and other locations on campus were clamoring for increased distributed computer power from a system already stretched to its limits.

Planning and Investigation

Shortly before the computer crisis of the spring of 1982, the major computer science and data processing decision makers at Rogers State College began to evaluate various possibilities for expanding the soon-to-be-outgrown computer system. The three possibilities which were given most attention were: (1) the direct expansion of the PDP 11/70 system to a forty terminal system; (2) the purchase of a new minicomputer system for instructional purposes, with the assumption the new system would free the PDP 11/70 system for administrative data processing; and (3) the purchase of microcomputers for all computer-related instructional purposes of the college.

The major criteria used in the decision-making process were: educational usefulness, cost-effectiveness, responsiveness to users, appropriateness to the present and perceived future of computer science and data processing, expandability, portability, reconfigurability, and robustness. The possibility of directly expanding the PDP 11/70 system was financially economical, but not feasible regarding the other criteria. The purchase of a new minicomputer system for instructional purposes was not cost-effective, not appropriate to the perceived future of computer science and data processing, and would not have led to a very portable, reconfigurable, or robust system.

The microcomputer option rated high among the decision-making criteria. Microcomputers could be used for all foreseen computer-related instructional purposes. The cost of fourteen sufficiently powerful microcompute. systems ranged from thirty thousand to seventy thousand dollars

in a non-network configuration, or forty-six thousand to ninety-five thousand dollars in a network configuration; compared to one hundred twenty-five thousand dollars or more for a fourteen-terminal minicomputer system (software not included). Microcomputers seemed easier to use and faster (more responsive) than minicomputer terminals for nonadministrative educational computer science and data processing purposes. Microcomputers were determined to be the most rapidly accelerating field of computer science and data processing. Local area networks of microcomputers promised to be a major facet of the computer science and data processing of the future. Since microcomputers do not require a specially prepared environment and are easy to install and move, networked or nonnetworked systems of microcomputers proved highly portable, easily expandable, and reconfigurable. A system of fourteen microcomputers seemed robust compared to a fourteen-terminal minicomputer system. In a system of microcomputers, if one computer failed, the others could still function. In a comparable minicomputer system, if the one computer in the system failed, then the entire system would be useless.

In the summer of 1982, the RSC Computer Science Division purchased two stand-alone microcomputer systems to investigate more carefully the possibility of microcomputers being used for all nonadministrative computer-related purposes on campus. RSC found that the microcomputers (micros) met or exceeded expectations based on the criteria mentioned above. RSC was especially delighted to find that ten thousand dollars for a microcomputer-based system (the cost of one computer language translator on a minicomputer) would purchase six different computer language translators, computer graphics software, a word processing package and other business software packages, a database management system, and a ten-megabyte hard disk drive.

But there was a negative factor in the initial microcomputer investigations during the summer of 1982. While each of the microcomputer systems had two floppy disk drives, the accomplishment of any but the most elementary procedure, on one of the micros, was very cumbersome. For anything other than the entering and running of a BASIC program, it was necessary to shuffle an average of three diskettes in and out of the two floppy disk drives. Also, RSC found the information transfer, from each floppy disk drive to a computer, to be very slow. In order for computer user productivity to be facilitated, it seemed clear that each of the microcomputer systems needed access to convenient and rapid hard disk storage.

Toward the end of the summer of 1982, one ten-megabyte hard disk drive was purchased and attached to one of the two microcomputers. All microcomputer floppy disk files were transfered to the hard disk. At a cost of four thousand dollars for the hard disk drive and computer-disk connection, the diskette shuffling and slow information transfer problems were solved for one microcomputer.

However, RSC could not afford to purchase fourteen hard disk drives (or fourteen printers) for the fourteen microcomputer systems. The RSC Computer Science Division began to plan the sharing of one or two hard disk drives and one or two printers, as well as software and data, among fourteen microcomputers through a local area network (LAN).

After investigating the microcomputers available in July of 1982, RSC decided that fourteen networked IBM-PCs would best fit the specifications. In July 1982, there was only one readily available LAN to accommodate IBM-PCs, the Corvus Constellation. Unfortunately, each Constellation would accommodate only eight IBM-PCs. (This limitation has now been overcome.)

Implementation

In August 1982, the Rogers State College Computer Science Division purchased and installed fourteen IBM-PCs, two printers, and two Corvus Constellations. Each Constellation included a ten-megabyte hard disk drive and a multiplexer, seven ribbon cables and interface cards for disk-computer interconnections, and network software. The two LANs of microcomputers were installed in a small microcomputer lab. Each LAN was an interconnected set of seven IBM-PCs, sharing ten megabytes of hard-disk storage, a printer, and software packages and data. Since a Corvus Constellation does not allow full connectivity of IBM-PCs, direct communication between PCs was not possible.

The RSC LAN of microcomputers implementation required the wiring of a small microcomputer lab for fourteen regular electrical outlets, the building of counter tops around the lab, the purchase of fourteen office chairs, and the purchase of the network and equipment to be interconnected. The total cost of the implementation, excluding the cost of the room, is indicated in table 9.

The equipment costs shown in table 9 have declined by approximately 20 percent since the RSC LAN implementation. Setting-up a minicomputer time-sharing lab, equivalent to the RSC LAN microcomputer lab, would have cost at least one hundred twenty-five thousand dollars. The cost of a mainframe-centered lab would have been still more expensive.

TABLE 9

COST OF IMPLEMENTING RSC LAN

Item	Item Cost	Quantity	Cost
Electrical outlet	$ 40	14	$ 560
Counter top	$ 50	14	$ 700
Office chair	$ 70	14	$ 980
IBM-PC	$4,000	14	$56,000
Corvus IBM-PC interface card	$ 800	14	$11,200
Forty feet of ribbon cable	$ 300	14	$ 4,200
Corvus 10 MB disk drive (network software included)	$4,500	2	$ 9,000
Integral Data Systems IDS-560 printer	$1,200	2	$ 2,400
Total			$85,040

The RSC LAN microcomputer lab is staffed, at no direct monetary cost, by computer science instructors and by student assistants from the RSC Cooperative Education Program. Students have access to the lab from 7 a.m. to 10 p.m. each weekday, and from 9 a.m. to 4 p.m. each Saturday. The lab is an open, first-come/first-served lab; students come when they choose, during the mentioned hours.

Program Description

The RSC LAN of microcomputers (which combines two Corvus Constellations) has allowed the RSC Computer Science Division to cost-effectively solve its instructional computer-power problems. The RSC LAN has freed the PDP 11/70 minicomputer system for noninstructional data processing uses. Microcomputers and microcomputer-related devices are inexpensive compared to larger computers and related devices. Software packages for microcomputers are only 5 percent to 10 percent as expensive as comparable packages on minicomputers. For example, a printer for a microcomputer LAN costs between four hundred and three thousand dollars. A printer for a minicomputer system costs between two thousand and thirty thousand dollars. A FORTRAN compiler for a microcomputer LAN may be purchased for five hundred dollars, whereas, a FORTRAN compiler for a minicomputer system may cost ten thousand dollars. (However, some microcomputer software companies charge extra licensing fees for the purchase of compilers and other software packages to be used in microcomputer networks.)

The RSC LAN is easy to learn and use (one can become familiar with it in an hour). Even with heavy usage, the RSC LAN is very responsive since there are many microcomputers sharing the work load. The ease-of-use and responsiveness of the LAN has increased the productivity of the computer science students and the computer lab. On the LAN, each student can accomplish more in a given time period than the student could accomplish in the same time period on a time-sharing computer terminal. (This conclusion is supported by investigations at RSC and by studies reported in an article by John King 1983.)

The relative cheapness of microcomputer software packages and the efficient hardware and software resource sharing through the RSC LAN has allowed RSC to purchase and use the usual computer science compilers in computer science courses: BASIC, FORTRAN, COBOL, and PASCAL. It has also allowed RSC to purchase and use some unusual, but very educationally appropriate software packages in computer science and other courses: microprocessor assemblers, computer graphics packages, an Ada compiler, and business-related software such as a word processing package and a database management system. Since the RSC LANs have only one kind of microcomputer attached and only one kind of operating system in use, the LANs have not necessitated concern regarding the software incompatibilities that may hinder resource sharing and communication when incompatible computers or different operating systems are in use in the same network.

The RSC LAN of microcomputers has been a very robust computer system. In a year and a half of operation, the total system has never been down, although four microcomputers and one hard disk drive have required maintenance.

Significance to Vocational Education

We in vocational education, need computer power that is cost-effective, productive, responsive, resourceful, intercommunicative regarding data and information, and robust. We need computer power that can be distributed over many curricula, and that is flexible as requirements

change with time. We need inexpensive computer systems ranging from small to large initially, and expandable in manageable, inexpensive increments. We need computer systems that are up-to-date and that will continue to be up-to-date for reasonable periods of time.

The RSC LAN of microcomputers has the above-mentioned characteristics; many have already been considered in this paper. In addition, the RSC LAN has allowed for the distribution of computer power over computer science, computer-aided design, computer engineering, data communications, business and engineering curricula. The RSC LAN has allowed for the planned distribution of computer power to process control, mathematics and science, health technology, language, music, and art curricula. In vocational education, fields such as computer science, computer-aided design, and computer engineering (computer maintenance) should be considered particularly important. According to the U.S. Department of Labor and others, the growth rates for needs for employees in these fields between 1978 and 1990 are 80 percent, 100 percent and 148 percent respectively. These growth rates are among the highest of all fields surveyed.

The RSC LAN has been inexpensive to start, maintain, and expand in increments of one microcomputer interconnection at a time. (RSC now has sixteen microcomputers interconnected in the network.) RSC could have started the network with two microcomputer interface cards, a hard disk drive and interface, and cabling for $4,500. Then, RSC could have expanded by connecting one microcomputer at a time, at a cost of $800 for each interface card, instead of initially connecting fourteen microcomputers and related equipment. These costs and other network costs to be mentioned in this paper cover connectivity of network devices, and ten megabytes of hard disk storage. They do not cover costs of microcomputers and printers.

The RSC LAN of microcomputers is not now the most up-to-date of all current LAN possibilities. It has been, and still is, quite usable according to the extensions of the initial evaluative criteria and system requirements in the present and projected future, and according to RSC's present and future plans. It is also highly significant that RSC's LAN can be used as part of a more extensive network possibility now available from Corvus. This means that RSC's LAN can be fully used in its own updating and expansion, with no foreseeable possibility for obsolescence.

In general, a LAN should be, and most often is, a very stable and easily reconfigurable, interconnective structure for connecting computers, printers, and hard disk drives. Since computer technology is changing much faster than the technology of LANs, disk drives, and printers, the interconnective structure, the hard disk drives, and the printers should become obsolete much more slowly than the computers. With proper vendor planning and support, the same LAN appropriate for the 8-bit microcomputers of 1981 should be appropriate for the 16-bit and 32-bit microcomputers of 1984 and 1985.

Program Quality

The quality of the RSC LAN of microcomputers program is attested to by the large numbers of students who have been attracted to it, by the desires of other institutions in Oklahoma to emulate it, by the number of new, important degree programs which it has spawned, and by the high quality of the degree programs relating to it.

Through a survey of students who use the RSC LAN of microcomputers, it has been determined that the up-to-dateness and user-friendliness of the microcomputers, and the ease-of-use of the network as a whole, have attracted students to RSC and encouraged them to remain. The LAN of microcomputers has been instrumental in increasing enrollment in computer-related courses from three hundred in the spring of 1982 to five hundred in the fall of 1983. Some students are

from nearby colleges and universities that have failed to modernize their equipment, procedures, and curricula in comparison to those at RSC. Several students are from RSC administration, faculty, and staff. The RSC president and vice-presidents have all taken computer-related courses on campus.

The RSC LAN of microcomputers has been emulated by three educational institutions and one industrial installation in Oklahoma. A discussion of the LAN was well received at the Southwest Computer Conference in Tulsa, Oklahoma, in October 1983, and the LAN was featured at the Oklahoma Conference of Science and Technology in December 1983. RSC receives an average of two inquires per week regarding the use of microcomputers and networking.

High-quality computer science, computer-aided design, computer engineering, business, and engineering degree programs have been directly facilitated by LAN at RSC. The LAN program has been part of the reason RSC has received a Title III federal grant relative to computer science, computer-aided design, and computer engineering. Ninety percent of RSC's computer science, computer-aided design, and computer engineering graduates are working or studying in computer-related fields.

RSC is planning improvement of the LAN. In the next year, new network hardware and software, and new microcomputers will be extended campus-wide. The present LAN will be included as a part. Full connectivity in the new LAN will allow for better communication between network devices. Cost-effective computer power will be distributed to all educational divisions on campus.

Program Transportability

Northeastern University, of Tahlequah, Oklahoma; Tulsa Junior College of Tulsa, Oklahoma; Northeast Area Votech School of Tulsa, Oklahoma; and McDonnell Douglas Corp., of Tulsa, Oklahoma are the four installations where the RSC LAN concept has been transported in the past year. Many other concerns in Oklahoma are using RSC LAN)ertise as a basis for investigating the possibility of obtaining and distributing computer power through the use of some form of LAN of microcomputers.

The RSC LAN of microcomputers program, and programs similar to it, are highly transportable due to the following: low start-up cost, the possibility of low-cost incremental expansion, ease of installation and reconfiguration, and appropriateness for most computer science and data processing purposes. Not including the cost of microcomputers and printers, the start-up cost can be as low as forty-five hundred dollars. The cost of each increment of expansion can be as low as six hundred dollars. Installation requires regular electrical outlets, little special site preparation, and no special technical knowledge or assistance. An installed network can be disassembled and reconfigured with ease and can serve the same kinds of purposes that larger and more expensive computer systems can serve.

Conclusion Regarding the RSC LAN Implementation

The need for increased and widely distributed computer power on the Rogers State College campus has been satisfied through the installation and utilization of a LAN of microcomputers. The LAN program has much significance for vocational education. The LAN and its extensions

allow an inexpensive computerized basis for present and future vocational programs of high quality at RSC and beyond. The RSC LAN program has been quite transportable and promises to continue to be so. The general LAN concept, of which the RSC LAN is a particular example, will be discussed in the second section of this paper.

CHAPTER 9

LOCAL AREA NETWORKS OF MICROCOMPUTERS

Introduction

Local area networks of microcomputers are popular today, and will have greater popularity in the future. Multiprocessor and parallel processor systems, including microcomputer LANs, are increasingly necessary for solving the complex, multifaceted problems faced in 1984 and beyond. The computer hardware and software, and computer-related devices needed for office automation, computer-aided manufacturing, process control, and similar concerns, must be interwoven in interconnected multiprocessor and parallel processor systems, if the computer systems are to be sufficiently isomorphic to the office, manufacturing, and other realities they are to model. The conclusions of this paragraph are supported by the content of an article by John H. Douglas (1983).

According to Edward Feigenbaum and Pamela McCorduck (1983), the need for single-processor, number-crunching and/or file-shuffling computers (like many of those in use today) is beginning to decline and will decline faster in the future. In the fifth generation of computer development, it is reasonable to assume the prototypical computer system will be a parallel processing system of many processors—a kind of network.

The implications of an article on telecommunications by Howard Frank (1981) are that within the next few years, IBM, American Bell, and other large computer or communications corporations will combine computer technology and communications technology through networking. We will have the possibility of computing and/or communicating through local area networks and through increasingly wider area networks; citywide, countrywide, and, probably, worldwide (this possibility already exists, to some extent).

Local area networks of microcomputers should be thought of as being at the lowest and least expensive level of network computer power in the present and projected future. However, according to King (1983), it will be at this lowest level that most users of networked computers will interface with networks and solve most of their computer-related problems. Even in the present, it is possible for microcomputers and larger computers to share in the same LAN and to distribute the many, relatively small problems to the less expensive microcomputers and the few, relatively large problems to the more expensive, larger computers. It is also possible to bridge between LANs and to gateway from LANs to wide area networks (probably containing still larger computers), and so further distribute problems of various sizes to computers of corresponding sizes in a larger communication area.

Educators owe students the opportunity to become familiar with what will probably be the computer workstation of the future, the microcomputer. Students should also be given the opportunity to become familiar with what will probably be the most widely pervasive configuration of computer workstations of the future, the LAN of microcomputers.

While LANs of micros are appropriate to both the present and future and are cost-effective, responsive, resourceful, transportable, reconfigurable, and robust, an educator (or anyone else) should approach a possible purchase of a LAN of micros with some knowledge of the purposes it can serve, nontechnical theory, selection criteria, and availability of LANs of micros in the marketplace.

Educational Uses

In education, microcomputer LANs can be used for noninstructional purposes, facilitating educational programs, and general distribution of computer power to students, faculty, and staff. Cost-effectiveness, productivity, efficient resource sharing, and increased communication and data processing possibilities are appropriately enhanced when LANs of microcomputers are used.

Noninstructional Uses

Although microcomputers are not as capable of handling large files or rapid number-crunching compared to larger computers, 16-bit and 32-bit microcomputers networked with appropriate printers and disk drives can easily serve noninstructional educational data processing purposes such as report generation; scheduling; counseling purposes; registration; payroll; and financial, attendance, and inventory accounting. A LAN of micros can also facilitate the sharing of the work load among many microprocessors, as compared to the load being on one processor in a minicomputer or mainframe system. A LAN of microcomputers can thereby allow for a very responsive system. A LAN of micros can also provide word processing; electronic mail; and voice, graphics, and video data transmission not provided by most non-network systems.

Educational Program Facilitation

Through text, sound, and visual forms, computers, including those in microcomputer LANs, can individualize communication of subject matter to students; provide individualized drill and practice for students; and allow for rapid exploration of combinations of elements, ideas, and concepts according to individual desires and needs. Software relative to such possibilities is inexpensive and powerful in microcomputer versions and can be shared within subject matter and across subject matter fields in LANs of microcomputers. Computer science, computer-aided design, computer engineering, languages, music, and art are among the educational fields that can be served optimally by LANs of microcomputers.

Computer Science

In computer science, microcomputers, the inexpensive, user-friendly, and responsive computer workstations of the present and future are the kind of computers on which beginning students should first become literate. The user-friendliness and responsiveness of LANs of microcomputers should be considered especially important for nonmajors in computer science who are seeking their first computer literacy experiences. The possibility for beginning computer science majors to have intimate, manageable, hands-on experiences with computer hardware and software, existing with LANs of microcomputers, is most educationally beneficial. The numerous, variable, inexpensive, and powerful computer language compilers and computer science software packages shared on LANs of microcomputers make the LAN computer power option attractive.

There are more different kinds of exciting educational computer science software possibilities for microcomputers than for other computers. Some are BASIC, FORTRAN, COBOL, PASCAL, ADA, LOGO, APL, and LISP compilers; assemblers; CPM, MS-DOS, UCSD-Psystem, and UNIX operating systems; various database management systems; and programmable, network-related software.

Computer-Aided Design

A survey conducted by International Data Corporation indicates there will be a 71 percent increase in the need for computer-aided design employees over the next two years. Computer-aided design hardware and software are especially expensive unless they are purchased in the microcomputer domain. Computer-aided design textbooks are microcomputer-appropriate and computer-aided design courses and programs can be easily and inexpensively based on microcomputers and LANs of microcomputers.

Computer Engineering

According to the U.S. Department of Labor, there will have been a 147.6 percent increase in the need for data processing machine technicians (computer engineers) between 1978 and 1990. The hands-on approach is a must in computer engineering. Computer engineering students must be able to explore relatively simple computers and computer systems, and to design, build, and test computer-related circuitry. LANs of microcomputers are simple and flexible enough to accommodate these possibilities.

Data Communications

A LAN of microcomputers is a prototypical data communications model. Various data communications fundamentals such as data transmission codes, data transmission media, accessing techniques, standards and protocols, and data transmission models can be easily studied based on a LAN of microcomputers.

Business

Office automation is being, and will be based on LANs of microcomputers, other LANs, and larger networks. The reification of the concept of "the paperless office" is almost synonymous with office automation. This will require that data and information be gathered electronically, from accounting machines, for example, transported through a word processing machine for annotation, stored electronically, and finally, if necessary, sent to a printer. This process is possible only if the proper machines are networked. Microcomputers and LANs of microcomputers will serve important purposes in this sequence, which should be stressed in business curricula. Studies reported by Poppel (1982) support the contents of this paragraph, and also support the conclusion that office automation leads to an increase in productivity of at least 15 percent in the office.

Word processing is not only important in the business field, but can also be an important tool for anyone who uses words in written form. Word processing is usually done on special-purpose word processors or on microcomputers. Microcomputers are much more flexible and appropriate general problem-solving tools than special-purpose word processors and are just as appropriate for word processing. Some microcomputer word processing packages, such as WordStar, have

become business and industry standards. LANs of microcomputers can well serve word processing purposes, as well as other office automation purposes. Business ed cators should consider familiarizing their students with word processing through the use of networked microcomputers.

Business educators should also familiarize their students with business software packages relative to accounting and modeling. Spreadsheet packages, order processing and inventory control, accounts receivable, purchase orders, accounts payable, general ledger, payroll, income tax, database management, business prognostication, and other packages are readily and inexpensively available for microcomputers. Microcomputer packages m ling various business situations and allowing gamelike interactions with students are also available. All such packages can be shared by microcomputer LANs.

Mathematics and Sciences

Calculation and modeling, both numerical and visual, are especially important in the fields of mathematics and sciences. Computerized number-crunching, equation solving, graphing, and experimentation can accelerate mathematics and science students past at least some of the drudgery of mathematics and science, on to some of the more exciting possibilities of the subject matters. Microcomputers and LANs of microcomputers can provide affordable "mind amplifiers" for mathematics and science students an can aid in rapid advances in the fields.

Engineering

Since engineering should be based on timely, accurate, and complete data, the capturing and processing of data from widely distributed points, instants of time, and other precise aspects of situations are increasingly important in engineering. This type of data capture and processing, in the complex engineering situations of today, can best be done through a network of widely distributed processors. However, unless the processors are microprocessors (microcomputers), networks of widely distributed processors can be prohibitively expensive. LANs of microcomputers can provide optimal cost-effective computer power for engineering students of the present and future.

Languages

Microcomputers are language appropriate toys and tools for language students from at least three different perspectives: (1) the speech synthesis and understanding perspective, (2) the language translation perspective, and (3) the word processing perspective, relative to written language. Sophisticated extensions of devices such as Speak and Spell, hand-held language translators, and word processors, have been and will be used in our language classrooms. Multiple sharing workstations can be possible through microcomputer LANs.

Music

Microcomputers, used in music synthesizers and in devices translating from notes to music and from music to notes, can extend and accelerate musical experimentation and production for students of music.

Art

Inexpensive microcomputer graphics hardware and software can allow for rapid and colorful translation of art from the minds of students to the CRT screens and printers of LANs of microcomputers.

General Uses by Instructors

LANs of microcomputers can cost-effectively provide the following for instructors: data communication and resource sharing, c(.nputer-aided instruction for classes, courseware creation, word processing, modeling, calculation, course accounting, and play. An instructor who has access to a LAN of microcomputers can access any of many possible software packages stored in the network and can communicate, through the network, with students and others on the network. Instructors can use LANs of microcomputers as an aid to instruction to communicate subject matter to students, allow students drill and practice, and help instructors manage the record keeping necessary tc instruction.

Through the use of a microcomputer software tool called an authoring system, the creation of courseware—materials for a course created by the instructors—can provide instructors with the exciting and expeditious possibility of tailoring their instructional materials according to their ideas and the needs of their students. Microcomputer word processors are easy to learn and use, and greatly increase the written word productivity of the user. Instructors who use word processors instead of typewriters have options available such as easy error correction, automatic paging, block movements of text, merging of text, computerized checking of spelling and grammar, and, assuming networking, electronic document transmission. Calculation and modeling through the use of a LAN of microcomputers can free instructors to concentrate their subject matter efforts in high creative domains. LANs of microcomputers connecting computerized student efforts and computerized instructor record keeping can expedite course accounting.

Play

Students, instructors, and others in education can derive great (though sometimes immeasurable) benefits from LANs of microcomputers sometimes used in productive (not seductive) play. The fact that microcomputers, as compared to other kinds of computers, are playful devices, is a major factor in explaining why people are so easily attracted to microcomputers, and why microcomputers and LANs of microcomputers optimally increase the productivity of users. This contention is supported by Papert (1980) and by King (1983).

CHAPTER 10

NONTECHNICAL THEORY

Intelligent consideration of LANs of microcomputers requires some understanding of the non-technical theory of microcomputer LANs. Network topologies (configurations), interconnection media, data transmission rates, kinds of networks, access techniques, and models and standards are the most important aspects of the nontechnical theory of microcomputer LANs.

Topologies

The pattern in which data flow from device to device in a LAN is called the topology of the LAN. The three typical LAN topologies are star, ring and bus. These topologies are sketched in figure 3. Microcomputers, printers and hard disk drives are represented by squares in the sketches.

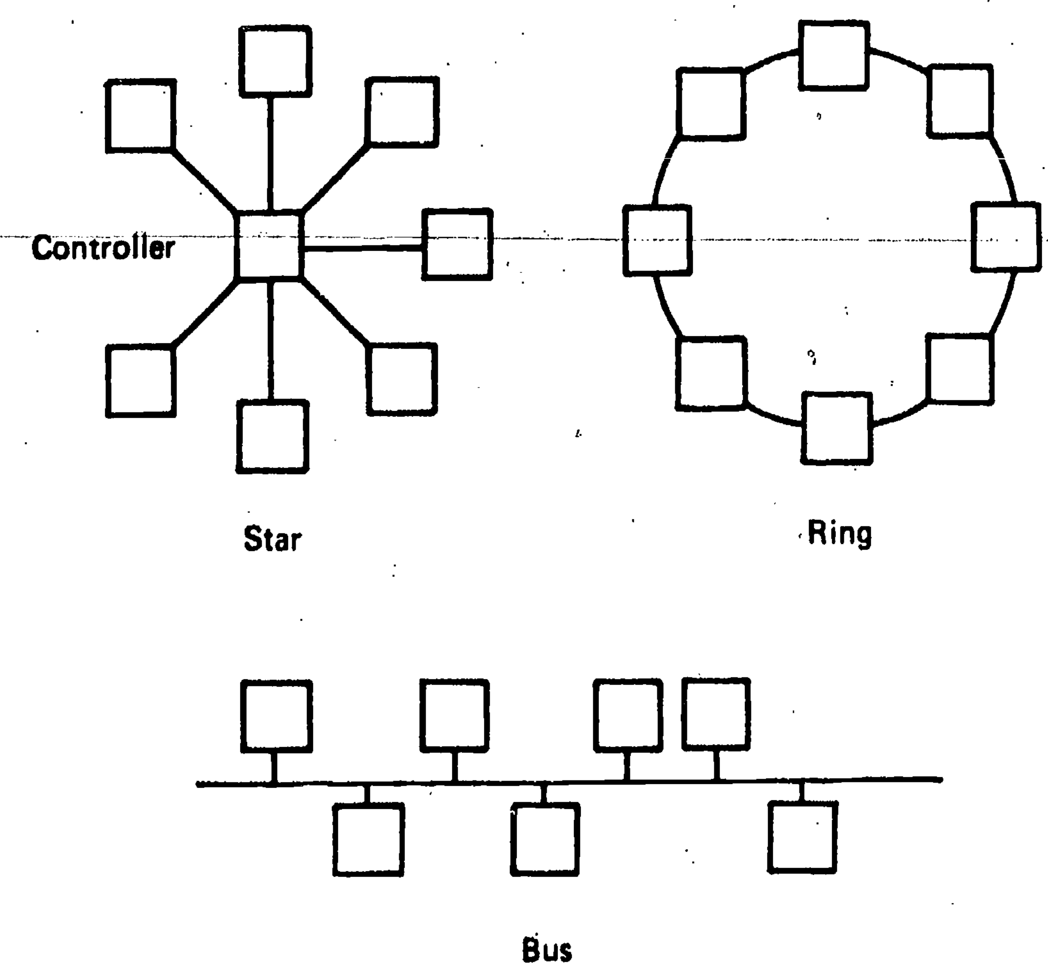

Figure 3. Three typical LANs topologies

Star

A star topology, the most traditional of LAN topologies, is based on a centralized controller, or data switch. The centralized controller controls the flow of data between any two devices in the LAN.

The controller must be connected to each device in the LAN and any data flowing from one device to another must flow through the controller. The device connection medium in a star LAN is usually twisted pair cable or ribbon cable. Star topologies are technologically simple and easy and inexpensive to implement. They are also easy to reconfigure, and easy to expand.

Each device in a star LAN must be connected to the controller with a cable, and there must be a nonshared data path through the controller between any two communicating devices; therefore, a star LAN requires a great deal of cabling. This hinders the extension of a star over a space larger than a small building. Also, the characteristics of the typical kinds of cabling and the data flow control cause slow information transfer in a star LAN. The central position of the controller in a star topology, makes the star LAN vulnerable to controller failure.

Ring

In a ring topology, devices in a LAN (or other kind of network) are arranged in a logically, if not physically, circular pattern. The control, or intelligence, in the network is at the various devices in the network, rather than in one central controller. The cabling between any two devices can be shared as part of many data paths, as data circulates aroung the ring. Ring networks minimize cable usage and optimize high-speed, error-free data transfer, especially when networks are being heavily used. Since no central controller exists in a ring, rings are, of course, not susceptible to central controller failure.

Although ring topologies have been popular in Europe, they have not become popular in the United States, because rings are technologically difficult to implement, expensive, difficult to reconfigure or extend, and somewhat susceptible to failure if more than one point of control fails. It is worth noting, however, that IBM will soon release its first ring topology LAN in this country.

Bus

In electronics, the term *bus* refers to a communication channel connecting various points in a total communication scheme. In a bus LAN topology, a bus runs the length (not necessarily straight) of the network. Network devices are connected to the bus through relatively short drop cables. Network control, or intelligence, is distributed throughout the network at the device locations. Data can be transferred between any two network devices through two drop cables and the shared network bus. A bus LAN topology is relatively simple technologically; easy and inexpensive to install, and very easy to reconfigure and expand, compared to a ring topology. Bus LANs are not prone to failure, and are the most popular of the three typical kinds of LAN topologies. Bus LANs are ordinarily more expensive than star LANs, and under heavy usage are less capable of high speed error-free data transmission than ring LANs.

Interconnection Media

The various media used to connect devices within LANs are: ribbon cable, twisted pair cable, coaxial cable, fiber optics cable, telephone lines, and microwave. These media vary according to expense, ease of handling, typical extension lengths, data transmission rates, data transfer bandwidths, susceptibility to interference (noise), data security, and other factors. The intelligent evaluation of LAN possibilities requires careful consideration of data transmission media choices.

In considering data transmission media choices, data transmission rate and data transmission bandwidth are terms which deserve careful attention. Data transmission rate refers to the amount of data able to flow through one communication channel on a communication line, in a given time. Data transmission bandwidth refers to the number of separate channels a communication line can contain (one in a baseband network, and many in a broadband network).

Ribbon Cable

Ribbon cable is rather expensive, difficult to string, and only appropriate for data transmission over short distances. It is used in interconnecting devices in some LANs, typically star LANs.

Twisted Pair Cable

Twisted pair (wire) cable is inexpensive, easy to string, very flexible, requires no cable taps, and is appropriate for moderate speed data transmission of one megabits per second or less over moderate distances of five thousand feet or less. Yet, data transmission over twisted pair cable can easily be contaminated by sources of interference and can be easily tapped by any one wishing to compromise data security.

Coaxial Cable

Coaxial cable can be quite economical, if it is already in place in the form of CATV cable. Otherwise, coaxial cable is more expensive than twisted pair cable and more difficult to string because it is somewhat stiff and requires cable taps. Coaxial cable is the most widely used of all data transmission media in LANs. It is not as susceptible as twisted pair cable to noise contamination or data security breaches through taps. It can be extended over long distances of fifteen miles or more and can allow high data transmission rates up to ten megabits per second. It can be used for baseband or broadband (rad'~ frequency) transmission and because of the use of coaxial cable by CATV and other concerns, p ...s and technology to support coaxial cable as a data transmission medium are well in place.

Fiber Optics Cable

Fiber optics cable as a data transmission medium in LANs is, at present, somewhat expensive and difficult to put into place because fiber optics cable parts and technology are not well established. Fiber optics cable is potentially less expenive than coaxial cable, can be extended over long distances, can accommodate very high data transmission rates up to twenty megabits per second, has a very broad bandwidth possibility, and is essentially impervious to noise intereference and inappropriate cable taps. For the present and near future, fiber optics cable is a very promising data transmission medium for LANs.

Telephone Lines

Telephone lines combined with modems can be used for .. transmission in a LAN. Telephone lines dedicated to data transmission can be expensive, t can relieve users from the responsibility of laying their own data transmission lines.

Microware

In a LAN, the microwave transmission of data between microwave antennas is expensive due to the necessary transformation of data at each antenna and the expense of microwave transmission equipment. However, microwave data transmission in a LAN is attractive because it lessens the necessity for stringing and possibly burying cable for data transmission purposes.

Data Transmission Rates

Data transmission over media in LANs can be measured in terms of baud rates or in terms of bits per second. Amount of data transmission can also be considered in terms of bandwidth.

A baud (Bd) is a discrete signal relative to a data transmission. A baud rate is the number of discrete signals per second in a data transmission. For example, if 2,400 discrete signals, 2,400 bauds, can be transmitted in one second, then the corresponding baud rate is 2,400 Bd. Naturally, the baud rate per data transmission is proportional to the amount of data transmitted in a given time over the transmission medium.

Each discrete signal in a data transmission, each baud, will carry one or more bits of data. This leads to the possibility of measuring data transmission in terms of bits per second, rather than baud rate. For example, given a baud rate of 2,400 Bd and the fact that each baud carries four bits of data, the rate of 2,400 Bd would be equivalent to 9,600 bits per second (bps). It is only possible to translate between baud rate and bits per second when the number of bits per baud is known.

Today, in LANs of microcomputers, there is a trend toward measuring data transmission rates in terms of bits per second (bps), kilobits (thousand of bits) per second (kps), and megabits (millions of bits) per second (mbps). A data transmission rate of one to ten megabits per second is typical.

The amount of data transmitted over a LAN data transmission medium is related to the number of channels in the medium. In a baseband LAN, there is effectively one channel per media cable through which data can flow. In a broadband LAN, there are many channels per media cable, each comparable to one baseband channel, through which data can flow. The information carrying capacity of a medium in a broadband LAN is therefore much greater than a simiilar medium in a baseband LAN.

Baseband

A baseband LAN is a LAN that effectively has only one channel of data transmission capability. This one channel must be shared by all users of a baseband LAN, one user at a time. This leads to the necessity of the intelligence of a baseband LAN assigning various separate brief intervals of time to multiple users, through a process called time division multiplexing. Baseband LANs are easier to set up and less expensive than their broadband counterparts. Despite the limitations

which the sharing of one data transmission channel places on any baseband LAN, baseband LANs are quite appropriate for the transmission of the character data and numeric data often associated with computer science and data processing.

A typical baseband LAN of microcomputers contains a disk server to coordinate a hard disk drive with the network; a printer server to coordinate a printer with the network; an interface device or card (transceiver and controller) for each device in the network; and the interconnective medium of the network (see figure 4). A baseband LAN of microcomputers may also require a cable tap for each device or set of related devices in the network (coaxial cable requires taps), and signal repeaters to boost data signals and extend the possible transmission distance in the network.

Baseband LANs are not as extendable with respect to distance, or as flexible with respect to the kinds or amounts of data they can pass in a given time, as are their broadband counterparts. Baseband LANs are usually not extended more than five miles, are not appropriate for video transmission, and may not be appropriate for voice transmission.

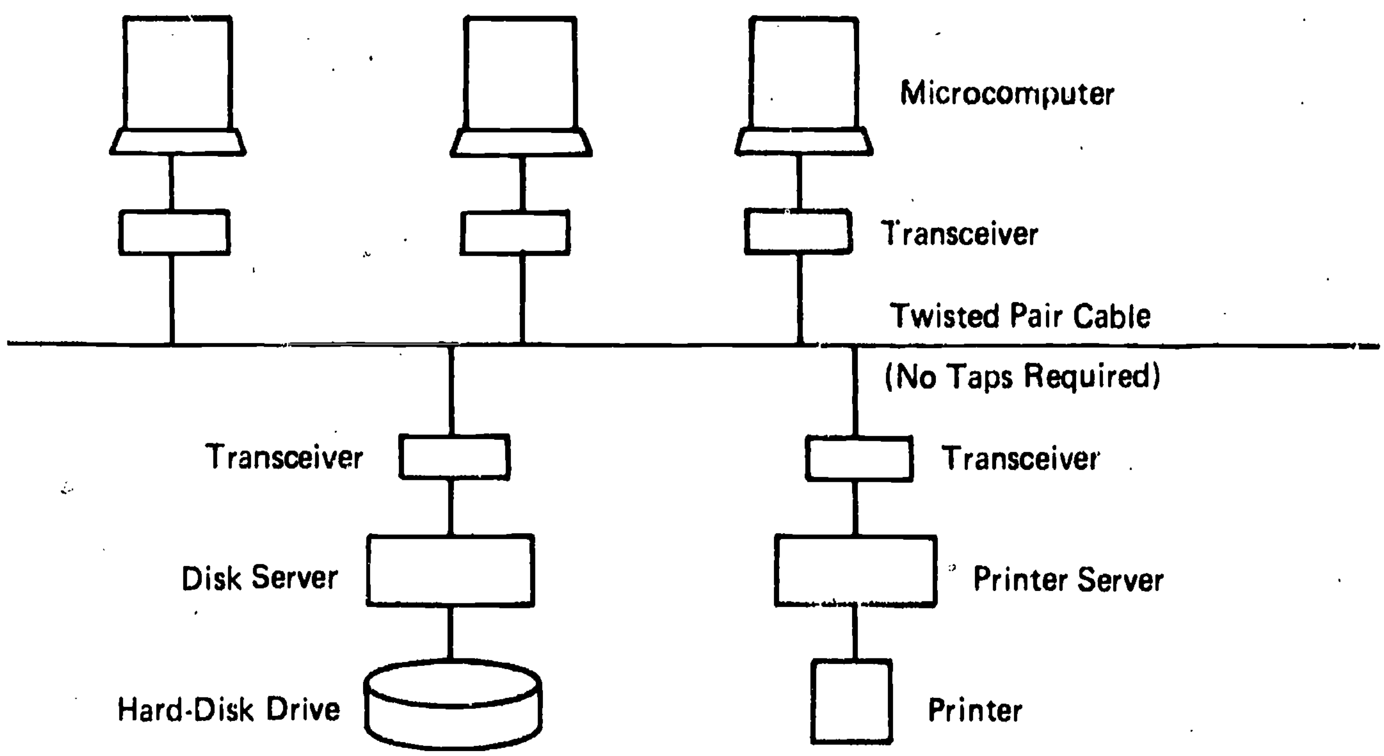

Figure 4. Typical baseband LAN of microcomputers

Broadband

In broadband LANs, the bandwidth of the transmission medium is divided into many channels, one hundred twenty in the case of one vendor's product. Data transmission can take place on many channels concurrently and the amount of data transmission in a given time can be sufficiently large to allow for the transmission of video, voice, and more usual kinds of data, all at the same time. The bandwidth of broadband LANs is divided into channels (narrow frequency bands), and data is appropriately transferred through these channels through a scheme called frequency

division multiplexing. Although broadband LANs are more expensive and more difficult to implement and maintain than baseband LANs, broadband LANs are becoming increasingly popular, especially in situations where LANs must cover large distances (on large campuses, for example), or in situations where large amounts of data may have to be transmitted in short amounts of time (for example, in office automation).

A typical broadband LAN of microcomputers contains a head-end or retransmission unit, an RF modem for each network device or related set of devices, and the interconnective medium of the network including cable taps. (See figure 5). A broadband LAN may also contain amplifiers to extend data transmission range.

In broadband LANs, there are two possible kinds of head-ends corresponding to two possible ways of using cable and bandwidths. When one cable is used in a broadband LAN, the bandwidth must be split into two equal divisions, one for transmitting and one for receiving. The head-end must be an active head-end in that it must receive frequencies from transmitting devices from one half of the bandwidth, and transform them and transmit them to receiving devices in the other half of the bandwidth. Thereby, one cable can be used for both transmitting and receiving. It is possible to use two cables, one for transmitting and one for receiving, in a broadband LAN. When this is done, the full bandwidth of the cabling can be used for transmitting and receiving The corresponding head-end is a passive head-end which connects the appropriate transmission and receiving cables, but does not transform frequencies. A one-cable broadband LAN system is typically less expensive than a two-cable LAN system, but uses only half (actually less than half) of its data transmission capability.

The purpose of a modem in a broadband LAN is to interface the device(s) it serves to the LAN, through being attuned to frequencies appropriate to the device(s).

Access Techniques

In a LAN microcomputers, or any other network, the method whereby each user gets a fair share of network resources, including time and successful data transmission, is called an access technique. The three main access techniques are polling, carrier sense multiple access with collision detection (CSMA/CD), and token passing.

Polling

Star topologies, in particular, may use an access technique, called polling, in which a master controller polls network devices for requests for service. Usually, all network devices are polled many times per second according to a preset schedule. In polling, the master controller coordinates the network, by sequencing device requests for service and by assuring that each request will be honored within a brief period of time.

CSMA/CD

Carrier-sense multiple access with collision detection (CSMA/CD) is the most widely used access technique in LANs of microcomputers. It is an extension of carrier-sense multiple access (CSMA) used by some LANs as an access technique, in combination with a collision detection (CD) scheme.

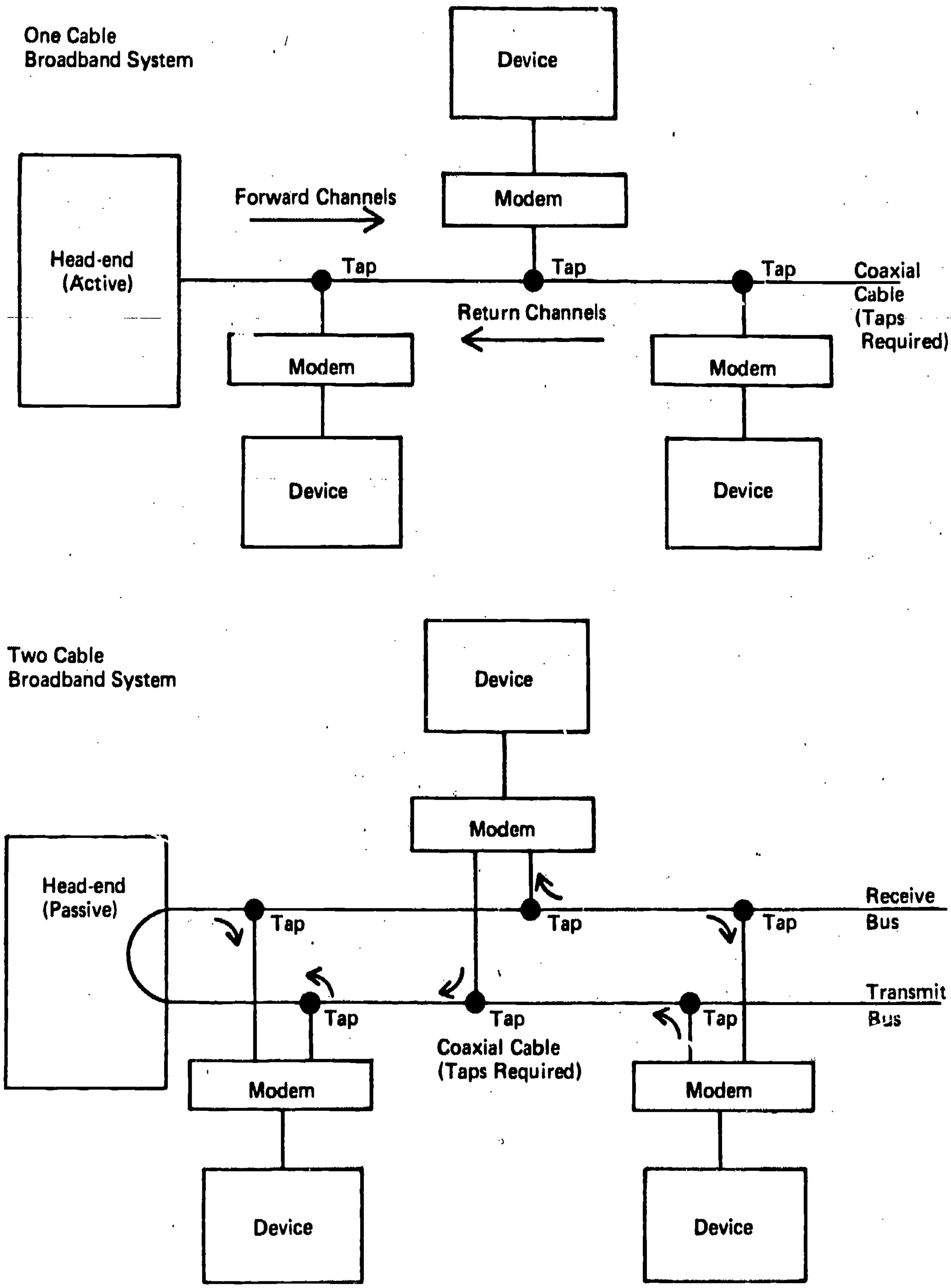

Figure 5. Typical broadband LAN of microcomputers

In a LAN using CSMA (without CD), the network intelligence, in an interface card or device, of a user seeking network service (a session), senses the network channel of the user and allows usage of the channel when it becomes available. If the session is successful, as tested for by another aspect of network intelligence (usually a CRC test), then the user's session can be terminated. If the session is not successful then the session must be redone (by the network) due to the probable fact that a collision of information by two or more simultaneous users has destroyed network information in the session. In the redoing of a session, the network intelligence of the unsuccessful user will probably try the session again after a short wait randomly selected by a backoff algorithm.

CSMA/CD is equivalent to CSMA, except for collision detection. In CSMA usage, when a session is not successfully completed, collisions are assumed and the time of the unsuccessful session is lost. In CSMA/CD usage, collisions are detected as they happen, rather than long after they have happened and caused unsuccessful sessions. When a hypothetical LAN of microcomputers has many simultaneous users who use the LAN heavily, then the time saved by using CSMA/CD as compared to CSMA in the LAN, could be significant. CSMA/CD is slightly more expensive and harder to implement than CSMA.

CSMA/CD is the simplest and least expensive of the three access techniques discussed in this paper. However, CSMA/CD can be wasteful in heavily used LANs because it allows collisions and compensates for them, rather than disallowing collisions altogether.

Token Passing

In LANs using token passing as an access technique, a token, a short electronic messege frame that can contain "the network is free" or "the network is busy" is circulated from one device to another, in an established sequence of devices and according to appropriate time constraints. In the token-passing sequence, when a device seeks network usage and the token containing "free" is available, then the device is given exclusive access to the network. The token is set to "busy" for a limited time, before relinquishing the token (which will again contain "free") to the next device seeking service.

Token passing in a LAN disallows collisions of information among contending users, and optimizes information transmission in heavily used networks. Token passing is more technologically complex and more expensive than polling or CSMA/CD. Also, the infrequent loss of a token in a token-passing LAN, can force temporary shutdown of the LAN.

Models

In order for the many and varied, small and large networks to be as useful as possible, the networks should be designed and created according to some common conceptual basis, or model. One network model covering all computers and data communications equipment, a not-to-be-realized-in-the-near future ideal, would optimize interconnectivity and the sharing of resources within networks and across networks around the world. At present, there are two models that cover the two largest subsets of networks, Open System Interconnection (OSI) from the International Standards Organization (ISO), and Systems Network Architecture (SNA) from IBM. In evaluating the purchase of a LAN of microcomputers, one should consider compatibility with OSI or SNA to be significant.

OSI

When fully developed, OSI is intended to be the "one network model" mentioned above. OSI should be thought of in terms of seven layers, or levels (see figure 6). Layer one has to do with electrical and physical interconnections between network units. Layers two through six are related to data preparation, flow, and communication in a network. Layer seven describes the interfacing of human users with networks. At this time, the three lowest-numbered OSI layers are technologically standardized; the other layers are theoretically coherent, but not technologically well defined.

SNA

When it was released by IBM in 1974, SNA was meant to be IBM's blueprint for interconnecting IBM products into networks. It has since become increasingly open to interconnections from other vendors. It is appropriate to consider SNA in terms of layers which correspond to the layers and functions of OSI mentioned above. There are six layers in SNA having general purposes consistent with corresponding layers in OSI, but named and implemented differently.

Standards and Protocols

Many different committees and industry organizations have set and are setting standards including protocols, relative to networks, including LANs of microcomputers. The most pervasive and influential standards are RS-232-C, X.25 and IEEE 802. The protocols most widely used are BISYNC, HDLC, and SDLC. The possibility of one all-purpose networking standard seems to be "an impossible dream" for the present or near future. Since only network devices covered by a certain standard are apt to be easily interconnectable, consideration of standards (including protocols) is advisable for those wishing to optimize interconnectivity of computers and other data communication devices.

Standards

The most important of all data communications standards is RS-232-C. It describes the characteristics of the electrical signals per a serial port of a computer or other data communications device, and also describes connectors and cables regarding the linking of data communication devices. RS-232-C, created by the Electronic Industries Association (EIA), is part of the larger X.25 standard and provides the most universal possibility for interconnecting data communication devices.

The X.25 standard is a broad standard developed by the Consultative Committee of International Telephone and Telegraph (CCITT). It covers the three lowest levels of the OSI model and is becoming increasingly important.

The Institute of Electrical and Electronics Engineers has completed parts of a wide-ranging standard, IEEE 802. The IEEE 802 will apply to LANs and larger networks. The precision and comprehensiveness of IEEE 802 is impressive. IEEE 802 is compatible with the OSI model, and should become very influential concerning all types of networks.

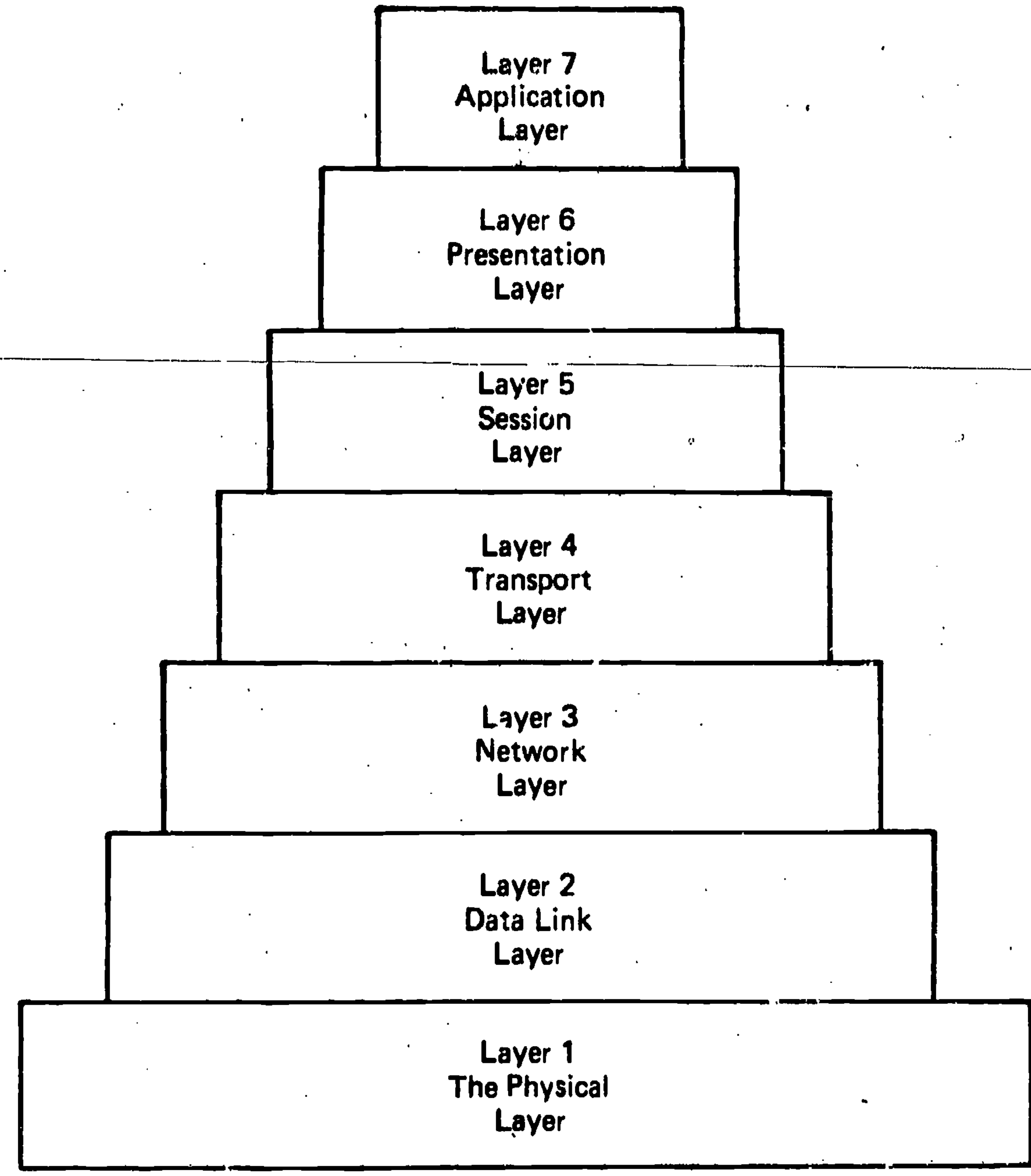

Figure 6. OSI model

Protocols

A network protocol is a set of rules, and therefore a standard, governing the transmission of data over a communication channel in a network.

Bisync, a popular protocol developed by IBM, can be used in facilitating communications between many different kinds of equipment. Bisync is a character-oriented protocol, in contrast to a bit-oriented protocol. In a character-oriented protocol, data transmission must be in terms of inflexible and lengthy data units called characters (with seven or eight bits per character); but in a bit-oriented protocol, transmission is in terms of flexible and short data units called bits. Bits may be used for character transmission but may also be used in transmitting other kinds of data. Since

bits are shorter and more flexible transmission elements than characters, bisync is slow and less generally useful than bit-oriented protocols such as HDLC and SDLC.

High-level data-link control (HDLC) is an ISO bit-oriented protocol consistent with the Data Link Layer of the ISO model and with X.25. In the non-IBM world of data communication, HDLC is the most important network protocol.

Synchronous data-link control (SDLC) is an IBM bit oriented protocol simillar in structure and function to HDLC. IBM is in the process of replacing bisync with SDLC, due to the possibility of faster and more useable data transmission through the use of SDLC, a bit-oriented protocol.

General Selection Criteria

The most important general selection criterion, regarding a LAN of microcomputers selection, involves whether a LAN of microcomputers can satisfy the requirements related to the LAN selection. In deciding this matter, there should be a well-defined set of requirements carefully developed by those to be affected by the selection of the LAN. Constant reference should be made to these requirements and their affordability throughout the LAN of microcomputers selection process. In order to evaluate intelligently the satisfaction requirements or any other selection criterion regarding a LAN of microcomputers, requirements and specifications must be written down. Information must be gathered from many sources, including vendors, and demonstrations of hardware and software must be required.

Initial and Future Costs

There are many costs, some not always obvious, associated with the purchase and installation of a LAN of microcomputers. Sometimes vendors are secretive about costs unless pressed for cost specifics. Often, vendors will only give costs of interfacing, and neglect to mention costs of other equipment, including cabling, even when pressed to do so.

Interfaces

In a LAN of microcomputers each network device must be coordinated with the network through an interface device or card. The interface device or card typically contains a transceiver and controller in a baseband LAN, and a modem in a broadband LAN. Interfacing costs range from three hundred to over two thousand dollars per device. Device interfacing in a broadband LAN is somewhat more complex and costly than in a baseband LAN.

Cabling

Though the cost of twisted pair cabling is negligible, the cost of coaxial cable is between one and two dollars per foot; use of fiber optics is still more expensive. In a LAN of microcomputers, the cost of installation of cable varies greatly from situation to situation, and from medium to medium, and can be extensive. There is much potential for hidden costs in the cabling cost category. Costs such as those for cable hardware, for construction, and for labor are sometimes overlooked.

Server

Each shared printer or disk drive in a baseband LAN ordinarily requires a server to further coordinate network operation with the device. The cost of a server varies from seven hundred to fourteen thousand dollars depending on what the server includes and the level of sophistication of the server.

Head-end

A broadband LAN requires either an active head-end (in a one-cable system) or a passive head-end (in a two cable system). An active head-end is usually more expensive than a comparable passive head-end. Yet, the cost of the second cable needed in a passive head-end system more than compensates for the difference in cost. The cost of an active head-end is thirty-five hundred dollars or more.

Hard-Disk Storage

Since hard-disk storage is an important part of a LAN of microcomputers, and many disk servers are permanently attached to hard disk drives (in baseband LANs), the cost of ten megabytes of hard disk storage will be considered in determining the total cost of any network treated in the remainder of this paper. The average cost of ten megabytes of network-usable, hard disk storage, without back up, is twenty-five hundred dollars.

Repeaters or Amplifiers

If a LAN of microcomputers is to be extended beyond a certain minimum range, a repeater (in a baseband LAN) or an amplifier (in a broadband LAN) must be used for each increment of extension of a certain length.

Future Costs

Possible future costs associated with LANs of microcomputers include: costs of devices to be added to an existing LAN, costs of extending the LAN, and maintenance costs for the LAN.

Expandability

So that interconnectivity, and therefore intercommunication, of devices, information, and people can appropriately increase over space and time, a LAN of microcomputers should be expandable. This exansion should be in terms of numbers of devices, extendable over space, and extendable to other kinds and sizes of networks, according to what can be afforded and what technology will allow.

In selecting a LAN of microcomputers, one should plan for the probability that devices will have to be added to the initial selection. Humans tend to use up rapidly whatever computer power is available to them, and insist on more and more. Unless the initial cabling and hookup possibilities in a LAN of microcomputers covers the entire area of an organization, it is also reasonable to assume there will be insistent requests from the "have nots" for extended cabling and hookups.

In planning for the future of a LAN of microcomputers, one should consider a network that can be interconnected with another similiar network through a bridge. A LAN capable of being interconnected to larger networks (such as SNA networks) through a gateway will have optimal possibilities for resource sharing and communication and a probable long life before obsolescence.

Multivendor Connectivity

A LAN of microcomputers interfacing with microcomputers, hard disk drives, and printers from many different vendors can allow network users considerable flexibility in choosing network hardware and software, and probably, a more open possibility of replacing network devices as replacement becomes desirable. Compatibility with the OSI model and with widely used data communications standards should be positive in this regard.

Ease of Installation, Maintenance, and Reconfiguration

In selecting a LAN of microcomputers, ease of installation, maintenance, and reconfiguration should be considered important. In evaluating the ease of installation of a LAN, factors of concern should be: kind of cabling; ease of stringing cable; requirements for taps; numbers of necessary repeaters or amplifiers; and sizes and numbers of necessary interfacing and servor or head-end units. A LAN of microcomputers should be easy to maintain. Parts of the LAN prone to failure should be easily accessed, bypassed, repaired or replaced. A vendor stock of spare parts and the possibility of vendor service should be available. A LAN of microcomputers, if easily reconfigurable, can be easily changed to satisfy new requirements as they arise.

Security

The security of hardware, software, and data in a LAN of microcomputers should be consistent with the needs of the potential users of the network. Restricted access to hardware, software, and data should be variable within the control of the director or directors of the network. All important software and data should be backed up as often as it is changed significantly.

Specific Ranges of Selection Concern

Much of the remainder of this paper will consider specific ranges of selection concern per LANs of microcomputers. The ranges will be relative to: cost per microcomputer interconnection, maximum range (length of cable), maximum number of interconnections, maximum number of brands of connectable microcomputers, and maximum data transfer rate.

In the remainder of this paper, cost per microcomputer interconnection information will be based on the average cost of a twenty-microcomputer LAN (not including costs of microcomputers and printers) containing: twenty microcomputer interface devices or cards, two thousand feet of cable, a disk-server (in a baseband LAN), a head-end (in a broadband LAN), network software, and ten megabytes of hard disk storage. With these qualifications in mind, the cost per microcomputer interconnection varies from three hundred fifty to four thousand dollars in a LAN.

The maximum range (maximum length of single cable) in a LAN of microcomputers is from twenty feet to three hundred fifty miles. Repeaters or amplifiers are required at approximate two

thousand feet to four thousand feet intervals to extend most LANs. In a LAN of microcomputers, the maximum number of microcomputer connections ranges from six to twenty-four thousand and the maximum number of brands of interconnectable microcomputers from one to twelve. The data communication rate in a LAN of microcomputers varies from six kilobits per second (kbps) to ten megabits per second (mbps).

Specific Representative LANs of Microcomputers

In table 10, the characteristics of six representative microcomputer LANs are shown. These have been chosen because of their popularity, multivendor connectivity, usability, expandability, and vendor responsiveness to requests for information. The qualifications of the previous sections will be in effect in this section also.

TABLE 10

SIX REPRESENTATIVE MICROCOMPUTER LANS

Ethernet	
Company name and address	INTERLAN, Inc. 3 Liberty Way Westford, MA 01886 617-692-3900
Kind of network	baseband
Topology	bus
Interconnection medium	coaxial cable
Data transmission rate	10 mbps
Access technique	CSMA/CD
Models and standards	OSI, RS-232-C consistency
Gateway	gateways to other Ethernets
Cost per microcomputer interconnection	$1,550
Maximum range	1.5 miles
Maximum number of interconnections	1,024
Kinds of connectable microcomputers	Apple, DEC, IBM, Osborne, TRS-80, Xerox, and others

TABLE 10—Continued

Local Net 20	
Company name and address	Sytek, Inc. 1225 Charleston Rd. Mt. View, CA 94043 415-966-7330
Kind of network	broadband
Topology	bus
Interconnection medium	coaxial cable
Data transmission rate	128 kbps
Access technique	CSMA/CD
Models and standards	OSI, RS-232-C consistency
Gateway	to other Local Nets, and to X.25 packet switching nets
Cost per microcomputer interconnection	$1,675
Maximum range	60 miles
Maximum number of interconnections	24,000
Kinds of connectable microcomputers	any microcomputer with an RS-232-C synchronous card

Net/One	
Company name and address	Ungermann-Bass, Inc. 2560 Mission College Blvd. Santa Clara, CA 95050 408-496-0111
Kind of network	baseband or broadband
Topology	bus
Interconnection medium	coaxial cable
Data transmission rate	10 mbps (baseband) 5 mbps (broadband)

TABLE 10—Continued

Access technique	CSMA/CD
Models and standards	RS-232-C, IEEE 802 consistency
Gateway	SNA gateway
Cost per microcomputer interconnection	$1,150
Maximum range	1,500 feet (before repeater in baseband) 10 miles (broadband)
Maximum number of interconnections	1,024 (baseband) 7,200 (broadband)
Kinds of connectable microcomputers	any computer with an RS-232-C interface

Omninet

Company name and address	Corvus Systems, Inc. 2029 O'Toole Ave. San Jose, CA 95131 408-946-7700
Kind of network	baseband
Topology	bus
Interconnection medium	twisted pair cable
Data transmission rate	1 mbps
Access technique	CSMA
Models and standards	OSI, RS-442 consistency
Gateway	SNA gateway
Cost per microcomputer interconnection	$745
Maximum range	1,800 feet
Maximum number of interconnections	64
Kinds of connectable microcomputers	Apple, Atari, Corvus, DEC, IBM, NEC, Osborne, S-100 bus, TRS-80, Vector Graphics, Xerox, Zenith

TABLE 10—Continued

Plan 4000	
Company name and address	Nestar Systems, Inc. 2585 E. Bay Shore Rd. Palo Alto, CA 94303 415-493-2223
Kind of network	baseband
Topology	star-burst (interconnected stars)
Interconnection medium	coaxial cable
Data transmission rate	2.5 mbps
Access technique	token passing
Models and standards	OSI consistency
Gateway	no information available
Cost per microcomputer interconnection	$1,850
Maximum range	22,000 feet
Maximum number of interconnections	255
Kinds of connectable microcomputers	Apple, IBM

Share/Net	
Company name and address	Novell Data Systems 1170 N. Industrial Park Orem, UT 84057 801-226-8202
Kind of network	baseband
Topology	star
Interconnection medium	twisted pair cable
Data transmission rate	1.5 mbps
Access technique	multiplexer (similiar to polling)

TABLE 10—Continued

Models and standards	OSI, RS-232-C consistency
Gateway	no information available
Cost per microcomputer interconnection	from $790 to $1,150
Maximum range	6,000 feet
Maximum number of interconnections	64
Kinds of connectable microcomputers	Apple, DEC, IBM, Victor

CHAPTER 11

CONCLUSION

The microcomputer LANs shown in table 10 are six of many appropriate microcomputer LAN possibilities available today. In evaluating microcomputer LANs for yourself and your institution, you should consider as many and varied an assortment as possible. Discussions and addresses of more than forty microcomputer LAN vendors can be found in the sources listed in the bibliography of this paper.

LANS of microcomputers is a rapidly changing concept. Some of the information in this paper will be out-of-date before the paper is published and some of the equipment mentioned in this paper will be obsolete before 1984 ends.

The current Rogers State College LAN of microcomputers will be in place, probably in some extended form, for years to come. The kinds of microcomputers interconnected may change in the near future. However, the interconnective structure and the possibility for the sharing of hardware, software and communications, the LAN, rather than the microcomputers it connects, will remain relatively stable. According to U.S. Department of Labor statistics and information from other predictive agencies, the degree programs the Rogers State College LAN has spawned should be timely, at least through 1995.

The pervasiveness of LANs of microcomputers and larger networks, in our world, and hopefully in our educational institutions, will continue in the foreseeable future. The ease-of-use, cost-effectiveness, and robustness of LANs of microcomputers; and the increased productivity allowed by LANs of microcomputers and other networks is causing our businesses and industries to increase their use of LANs in the present and to plan for even greater usage of LANs in the future. IBM, American Bell, and other information processing/communications companies have planned for microcomputers and LANs of microcomputers to be the computer/communications workstations, if not the telephone replacements, of the present and future. We in education need, and will need, computer/communication power in solving our problems and in educating our students for "the information society."

Baseband and broadband networks; ring and bus topologies; coaxial cable and fiber optics cable media; twenty mbps transmission rates; CSMA/CD and token passing access methods; the OSI model; and the X.25 and the IEEE 802 standards should continue to be major factors in the microcomputer LANs of the future. With appropriate distributed data processing (small computers solving small problems and large computers solving large ones), and attendant increases in productivity, the following factors: greater standardization in models, standards and protocols; gateways; processor-independent and increasingly user-friendly operating environments; and portable languages should allow greater interconnectivity of LANs of microcomputers to other microcomputer LANs and to larger networks.

Computer power and communication are growing and merging into a new and widely important field. As we continue "the information revolution," LANs of microcomputers are the most appropriate vehicles through which we can make use of the problem-solving power and education potential of the computer/communication field.

REFERENCES

Ambler, John S. "Local Area Network Protocols." *Computerworld on Communication*, 18 May 1983, pp. 93-98.

Bentley, Terry. "Weighing the LAN Sides: Baseband v. Broadband." *DM*, June 1983, pp. 21-26.

Blumenthal, Marcia. "Business Graphics Use Proliferates." *Computerworld*, 23 February 1981, p. 10.

Bowerman, Robert "Choosing a Local Area Network." *Interface Age*, July 1983, pp. 55-59.

Caslin, Jerry. "Open System Architecture." *Computerworld Extra*, 17 March 1982, pp. 54-56.

Davis, George R., ed. *The Local Network Handbook*. New York: McGraw Hill, 1982.

Derfler, Frank J., Jr. "To LAN or Not to LAN." *Popular Computing*, August 1983, pp. 213-217.

Derfler, Frank J., Jr., and Stallings, William. "Local Networks: A Guide for the Perplexed." *Popular Computing*, August 1983, pp. 237-268.

Derfler, Frank Jr., and Stallings, William. *A Managers Guide to Local Networks*. Englewood Cliffs, NJ: Prentice-Hall, 1983.

Douglas, John H. "New Computer Architectures Tackle Bottleneck." *High Technology*, June 1983, pp. 71-78.

Edwards, John. "The Desktop Buyer's Guide to Local Area Networks." *Desktop Computing*, August 1983, pp. 60-63.

Feigenbaum, Edward, and McCorduck, Pamela. "Land of the Rising Fifth Generation Computer." *High Technology*, June 1983, pp. 65-70.

Frank, Howard "Telecommunications." *Computerworld Extra*, 18 March 1981, pp. 85-88.

Hafner, Katherine. "Seven of 10 Managers Polled Plan Local Nets." *Computerworld*, 17 October 1983, p. 24.

King, John. "Future Networking with IBM." *Computerworld on Communications*, 28 September 1983, pp. 15-29.

Kinnucan, Paul. "Local Networks Battle for Billion-Dollar Market." *High Technology*, Nov./Dec 1981, pp. 64-72.

Laberis, Bill. "Labor Stats: DP Industry to Skyrocket in '80s." *Computerworld*, 12 October 1981, p. 29.

Lecht, Charles P. "Future Networks." *Computerworld on Communications*, 18 May 1983, pp. 20-29.

Levy, Walter. "The Birth of AIS/NET 1." *Computerworld*, 30 August 1982, pp. 27-35.

Miller, Landon. "Telecomm Support Begins with Focus on Requirements." *DM*, June 1983, pp. 12-16.

Mines, Christopher. "Bell's New Strategies for the '80s." *Computerworld Extra*, 17 March 1982, pp. 21-26.

Miyashiro, Glenn. "LAN isn't an 'all or nothing' technology." *DM*, June 1983, pp. 17-19.

Papert, Seymour. *Mindstorms*. New York: Basic Books, 1980.

Poppel, Harvey L. "Who Needs the Office of the Future." *Harvard Business Review*, Nov./Dec. 1982, pp. 146-155.

Posa, John G. "Phone Net Going Digital." *High Technology*, May 1983, pp. 37-46.

Power, Gerald L. "A Survey of Distributed Network Architectures." *Computerworld Extra*, 18 March 1981, pp. 39-63.

Schultz, Gary D. "Anatomy of SNA." *Computerworld Extra*, 18 March 1981, pp. 35-38.

Weitzman, Cay. *Distributed Micro/Minicomputer Systems*. Englewood Cliffs, NJ: Prentice-Hall, 1980.

PART 3

SYSTEMS APPROACH TO COMPUTER LITERACY FOR VOCATIONAL EDUCATORS: A PROFESSIONAL DEVELOPMENT SEMINAR FOR FACULTY AND STAFF

Mildred Fitzgerald Johnson
Cheyney University of Pennsylvania

CHAPTER 12

PROFESSIONAL DEVELOPMENT FOR FACULTY AND STAFF

Relevance of Staff Development

In a special report on computers in education, Edward Fiske (1983) looks seriously at what is going on in our schools and reports:

> Schools are in the grip of a computer mania. Ordinarily conservative and slow to change, schools are embracing new technology and new educational methods more rapidly than they can learn to use them. During the past few years, the influx of microcomputers in education has grown from a mere trickle to a torrent, engulfing teachers and administrators in a flood of confused expectations and unfulfilled promises (p. 82).

There is no way to know all of the issues surrounding computer education, uses of microcomputers, or special computer literacy projects. However, vocational educators are giving recognition to the computer as a tool to help teach the fourth "R"—reasoning—that has been added to curricula.

Research literature shows that secondary schools remain the largest precollege users of microcomputers. Microcomputers are being used not only as a tool for problem solving but as a resource. In vocational education the computer is as much an object of instruction as it is a major work tool. Therefore, vocational educators need to become computer literate.

A perusal of textbooks, journals, and conference agenda reveals that very little attention is being paid to the unique role and needs of vocational educators, even though computers are being recognized as a necessity in education.

As vocational educators review and redefine curriculum goals geared toward educating or producing effective citizens, they are becoming increasingly aware of the fact that they cannot achieve these goals without electronic technology—especially at a time when information will be the dominant industry by the year 2000.

This staff development effort is significant to vocational educators because every facet of their lives, in or out of the classroom, is impacted by the computer. Since they are served by the computer daily, they should know about it and how to use it. The computer is changing everyday vocabulary, making it necessary for vocational educators to be computer literate in order to communicate with others.

If vocational educators are to remain a vital force in the education process and cope with the computer mania that is sweeping today's classrooms, they must make every effort to understand the functional and operational requirements of computers. Vocational educators who do not have time to write their own programs, nor the inclination to learn a procedural dialect, should be able to operate a microcomputer and use preprogrammed software. This knowledge allows the novice to use a computer, run a program, and then inspect, modify, and correct it with a minimum of frustration and/or intimidation.

Computer Literacy Project

The Cheyney University of Pennsylvania computer literacy project was developed in an attempt to define and defend a workable computer literacy program for training vocational educators and staff. This project was an attempt to define computer literacy based on the needs and resources of the local community—just as other communities have had to define their programs based on financial and human resources available and on needs of their targeted populations. Educators are experiencing computer shock in the classrooms and want to become computer literate. This challenges educators to define or defend their programs of computer education.

Andrew Molnar, program director at the National Science Foundation, predicted in 1978 that computer literacy would become education's next challenge. He indicated that "defining computer literacy is like aiming at a moving target."

Research studies and periodical literature of the past decade report two distinct schools of thought on computer literacy. One group believes that people cannot be computer literate if they cannot program. The other group believes people can be computer literate without mastering programming skills.

The author of this paper believes that basic elements of programming and data processing should be taught in a computer literacy course. The two different viewpoints probably emerged because those educators who did not have access to hardware did not stand by idly and refuse to teach basic computer concepts.

Where schools do not have adequate hardware to develop expert programming skills, students should be taught the nature and characteristics of software. If students do not have the skill or inclination to write a programming language, they should be taught how to select and use preprogrammed software. This course should be an introductory, first level course that does not concentrate too heavily either on computer technology or computer science.

At the introductory level, educators should not concern themselves with developing expert computer operational skills or expert computer hardware and software design skills. Instead, instruction should focus on introductory concepts regarding the characteristics of computer hardware, software, data, personnel, and procedures.

It is the writer's philosophy that if the equipment is available, programming language should be taught. However, if hardware is not available, instructors should utilize a multimedia instructional approach to teach basic programming concepts just as they would teach about the computer and data processing concepts.

If educators are going to help other educators and students unravel the mystery of the computer through a basic concepts course, they must not let instruction become mired in programming various levels of computer languages, especially since there are so many choices. Also, when consumers buy a personal or small computer, the language normally comes with it.

BASIC (Beginners All-purpose Symbolic Instruction Code) is recommended for computer literacy training because it is the most popular of all computer languages used in education. Of course, if educators are familiar with another language or desire to teach LOGO, PILOT, PASCAL, or any other language, they should have the freedom to do so if it meets the school's curricula goals.

Computer Literacy Defined

Professional literature shows that computer education experts are in general agreement regarding the essential concepts that should be included in a computer literacy course. These orientation/awareness training concepts include what a computer is, what a computer can and cannot do, how to use a computer as a tool, the roles of computers in our everyday lives, and futuristics of computer technology.

The author suggests the following definition for computer literacy as reported by Johnson (1982):

> *Computer literacy* is the general education or knowledge which precedes computer professional literacy and implies an understanding of basic computer concepts which are data processing's fundamental concepts.
>
> Knowledge of basic computer concepts represents the state of being literate or insightful about the characteristics of computer hardware, software, data, procedures, computer personnel, and users in a computer-based information system.

This definition implies that a computer literate person is informed and knowledgeable about a computer—what it is and how it works. The computer literate person possesses verbal competence to discuss the social impact of computers upon daily lives, is informed about scientific and business data processing careers, has the ability to read and understand computerized reports and oral data processing presentations, and is able to do computing—that is, conceptualize problems algorithmically, enter, debug, and run a short BASIC program, and express in writing clear and concise computational ideas.

CHAPTER 13

PROCEDURAL STEPS FOR SYSTEMS MODEL

Systems Model

A model of the systems approach for conducting a successful data processing workshop is illustrated in figure 7. The model is designed for a one to three day highly concentrated data processing teaching-learning experience. The eleven procedural steps are as follows.

Step 1: Conduct client needs assessment. By surveying the target audience, a needs assessment provides insight into the background of each participant and helps determine the subcompetencies used in establishing workshop goals. The results of a client needs assessment should identify the real problem or need for a workshop. Also, the results should establish clear boundaries for the areas of study and type of instructional delivery system desired by the targeted population.

The needs assessment does not need to involve a scientific population sample. However, the potential clients surveyed should be representative of the target audience. If the needs assessment is administered during an inservice training day, a 100 percent response rate can be achieved.

Step 2: Identify and classify basic computer literacy competencies. This step is probably one of the most important parts of the model. By conducting a thorough review of available computer literacy data, behavorial objectives can be specified. The objectives should encompass the components of a typical business data processing computer system. Objectives should include hardware, programs, data, procedures, and personnel.

The following are examples of behavorial objectives for computer literacy. Upon completion of the workshop, the participant should be able to do the following:

- Explain the three elementary functions a computer can perform.
- Distinguish between data and information.
- Define "computer."
- Distinguish between applications and systems programs.
- Demonstrate an understanding of the concept of business computer systems.
- Explain how computer systems are classified.
- Identify by name major computer manufacturers.

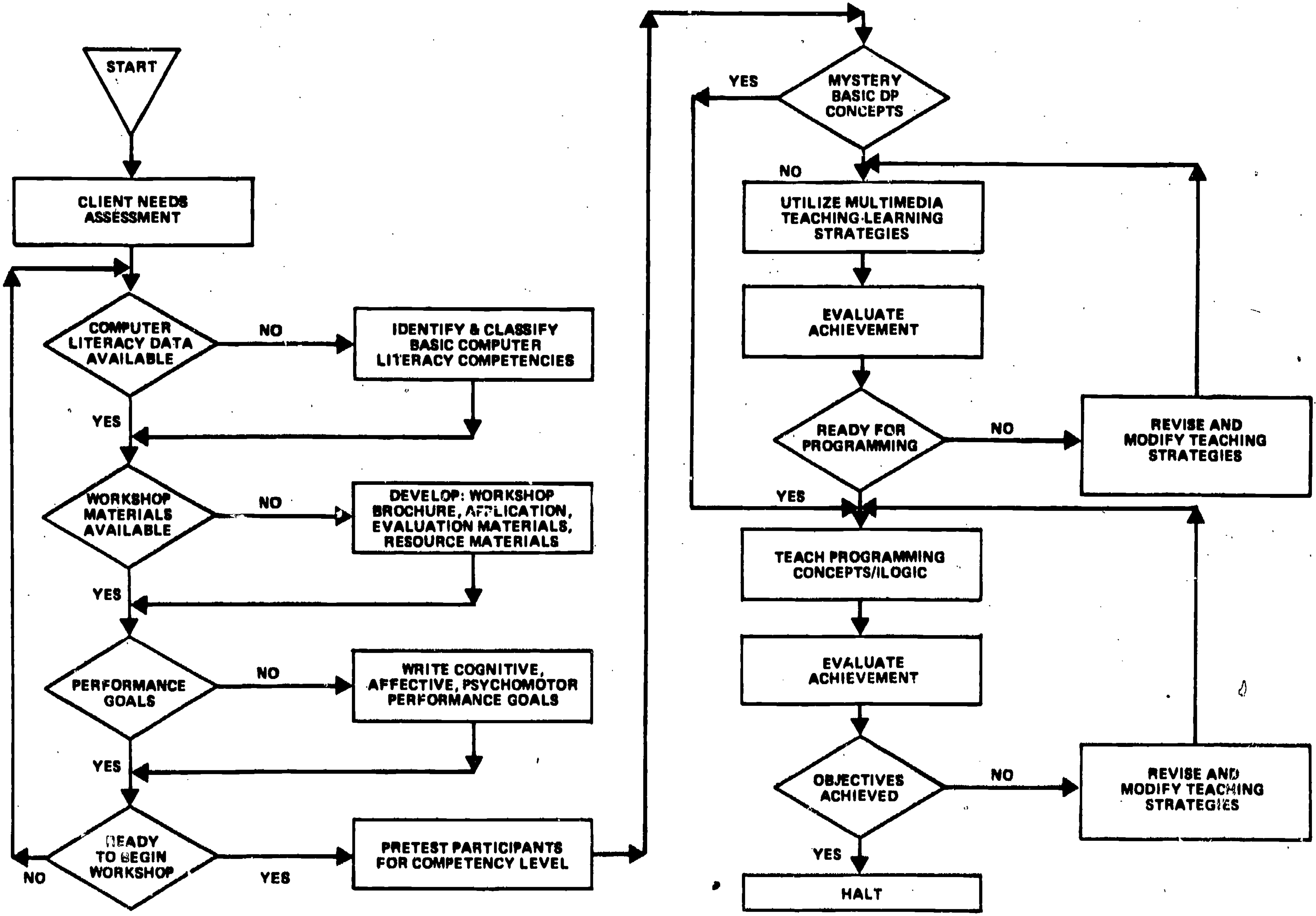

Figure 7. Systems model for conducting a successful data processing workshop

- Distinguish between software and hardware.
- Identify common input-output devices.
- Demonstrate an understanding of how data is stored—storage media.
- Explain the function of the three basic components of the CPU.
- Explain why the binary numbering system is ideally suited to computing.
- Identify different types of programs that are part of an operating system.
- Explain the difference between high-level languages and low-level languages.
- Identify the functions of assemblers and compilers.
- Explain the purpose of a flowchart; basic symbols used.
- Write elementary BASIC programs.
- Identify criteria for selecting and purchasing a microcomputer.
- Identify criteria for selecting software.
- Identify data processing career positions.
- Use basic computer terms correctly in oral and written communications.

Step 3: Develop workshop brochure, application, evaluation material, resource materials. This step involves planning the content of the workshop and the presentation methods. In order to measure the participant achievement of goals and the effectiveness of the teaching-learning system, pre-and posttests must be developed. The criterion-referenced measures must reflect precisely what is to be evaluated.

The workshop content should include review of fundamental data processing concepts and trends. The content should provide practical logic exercises and short BASIC language programming activities. These activities should be designed to help remove the mystique surrounding computers and to help the participants communicate with data processing personnel.

Step 4: Write cognitive, affective, psychomotor performance goals. The ending performance goal for participants is to raise their level of computer literacy. The computer literate person—

- is informed and knowledgeable about what a computer is and how it works;
- possesses verbal competence to discuss the social impact of computers on daily life;
- is informed about data processing careers;
- has the ability to read and understand computerized reports or oral data processing presentations;

- is able to do computing—conceptualize problems algorithmically; enter, debug, and run programs;

- is able to express computational ideas clearly and concisely in writing.

Step 5: Pretest participants for competency level. Prior to the start of the workshop the pretest evaluation instrument should be administered. The pretests can be scored while participants view short computer literacy films. The pretest results can be utilized to determine if some participants should advance to the programming step in the systems model. As an example, on a fifty-item pretest, a participant scoring above forty-six could advance to the programming step. Rarely does a participant score this high.

Step 6: Utilize multimedia teaching-learning strategies. A multimedia teaching-learning approach, without a doubt, is vital to increasing levels of computer literacy. Space restraints preclude the listing of learning materials and resources that could be utilized in the teaching of what a computer is, how it works, and how it is used as a problem-solving tool. However, a resourceful workshop leader should prepare transparencies of basic concepts, compile a list of recent reference materials, and develop a workshop notebook of data processing fundamentals. The workshop leader should develop "how-to" workshop exercises and model BASIC programs. The workshop leader should utilize 16mm computer literacy films (ten to thirteen minutes each), oral quizzes, written pre- and posttests, and highly qualified instructors from education and industry. Also, a tour of a computer center should be planned.

Participants should interact by having hands-on experiences, observing, writing, reading, listening, and discussing computer and data processing concepts.

Step 7: Evaluate achievement. Evaluation is an integral part of the systems model. The evaluation data should pinpoint strengths and weaknesses of the information delivery system, reveal whether participants achieved the minimum level or above, and whether the testing instruments measure the stated goals.

Step 8: Revise and modify teaching strategies. If the participants have not achieved a minimal level of competence, it may be necessary for the workshop leader to revise and modify teaching strategies. Key areas may need to be clarified, explanations may need to be simplified, or practice exercises may need to be utilized.

Step 9: Teach programming concepts/logic. When workshop participants have mastered the introductory concepts regarding the characteristics of computer hardware, software, data, personnel, and procedures, programming language should be taught. If proper equipment is not available, then the concepts of programming and its logic should be taught.

Step 10: Evaluate achievement. The evaluation data should pinpoint the strengths and weaknesses of the information delivery system and should indicate whether participants have achieved a minimum level of performance in mastering programming concepts and logic.

Step 11: Revise and modify teaching strategies. If the participants have not mastered programming concepts and logic, the workshop leader may need to reclarify key concepts. However, if time restraints do not allow for a complete review, the modifications of teaching strategies should be utilized in the next workshop.

Computer Literacy Course Content and Workshop Format

Developing the course content and workshop format to meet the specified behavioral objectives, is a substantial element of the model. Johnson (1982) recommends the following basic content for plotting a computer literacy course for faculty and/or staff:

- **Computer vocabulary:** Basic technical computer vocabulary to help make communications easier with computer personnel and others in our increasingly computer-oriented society.
- **Computer anatomy:** What it is, what it is not; configuration of equipment found in typical computer center; input/process/output basic processing cycle.
- **Computer capabilities and limitations:** Nontechnical and low-technical aspects of the capabilities and limitations of computers, system capabilities, input/output capacity, speed of CPU.
- **Computer applications:** Uses of computers; recent technology and projections as to what is to come in computing, for example, telecommunications, simulations of traffic patterns, CAI, information storage, AIM/ARM, control satellites, daily directory update, sort subscription lists, and so forth.
- **Scientific method of problem solving:** Introductory skills that enable one to conceptualize problems algorithmically; use of specific rules or procedures designed to solve problems scientifically.
- **Flowchart:** An understanding of the flowchart as a program design tool; an understanding of the logic required to solve problems commonly found in business applications programming.
- **Computer programming:** Familiarization with the seven most widely used programming languages: Assembler Language, FORTRAN, COBOL, PL/1, RPG, BASIC, and PASCAL.
- **Introduction to BASIC language:** Identify the purpose of the BASIC computer language; explain and illustrate a set of BASIC statements and commands used to direct the computer; write and execute a program which has been previously written; write a short application program in area of interest.
- **Computer career education:** An understanding of training needs of computer personnel and typical salaries; the role played by computer operators, data entry operators, tape librarians, programmers, and systems analysts in typical computer centers; organizational changes.
- **Social implications:** Be able to read an article in the newspaper or listen to a news report concerning business or scientific applications of computers and know, in general, what is being discussed; the issue of privacy with respect to the computer age.
- **Futuristics:** An appreciation of the excitement and vitality of the data processing industry; innovation, new technology, trends in artifical intelligence, and robotics.

A suggested workshop format is as follows:

1. Registration
2. Introduction
3. Workshop Overview (presenter/participant goals)
4. Pretest Participants (level of competence)
5. Computer Literacy Films (definitions, history, impact, applications)
6. Introduction to the Computer (anatomy)
7. Data Processing Cycle (input/process/output)
8. Computer Center Tour (configuration of hardware)
9. Introduction to Programming (examples and questions)
10. BASIC Programming (write, enter, debug, run)
11. Posttest (participant achievement)
12. Workshop Evaluation (system effectiveness)
13. Presentation of Professional Development Certificates
14. Adjournment.

CHAPTER 14

SUCCESSFUL IMPLEMENTATION OF SYSTEMS MODEL

An organized methodology was utilized to develop and implement the systems approach to conducting a successful computer literacy workshop for the Delaware County vocational educators. The systems model (as shown in figure 7) illustrates the logic and detailed steps that led to the implementation of the computer literacy workshop.

The workshop leader first examined the entire problem of computer literacy education to determine which tasks had to be accomplished in order to help vocational educators unravel the mystery surrounding the computer. The investigation started with an assessment of need for the targeted population.

Vocational Educators Needs Assessment

The computer literacy workshop was developed in response to requests from educators and administrators for an inservice computer workshop. An investigation was then conducted to identify the real problem or need for a workshop. The survey instrument (see appendix A) was designed and pilot tested to establish clear boundaries for the areas of study and type of instructional delivery system desired by the educators.

A computer literacy needs assessment survey form (see appendix B) was designed, typed, and distributed to administrators and vocational educators employed in the nearby Delaware County Vocational schools, and vocational educators at Cheyney University of Pennsylvania. A 100 percent response rate was obtained from the ninety-one Delaware County vocational educators surveyed.

The survey results helped to determine the scope and depth of the problem and enabled the workshop leader to formulate the objectives of the problem solution. A total of seventy-two Delaware County respondents indicated that they would participate in a data processing concepts inservice training workshop. Their instructional delivery system preference was for an inservice day workshop—the second choice was for a data processing seminar/short course. The respondents' preferences for computer languages were BASIC, COBOL, and FORTRAN respectively.

Participant Recruitment

Letters of invitation and workshop brochures were mailed to Delaware County Vocational Technical Schools and to educators and administrators at Cheyney University of Pennsylvania. The letter (see appendix C) was an invitation to educators who had indicated an interest in improving their knowledge about computers or investigating computers as a means by which they could help to prepare students to function more efficiently in our technological society.

The workshop brochure (see appendix D) provided information regarding program goals and procedures for the workshop. The brochure listed special workshop benefits, workshop topics, time allocated for each learning activity, workshop faculty, specially prepared materials, tuition for seminar workshop, and workshop sponsors.

Participant Selection

Since a limited number of terminals were available for use by workshop participants, the cutoff number for registrants was forty. Because of the overwhelming response, seventy-five participants were accepted and registered. The overflow participants had preregistered with the understanding that they probably would not have hands-on experience—that is, running and debugging a short BASIC program.

Sixty-four participants were in attendance on the day of the workshop. Therefore, not all participants were able to go to the computer center for hands-on computer experience. These participants indicated that this did not detract from the knowledge gained regarding basic computer concepts.

Workshop Staff

The staffing needs for this workshop required a director, programmer, systems analyst, and secretary knowledgeable in the areas of computer systems, programming, and teaching-learning systems. Appendix E lists the faculty for the computer literacy workshop. This author believes that it is absolutely essential for the workshop faculty to be composed of an industry-education mix. This mixture adds excitement and vitality to the presentation or instructional system. If the workshop is conducted on a Saturday, it is much easier to obtain personnel from industry. Of course, business and industry are usually most cooperative. With ample notification and clearly specified program goals, they will honor educators' request for assistance.

Workshop Duration

The computer literacy workshop was held for one day but is designed so that it could be extended from one day to one week or to one semester. Longer time periods permit greater breadth and depth in the teaching of computer technology and data processing concepts.

Computer BASICS Pretest/Posttest

A twenty-item test covering the workshop objectives was administered as a pretest and again as a posttest by the workshop director (see appendix F). In order to provide the participants with immediate feedback, the pretest was scored by workshop assistants. Posttest items were received at the end of the session so that participants could check their accuracy on each test item and raise questions if the answers were not clear.

Workshop Evaluation by Participants

A postworkshop questionnaire was administered to all participants in order to get their opinions of the quality of the workshop (see appendix G). Each participant completed the workshop

evaluation form, which listed ten items to be rated on a scale of one to five, and with space for additional comments regarding major strengths and weaknesses.

The Cheyney University of Pennsylvania workshop was rated *excellent* and *superior* in the majority of the evaluation areas (see appendix H). There were many requests for additional workshops, longer periods of time (several days to a week), or a semester course for non-data processing professionals. Some comments were as follows:

- "Simplicity"
- "Content of session was excellent"
- "Energetic and graphic"
- "Big subject to cover in one session—good job"
- "You made us feel comfortable and left us wanting more"
- "Perhaps more educators would attend workshops if they were all as informative as this one"
- "Nice to hear someone addressing the problems we are having and not just going around them"
- "Workshop very beneficial—my computer taste buds were enhanced"
- "Received many ideas I plan to implement in my classroom"
- "Alleviated my fear of the computer—once one understands, one doesn't fear"
- "Workshop met all my expectations—thanks for helping me become computer literate!"

Professional Development Certificate

Each participant received a Professional Development Workshop and Data Processing Certificate signed by the workshop director and the Cheyney University of Pennsylvania Dean of Education.

Workshop Budget

The expenditures for the computer literacy workshop were as follows:

Administration (clerical support services)	$ 350.00
Consultants (programmers and systems analyst)	300.00
Printing	100.00
Postage, supplies, xeroxing, films, etc.	500.00
Total expenses	$1,250.00

Other costs for refreshments and lunch were defrayed by a fifteen-dollar registration fee for each participant.

Workshop Replication

This systems approach to computer basics training can be implemented with or without computer hardware. It can be replicated at any educational level with comparable results when competent staff, technical assistance, and secretarial support services are utilized.

CHAPTER 15

REPLICATION OF SYSTEMS MODEL

To replicate the proposed systems approach to computer literacy for vocational educators, a professional development seminar for faculty and staff needs to address the following areas:

- Vocational Educators Needs Assessment
- Survey Results
- Participant Selection
- Workshop Staff
- Workshop Duration
- Pretest/Posttest
- Suggested Instructional Methodology
- Workshop Evaluation
- Professional Development Certificate
- Workshop Budget
- Workshop Documentation/Replication.

The use of a systems approach for designing and implementing computer education activities must begin with an investigation to identify or isolate the real problem.

Stated very simply, the problem is that vocational educators must become computer literate because microcomputers have caused "shock in the classroom." The recognition of need is the point at which the system's approach really begins. In this project, a survey instrument was utilized to identify specific computer education needs.

The solution of the identified problem comes with the development and modification of existing curriculum materials and instructional delivery systems. The goal is to utilize a methodology for developing subsystems that will enable educators to meet perceived computer literacy needs.

The current approach has been documented and includes comprehensive descriptions of what the systems model does and how it works. All input letters and brochures, output reports and forms, and procedures have been made a part of the documentation for this project.

The systems model was evaluated by the seminar participants and staff to identify potential improvements for the computer literacy workshop. One suggestion for improvement was that more handouts be included for participants.

Based on the repeated suggestions by participants for a longer time frame for the workshop, it is the recommendation of the workshop leader that all computer literacy workshops of the nature described in this paper be at least three to five days long.

No system can be implemented or replicated without trained leaders and/or data processing personnel. It takes a careful leader, who is committed to technology and software research, alert to assimilate information acquired and communicate what has been learned, with an ability to articulate ideas as well as assimilate them. Creative and innovative professionals quickly perceive problems, alternatives, and solutions for helping vocational educators become computer literate.

CHAPTER 16

SUMMARY

The purpose of this presentation was to share the procedures utilized in planning, implementing, and evaluating a successful computer literacy workshop for vocational educators.

Conclusions

When planning for a computer literacy workshop, the leader should assume participants possess no prior knowledge of computers and lead them step-by-step from beginning principles and concepts to microcomputer technology. If this is done, by the end of the workshop/seminar, participants will have discovered the capabilities, limitations, and fascination of microcomputers.

The graphic or schematic drawing of the data flow through the systems model, helps to provide an understanding of the procedures utilized by the workshop leader.

The success of the workshop was indicative of the value of a carefully designed and well thought-out plan that benefits the participants because learning took place. The plan benefitted the workshop leader because a clear course of action was outlined for unifying actions and activities vital to the teaching-learning system.

The presentation identified and defined the production aspects of the workshop as follows:

1. Conduct client needs assessment.
2. Identify and classify basic computer literacy competencies.
3. Develop workshop brochure, application, evaluation, and resource materials.
4. Write cognitive, affective, and psychomotor performance goals.
5. Pretest participants for competency levels.
6. Utilize multimedia teaching-learning strategies.
7. Evaluate achievement.
8. Revise and modify teaching strategies.
9. Teach programming concepts/logic.
10. Evaluate achievement.

11. Revise and modify teaching strategies.

Recommendations

Phase I of the systems approach to computer literacy model should be utilized to help vocational educators understand the components of any computer system: software, hardware, business procedures, data, and computer personnel. It is recommended that a concentrated, multimedia instructional approach to computer basics cover vital data processing concepts that educators and administrators must understand if they are to function efficiently in our technological society.

Also, the goals of the workshop should be designed to help remove the mystique that surrounds computers and to demonstrate teaching-learning strategies that may be employed by vocational educators. If time permits, the workshop leader should provide up-to-date information on criteria for selecting software and selecting a microcomputer for the classroom or personal use.

Phase II of the systems model for writing application programs should be presented, using standard language commands that support the minimum version of the BASIC language. Even if participants do not get a chance to have hands-on experience because of time constraints or lack of hardware, introduction to programming is a vital phase. This phase is a must when the workshop is three to five days in duration or longer.

Although the BASIC language is readily learned by participants, it is recommended that the goal not be to make participants skilled in writing programs but rather to help them understand basic concepts involved in programming. The goal for a one-day workshop should be to help participants understand BASIC language.

Participants may not be able to write and execute a program successfully at the end of the day because learning or acquiring proficiency in designing programs and implementing them requires a great deal of patience, persistence, and repetitive practice. Programming is a general problem-solving skill, while coding of programs in the BASIC language is a secondary, support-type skill. Therefore, it is far more important in phase II to help participants understand how to design programs that provide solutions to problems than simply to learn how to code in BASIC. These two separate skills, programming and program coding in BASIC, provide a fundamental understanding of the structure and capabilities of the BASIC language.

APPENDIX A

NEEDS ASSESSMENT FOR VOCATIONAL EDUCATORS

This questionnaire has been designed for use in securing information about inservice teacher-training needs of vocational educators, who may or may not have access to a computer system for instructional applications.

Your completion of this survey form will be greatly appreciated.

THANK YOU FOR YOUR HELP!

COUNTY__________ SCHOOL__________

CITY__________ POSITION__________ SEX: M ____ F ____

1. Please check ( ) type of school in which you are employed:

   Comprehensive high school ____ 2-year college ____
   Vocational-technical school ____ 4-year college/university ____
   Skills center ____ Private business school ____
   Other__________
   (please specify)

2. Would you participate in an inservice teacher-training program in business data processing if available to you? Yes ____ No ____ Undecided ____

3. Has your use of the computer (hands-on experience) changed during the past two years? Yes ____ No ____

4. Have you developed or modified materials for computer literacy instruction? Yes ____ No ____

   If "yes," are they available to others? Yes ____ No ____

   Indicate published reference__________

5. Do you plan to change your level of computer literacy within the next two years? Please indicate how by checking appropriate items below.

   Basic Computer Concepts Course ____ *Attend Seminars/Short Courses* ____
   Learn A Programming Language ____ Attend Computer Conferences ____
   Visit Data Processing Centers ____ Other__________
   (please specify)

6. Please indicate subject area (s) in which you currently teach data processing concepts.

Single Subject (one semester or longer)

Word Processing Course ____
Data Processing Course ____
Programming Course ____
Other________________________
(specify)
NONE ____

Integrated Data Processing Approach

Accounting ____
Bookkeeping ____
Business Machines ____
Keypunching ____
Other________________________
(specify)

7. Please indicate the type of hardware you have available for instructional purposes.

Computer Hardware

Large Mainframe ____
Minicomputer ____
Microcomputer ____
Computer Terminal ____
Programmable Calculator ____
Unit-Record Equipment ____
None ____

Hardware Mode

Batch (card reader, line printer) ____
Interactive (hard-copy terminals) ____
Interactive (CRT Displays) ____
Interactive (Graphics Displays) ____
None ____

8. Using a scale of 1 to 4 (1 = High; 4 = Low), rank your needs for computer literacy training. Which of the following types of computer literacy instruction and/or materials are you most interested in studying and/or developing in the next two years?

Training Courses Needed

COBOL ____
BASIC ____
FORTRAN ____
APL ____
PASCAL ____
PL/1 ____
Other________________________
(please specify)

Learning Activities Needed

Basic computer concepts ____
Instructional Appls. ____
Problem-Solving ____
Test Generation ____
Test Scoring ____
Demonstrations ____
Other________________________
(please specify)

APPENDIX B

FACULTY COVER LETTER AND FACULTY NEEDS ASSESSMENT

November 21, 1983

Dear Faculty Member:

We need your help!

Because the 1980's promise to be a time of unprecendented growth in the use of microcomputers in education, one of the College's priority goals is to work with the faculty to raise our level of computer literacy. This Computer Literacy Education Project is tailored to meet the faculty's needs, interests, and to help unravel the mystery that surrounds the computer. You have an opportunity to help us accomplish our goals by taking part in this unique project here at Cheyney.

Please complete the attached questionnaire which is designed to obtain facts that will provide staff development specialists with a means of identifying relevant training content, specifying learning objectives, and evaluating performance in computer applications.

Not only will this mean improved classroom instruction and efficient management of time, but think of what it could mean to our campus to have a computer literate faculty and to be able to make a contribution to research by helping to define the catch word of today—"computer literacy."

Please do not let all of the hours of study and concern behind this project go to waste. Without nearly 100% participation on our part, a completely true analysis cannot be made. The results of this study will be made available to you during the semester.

Will you return your questionnaire today? It will take only 5 minutes of your time! Thank you for your help.

Sincerely yours,

Mildred F. Johnson, ED.D.
Investigator

Clarence A. Porter, PH.D. Principal
Vice President for Academic Affairs

Attachment: Questionnaire Form

DEPARTMENT OF EDUCATION
CHEYNEY UNIVERSITY OF PENNSYLVANIA
CHEYNEY, PA 19319

The purpose of this survey is to obtain information from faculty members to assist in planning staff development computer literacy curriculum materials, seminars, or courses. Please answer each question and *return this form today to*: DR. MILDRED F. JOHNSON, PRINCIPAL INVESTIGATOR, PROFESSIONAL DEVELOPMENT FOR FACULTY, P.O. BOX 45, CHEYNEY UNIVERSITY OF PA. THANK YOU FOR YOUR HELP!

1. Please check Academic Division in which you are employed.
   a. Graduate/Continuing Ed. ____
   b. Arts and Sciences ____
   c. Education ____
   d. Technical and Applied Sciences ____

2. Please check rank:
   a. Professor ____
   b. Associate Professor ____
   c. Assistant Professor ____
   d. Instructor ____
   e. Other ____ ________________ (please specify)

3. Please indicate your interest in participating in a Professional Computer Literacy Seminar:
   a. Very Interested ____
   b. Not Interested ____
   c. Undecided ____

4. Please check what you desire from a COMPUTER LITERACY COURSE. Indicate order of preference by writing 1, 2, 3, 4.
   a. Computer Awareness/ Orientation ____
   b. Personal Computer Operations ____
   c. Using Preprogrammed Software ____
   d. Writing Computer Programs in BASIC ____
   e. Other ________________ (please specify)

5. Please check your preference for an instructional delivery system:
   a. Weekend Workshop/ Seminar ____
   b. Full Semester Course ____
   c. Class once a Week—3 hrs. ____
   d. Evening Classes—TTH, 4 hrs ____

6. Please check computer applications.

Current Uses Made of Computer	**Uses I Would Like to Make of Computer**
a. Computer-Assisted Instruction (CAI) ____	a. Comput‹ ‑ ssisted Instruction (CAI) ____
b. Computing Student Grades ____	b. Computing Student Grades ____
c. Test Generation ____	c. Test Generation ____
d. Remediation/Tutorial ____	d. Remediation/Tutorial ____
e. Simulations/Games ____	e. Simulations/Games ____
f. Research Projects ____	f. Research Projects ____
g. Word Processing ____	g. Word Processing ____
h. None ____	h. None ____
i. Other ____________ (please specify)	i. Other ____________ (please specify)

7. Please check computer hardware owned by you:
   a. Personal Computer ____
   b. Disk Drive(s) ____
   c. Printer ____
   d. Modem ____
   e. Memory Size: 4K ____, 16K ____, 32K ____, 64K ____
   f. Machine: APPLE ____ IBM PC ____, TRS-80 ____
   g. Other ____________ (please specify)

8. Do you plan to buy a microcomputer? Yes ____ No ____

9. Please indicate your keyboarding/typewriting skills:
   a. 0-15wpm ____
   b. 16-20wpm ____
   c. 21-25wpm ____
   d. 26+ ____
   e. None ____

10. Please check the "language(s)" you presently utilize in writing programs:
    a. COBOL ____
    b. BASIC ____
    c. FORTRAN ____
    d. LOGO ____
    e. Other ____________ (please specify)
    f. Other ____________ (please specify)
    g. Other ____________ (please specify)

11. Please indicate your interest in working with the Faculty Development Staff in conducting a computer training program here at Cheyney:
    a. Interested ____
    b. Not Interested ____

12. Please indicate your preference for beginning the professional development program in computer education:

Dec. ____	Feb. ____	April ____	Summer ____
Jan. ____	Mar. ____	May ____	Other ____________ (please specify)

13. Comments/Suggestions:

Date ____________________ Name ____

APPENDIX C

WORKSHOP LETTER OF INVITATION

April 10, 1981

COMPUTER LITERACY WORKSHOP FOR EDUCATORS

You are invited to participate in an in-service computer literacy workshop, June 13, 1981, at Cheyney State College, Cheyney, Pennsylvania. The attached brochure provides information regarding workshop goals and procedures.

This workshop has been planned in response to an area COMPUTER LITERACY NEEDS ASSESSMENT for vocational educators. It is not surprising that more and more educators are beginning to believe that ignorance of computers will render people as functionally illiterate as ignorance of reading, writing, and arithmetic.

Workshop participants will learn what a computer is, how it functions, and will utilize curricula that have been developed for the purpose of teaching secondary school students about computers. Programming exercises are designed to be run by participants with hands-on access to terminals.

A comprehensive course, INTRODUCTION TO COMPUTERS AND DATA PROCESSING, will be offered at a later date for educators *who are turned on by this workshop* or have requested a complete introductory data processing course.

If you are interested in improving your knowledge about computers or in investigating computers as a means by which you can help to prepare students to function more efficiently in our technological society, please fill out and return the form below today.

DR. MILDRED F. JOHNSON, WORKSHOP LEADER

....

PLEASE MAIL SEMINAR WORKSHOP FORM BEFORE JUNE 1 TO:

Dr. Mildred F. Johnson, Professor
Business Education
Division of Education
Cheyney State College
Cheyney, PA 19319 (215) 758-2407

Name ____________________ Phone (Home) ____________________
Home Address ____________________ Phone (Work) ____________________
City ____________________ State Zip ____________________
School ____________________ Position ____________________
Registration Fee ____________________ Date ____________________

APPENDIX D

WORKSHOP BROCHURE

105

SEMINAR FACULTY

Seminar Leader: Dr. Mildred F. Johnson, Professor
Business Education
Division of Education
Cheyney State College
Cheyney, PA 19319

Seminar Instructor:

Seminar Consultant:

Computer Terminals furnished by

Specially Prepared Course Materials
A course workbook or other supporting materials have been prepared by the instructor for the seminar. You will find that these materials will enhance your understanding of the presentation and will prove to be an invaluable reference in the future.

Tuition for Seminar Workshop
A dynamic one-day presentation by highly qualified instructors for just $10 per person. The fee for the seminar includes course registration, workbook or other materials, coffee breaks, luncheon, and fruit and cheese reception.

Registration fee of $10 must be paid before June 1. Participants selected and assigned to computer terminals on a first-come, first served basis.

Sponsored by Cheyney State College and Temple University under a project funded by Pennsylvania Vocational Education Department.

ONE-DAY

INTRODUCTION TO COMPUTERS AND DATA PROCESSING

PEDAGOGICAL SKILLS WORKSHOP

for

BUSINESS EDUCATORS

VOCATIONAL EDUCATORS

SUPERVISORS

ADMINISTRATORS

Sponsored by

Business Education Program
Division of Education
Cheyney State College
Cheyney, Pennsylvania 19319

June 13, 1981

SPECIAL SEMINAR BENEFITS

One Day Learning Experience. This concentrated seminar covers vital data processing concepts that educators and administrators are expected to know about computers. It is the purpose of this workshop to utilize a hands-on, multimedia instructional approach to explain what a computer is, how it works, and how the computer is utilized to assist in solving problems, not only in business and science, but in our classrooms and offices.

GOAL: TO HELP REMOVE THE MYSTIQUE SURROUNDING COMPUTERS TO REASSURE UNEASY BEGINNERS TO THE FIELD

SEMINAR TOPICS

1. An Introduction to the Computer
   - Familiarization with the basic data processing cycle—input, process, and output
   - Familiarization with the function of a computer program
   - Familiarization with the types of equipment found in typical computer centers
   - Familiarization with the roles played by computer operators, data entry operators, tape librarians, programmers, and systems analysts in typical computer centers
   - Familiarization with different sizes and types of computers
2. Processing Data on a Computer
   - A detailed understanding of the input/process/output basic processing cycle
   - An understanding of the operational capabilities of a computer system—input/output, arithmetic, and logical operations
   - An understanding of the capability of a computer system to store data on auxiliary storage for access at a later time by the same or different program
3. BASIC Computer Programming Language
   - Utilize scientific method of problem solving
   - Represent problem in syntax of a language
4. Tour Computer Center to Observe Topics Discussed
   - Observe configuration of equipment
   - Identify terminals, tape library, and disk devices, professor unit, punched cards, continous form reports, floppy disks, reels of magnetic tape, and a disk pack

DATA PROCESSING PEDAGOGICAL SKILLS WORKSHOP

June 13, 1981

8:30- 9:00 AM	Continental Breakfast
9:00-10:00 AM	Welcome
	Overview: What is Computer Literacy?
Film:	BASIC COMPUTER CONCEPTS
10:00-11:00 AM	AN INTRODUCTION TO THE COMPUTER
11:00-12:00 PM	PROCESSING DATA ON A COMPUTER
12:00-12:30 PM	TOUR OF COMPUTER CENTER
12:30- 1:30 PM	L U N C H E O N
1:30- 3:00 PM	INTRODUCTION TO PROGRAMMING
3:00- 3:15 PM	REFRESHMENTS
3:15- 4:00 PM	PROGRAMMING: CLASSROOM APPLICATION
	FRUIT AND CHEESE RECEPTION
	WORKSHOP EVALUATION

"The computer revolution is the most advertised revolution in world history. Yet one of the funny things about it is that we probably still underestimate its impact."[1]

[1]"Computers and the Future of AMERICA," Hesh Weiner, COMPUTER DECISIONS, January, 1977.

APPENDIX E

WORKSHOP FACULTY

Lonnie Carl Johnson, Project Manager and Senior Systems Analyst
Sun Company, 1608 Walnut Street, Philadelphia, Pennsylvania

Designs and develops all five components of a business computer system; works closely with business users, managers, and technical data processing personnel for SUN PETROLEUM PRODUCTS COMPANY to identify and develop system solutions to business problems; possesses a broad background in both computer-based business and management information systems which provide operational and financial information to managers. B.S. Degree, Morehouse College (Atlanta), M.B.A. Degree, LaSalle College

Victoria Perry, Business Systems Analyst
Sun Company, 1608 Walnut Street, Philadelphia, Pennsylvania

Designs and develops automated office systems for SUN PETROLEUM PRODUCTS COMPANY'S home and field office locations; develops standards, policies, and procedures effecting office systems technology; develops and conducts all orientation and training with management and staff personnel to provide nontechnical personnel with a fundamental knowledge of newly installed computerized systems. Possesses a background in systems analysis, programming, chemistry, and human resources systems. B.S. Degree, University of Pennsylvania.

Deanna Shelton, Assistant Professor, Business Administration
Cheyney University of Pennsylvania, Cheyney, Pennsylvania

Data processing work experience includes Senior Associate Analyst, IBM Corporation, Federal Systems Division; Applications Programmer, Department of Army, USAMSSA, The Pentagon, Washington, D.C.; teaching experience at Morris County Community College and Delaware County Community College. B.S. Degree, Howard University and M.P.A. Degree, American University, Washington, D.C.

Mildred Fitzgerald Johnson, Professor of Education
Cheyney University of Pennsylvania, Cheyney, Pennsylvania

Work experience includes teaching at junior and senior high, community college, college/university levels; non-professional teaching assignments include program developer, curriculum consultant, examiner for Educational Testing Service (ETS), data processing consultant; professional speaker and writer in the area of computers and data processing; Task Group Leader for Association of Computing Machinery's (ACM) Elementary and Secondary Schools Subcommittee to research, write, and produce high quality data processing curriculum documents suitable for widespread distribution. B.S. Degree, Virginia State University, Petersburg, VA: Masters and Doctorate Degrees, Temple University, Philadelphia, PA.

APPENDIX F

PRETEST/POSTTEST FORM

1. STATE THE FIVE BASIC UNITS OF THE COMPUTER

2. IDENTIFY THE UNIT OF THE CPU THAT IS DESCRIBED BELOW

   Storage Area for Computer Applications Programs
   Calls Upon the I/O Devices when Data is being Stored or Retrieved.
   Performs Arithmentic Operations
   Random-Access Storage Medium

3. THE DECIMAL EQUIVALENT OF THE BINARY NUMBER 011010 IS

4. APPROXIMATELY HOW LARGE IS MEMORY WITH 32K?

   WHAT IS THE EXACT SIZE OF MEMORY WITH 32K?

5. IDENTIFY FOUR OPERATIONS A COMPUTER OPERATOR PERFORMS AT A CONSOLE.

6. DISTINGUISH BETWEEN RAM AND ROM.

   RAM
   ROM

7. IDENTIFY FOUR FACTORS WHICH DETERMINE THE DATA PROCESSING CAPABILITY (SIZE) OF COMPUTER SYSTEM.

8. IDENTIFY FOUR HIGH-LEVEL LANGUAGES.

9. IDENTIFY TWO TYPES OF SOFTWARE.

10. A STEP-BY-STEP LIST OF INSTRUCTIONS GIVEN TO A COMPUTER TO SOLVE A PROBLEM IS

11. IDENTIFY BY VENDOR NAME FIVE POPULAR MICROCOMPUTERS OF THE 80's.

12. SPECIFY AT LEAST SIX IMPORTANT FEATURES OF MICROCOMPUTERS THAT SHOULD BE CONSIDERED BY ANY POTENTIAL BUYER.

13. IDENTIFY THREE SOURCES FOR PURCHASING OR LEASING COMPUTERS.

14. LIST AT LEAST SIX COMMON APPLICATIONS FOR COMPUTERS IN EDUCATION.

15. IDENTIFY AT LEAST SIX COMPUTER PUBLICATIONS: TEXTBOOKS, TECHNOLOGY JOURNALS, COMPUTER LITERACY OR INSTRUCTIONAL MANUALS THAT HAVE HELPED YOU PUT TECHNICAL TERMS AND COMPUTER JARGON IN PROPER PERSPECTIVE.

16. A PERSON WHO WRITES DETAILED INSTRUCTIONS FOR SOLVING A PROBLEM ON A COMPUTER.

17. A PERSON WHO ACCEPTS COMPUTER INPUTS, CONVERTS DATA TO COMPUTER-SENSIBLE FORMS, OPERATES COMPUTER HARDWARE, AND DISTRIBUTES COMPUTER OUTPUTS.

18. A PERSON WHO STUDIES THE ACTIVITIES, METHODS, TECHNIQUES, AND PROCEDURES OF SYSTEMS FOR THE PURPOSE OF COMPUTERIZING THOSE SYSTEMS.

19. A PERSON WHO DESIGNS COMPUTER HARDWARE AND/OR DEVELOPS SOFTWARE.

20. IDENTIFY THE COMPUTER OCCUPATIONS WITH THE GREATEST AND LEAST PROJECTED GROWTH RATES FOR 1990.

greatest: least:

APPENDIX G

WORKSHOP EVALUATION QUESTIONNAIRE

CODE NAME ______________________________

DATE ______________

POSITION Administrator __________ Teacher __________ Other __________

COMPUTERS AND DATA PROCESSING WORKSHOP EVALUATION

Directions: On a scale of 1-5 (1 = low and 5 = high), please rate the DP workshop. Encircle number. Your name does not have to be signed.

	SCALE
1. Workshop contributed to personal growth and professional development	5 4 3 2 1
2. Preparation and org·nization of workshop by Workshop Director	5 4 3 2 1
3. Value of workshop in aiding my understanding about computers and data processing	5 4 3 2 1
4. Workshop faculty preparation (clear objectives)	5 4 3 2 1
5. Knowledge of subject matter by presentors	5 4 3 2 1
6. Effectiveness of presentations	5 4 3 2 1
7. Adequate handouts, audio visual, and instructional media	5 4 3 2 1
8. My overall evaluation of the data processing workshop would be	5 4 3 2 1
9. Would you be interested in an in-depth, hands-on, semester course	YES NO
10. Are you willing to be a reference for the workshop?	YES NO

COMMENTS (Major strength/weakness)

APPENDIX H

WORKSHOP EVALUATION RESULTS

CODE NAME ______________________________

DATE ______________

POSITION Administrator ____________ Teacher ____________ Other ____________

COMPUTERS AND DATA PROCESSING WORKSHOP EVALUATION

Directions: On a scale of 1-5 (1 = low and 5 = high), please rate the DP workshop. Encircle number. Your name does not have to be signed.

	SCALE Percentages 5	4	3	2	1	
1. Workshop contributed to personal growth and professional development	.12	.44	.41	.03	.00	
2. Preparation and organization of workshop by Workshop Director	.50	.40	.10	.00	.00	
3. Value of workshop in aiding my understanding about computers and data processing	.14	.43	.34	.09	.00	
4. Workshop faculty preparation (clear objectives)	.24	.62	.14	.00	.00	
5. Knowledge of subject matter by presentors	.49	.42	.09	.00	.00	
6. Effectiveness of presentations	.25	.46	.23	.03	.00	.03
7. Adequate handouts, audio-visual and instructional media	.32	.41	.22	.03	.00	.03
8. My overall evaluation of the data processing workshop would be	.30	.35	.35	.00	.00	

9. Would you be interested in an in-depth hands-on, semster course — YES 78% NO 16% NO ANSWER 6%

10. Are you willing to be a reference for the workshop? — YES 82% NO 6% NO ANSWER 12%

COMMENTS (Major strength/weakness) (1) Knowledgeable presenters; (2) good organization; (3) good preparation; (4) quality notebook; (5) need more time—two to three days; (6) would like more handouts.

REFERENCES

Fiske, Edward. "Computers in Education." *Popular Computing* 2, no. 10 (August 1983): 82.

Johnson, Mildred Fitzpatrick. "The Content of a Computer Literacy Course." *The Balance Sheet* (September/October 1982): 27-30.

BIBLIOGRAPHY

Abel, Peter. *COBOL Programming: A Structured Approach.* Englewood Cliffs, NJ: Prentice-Hall, Inc., 1980.

Adams, Anthony, and Jones, Esmor. *Teaching Humanities in the Microelectronic Age.* New York: Taylor & Francis, 1983.

Adams, David, and Leigh, William E. *Programming Business Systems with BASIC.* New York: South-Western Publishing Co., 1984.

Adams, David R.; Wagner, Gerald E.; and Boyer, Terrence J. *Computer Information Systems: An Introduction.* New York: South-Western Publishing Co., 1983.

Allen, Warren W., and Klooster, Dale H. *Automated Accounting for the Microcomputer.* New York: South-Western Publishing Co., 1982.

Anabarlian, Harry. *An Introduction to Visicalec Matrixing with Apple and IBM.* Hightstown, NJ: McGraw-Hill Book Co., 1982.

Badrikhan, Kamiran S., and Larky, David N. *Electronic Principles and Applications.* New York: South-Western Publishing Co., 1984.

Bartee, Thomas C. *BASIC Computer Programming.* Philadelphia, PA: Harper & Row Publishers, 1981.

Bartee, Thomas C. *Digital Computer Fundamentals.* 5th ed. New York: McGraw-Hill Book Co., 1982.

Becker, Henry J. "How Schools Use Microcomputers." *Classroom Computer Learning* 4, no. 2 (September 1983): 41-43.

Bell, Donald R. *Basic Concepts in File Processing with COBOL.* Englewood Cliffs, NJ: Prentice-Hall, 1980.

Bent, Robert J., and Sethares, George C. *An Introduction to Computer Programming.* Monterey, CA: Brooks/Cole Publishing Co., 1982.

Bent, Robert J., and Sethares, George C. *FORTRAN with Problem Solving: A Structured Approach.* Monterey, CA: Brooks/Cole Series in Computer Science, 1982.

Bitter, Gary, and Watson, Nancy. *The Apple Logs Primer.* Reston, VA: Reston Publishing Co., 1982.

Capron, H. L., and Williams, Brian K. *Computers and Data Processing.* Reading, MA: The Benjamin/Cummings Publishing Co., 1982.

Carver, D. K. *Beginning BASIC*. Monterey, CA: Brooks/Cole Publishing Co., 1982.

Carver, D. K. *Beginning Structured COBOL*. Monterey, CA: Brooks/Cole Publishing Co., 1982.

Cassel, Don, and Jackson, Martin. *Introduction to Computers and Information Processing*. Reston, VA: Reston Publishing Co., 1980.

Clark, James F., and Bux, William E. *Data Entry Activities for the Microcomputer*. New York: South-Western Publishing Co., 1982.

Clark, James F., and Drum, William O. *BASIC Programming: A Structured Approach*. New York: South-Western Publishing Co., 1983.

Clay, Katherine. *Microcomputers in Education: A Handbook of Resources*. Phoenix: ORYX Press, 1982.

Condon, Robert J. *Data Processing with Applications*. Reston, VA: Reston Publishing Co., 1981.

Finkel, LeRoy, and Brown, Jerald R. *Apple BASIC, Data File Programming*. New York: John Wiley & Sons, 1982.

Fiske, Edward. "Computer in Education." *Popular Computing* 2, no. 10 (August 1983): 82.

Godfrey, David, and Sterling, Sharon. *The Elements of CAL: The How-to-Book on Computer-aided Learning*. Reston, VA: Reston Publishing Co., 1982.

Golden, Neal. *Computer Programming in the BASIC Language*. New York: Harcourt Brace Jovanovich, 1981.

Grogono, Peter. *Programming in PASCAL*. Rev. ed. Reading, MA: Addison-Wesley Publishing Co., 1980.

Groves, David, and Poirot, James L. *Computers and Data Processing*. Austin, TX: Sterling Swift Publishing Co., 1982.

Hennefeld, Julien. *Using BASIC: An Introduction to Computer Programming*. 2d ed. Boston, MA: Prindle, Webent, Schmidt, 1982.

Horn, Carin E., and Poirot, James L. *Computer Literacy: Problem-Solving with Computers*. Austin, TX: Sterling Swift Publishing Co., 1982.

Johnson, Mildred Fitzpatrick. "The Content of a Computer Literacy Course." *The Balance Sheet* (September/October 1982): 27-30.

Kernighan, B. W., and Plauger, P. J. *The Elements of Programming Style*. 2d ed. Highstown, NJ: McGraw-Hill Book Co., 1982.

Langenbach, Robert C. *Transparencies for Introduction to Data Processing*. 2d ed. New York: South-Western Publishing Co., 1981.

Logsdon, Tom. *Programming in BASIC with Applications*. Brea, CA: Anaheim Publishing Co., 1981.

Lott, Richard W. *BASIC with Business Applications*. 2d ed. New York: John Wiley & Sons, 1982.

Luehrmann, Arthur, and Peckham, Herbert D. *Computer Literacy: A Hands-On Approach*, First Apple Edition. New York: McGraw-Hill Book Co., 1983.

Luehrmann, Arthur, and Peckman, Herbert D. *Apple PASCAL: A Hands-On Approach*. New York: McGraw-Hill Book Co., 1981.

Mandell, Steven L. *Computers and Data Processing—Concepts and Applications With BASIC*. 2d ed. St. Paul, MN: West Publishing Co., 1982.

McRitchie, Margaret. *Programming in BASIC*. New York: Holt, Rinehart and Winston, 1982.

Medley, Don B., and Eaves, Ronald W. *Programming Principles with COBOL I*. New York: South-Western Publishing Co., 1984.

Mims, III, Forrest M. *Beginners Guide to Computers*. Fort Worth, TX: Radio Shack, a Tandy Corporation Co., 1982.

Newman, William, and Sproll, Robert. *Principles of Interactive Computer Graphics*. 2d ed. Hightstown, NJ: McGraw-Hill Book Co., 1982.

Osborne, Adam *An Introduction To Microcomputers*. Vol. 1. 2d ed. Berkeley, CA: Osborne/ McGraw Hill, 1980.

Parker, Alan J., and Silbey, Val. *BASIC for Business for the PDP-11*. Reston, VA: Reston Publishing Co., 1980.

Peckham, Herbert D. *Hands-on BASIC for the IBM Personal Computer*. Hightstown, NJ: McGraw-Hill Book Co., 1982.

Peckham, Herbert D. *BASIC: A Hands-on Method*. 2d ed. New York: McGraw-Hill Book Co., 1981.

Poirot, James L. *Computers, Computers and Education*. Austin, TX: Sterling Swift Publishing Co., 1982.

Poirot, James L. *Computer Science for the Teacher*. Austin. TX: Sterling Swift Publishing Co., 1982.

Poirot, James L. *Microcomputer Systems and Apple BASIC*. Austin, TX: Sterling Swift Publishing Company, 1982.

Poirot, James L., and Groves, David. *Beginning Computer Science*. Austin, TX: Sterling Swift Publishing Company, 1982.

Poirot, James L., and Retzlaff, Don. *How to Program in BASIC Tutorials*. Austin, TX: Sterling Swift Publishing Company, 1982.

Polin, Glenn M. *Will Someone Please Tell Me What an Apple Can Do?* Austin, TX: Sterling Swift Publishing Company, 1982.

Presley, Bruce. *A Guide to Programming in Apple Soft.* New York: Van Nostrand Reinhold Company, 1982.

Pressman, Roger S. *Software Engineering. A Practitioner's Approach.* Hightstown, NJ: McGraw-Hill Book Co., 1982.

Price, Wilson. *Fundamentals of Computers and Data Processing with BASIC.* New York: Holt, Rinehart and Winston, 1983.

Raden. ·· ier, Robert, and Gibson, Harry. *An Introduction to Computers and Information Systems.* New York: South-Western Publishing Co., 1983.

Rich, Didday, and Page, Rex. *Using BASIC.* St. Paul, MN: West Publishing Co., 1981.

Shelly, Gary B., and Cashman, Thomas J. *Introduction to BASIC Programming.* Fullerton, CA: Anaheim Publishing Co., 1982.

Shelly, Gary B., and Cashman, Thomas J. *Introduction to BASIC Programming—Test Bank.* Fullerton, CA: Anaheim Publishing Co., 1982.

Shelly, Gary B., and Cashman, Thomas J. *Introduction to BASIC Programming—Transparency Masters.* Fullerton, CA: Anaheim Publishing Co., 1982.

Shelly, Gary B., and Cashman, Thomas J. *Introduction to BASIC Programming—Workbook and Study Guide.* Fullerton, CA: Anaheim Publishing Co., 1982.

Shelly, Gary B., and Cashman, Thomas J. *Introduction to Computers and Data Processing.* Fullerton, CA: Anaheim Publishing Co., 1980.

Siewiorek, Daniel; Bell, Gordon C.; and Newell, Allen. *Computer Stru ures Principles and Examples.* Hightstown, NJ: McGraw-Hill Book Co., 1982.

Spencer, Donald D. *Data Processing—An Introduction with BASIC.* 2d ed. Columbus, OH: Charles E. Merrill Publishing Co., 1982.

Spencer, J. Wayne. *COBOL for the 80's.* St. Paul, MN: West Publishing Co., 1982.

Stout, David F. *Microprocessor Applications Handbook.* Hightstown, NJ: McGraw-Hill Publishing Co., 1982.

Struble, George. *Business Information Processing BASIC.* Reading, MA: Addison-Wesley Publishing Co., 1980.

Thomas, James L. *Microcomputers in the Schools.* Phoenix, AZ: ORYX Press, 1982.

Thomas, Rick. *Discover BASIC: Problem Solving with the APPLE II Computer.* Austin, TX: Sterling Swift Publishing Co., 1982.

Wanous, S. J.; Wagner, Gerald E.; and Lambrecht, Judith J. *Fundamentals of Data Processing.* 2d ed. New York: South-Western Publishing Co., 1981.

TO ORDER ADDITIONAL COPIES OF THIS PUBLICATION, USE—	ORDER NUMBER	PRICE
• *Strengthening Computer Technology Programs*	SN 49	$10.50

TO ORDER RELATED PUBLICATIONS, REFER TO—		
• *Microcomputers in Voc Ed: A Decision Guide*	RD 239A	$ 8.75
• *An Administrator's Guide to Microcomputer Resources*	RD 239B	$ 9.50
• *Updating Teachers for Tomorrow's Technology: Programs and Practices*	RD 241	$ 5.75
• *Updating Teachers for Tomorrow's Technology: A Strategy for Action*	RD 242	$ 4.95
• *Courseware Evaluation: Form & Guide for Vocational and Technical Education*	SN 44	$ 2.50
• *Microcomputer Software for Adult Vocational Education: Guidelines for Evaluation*	IN 261	$ 3.25

ORDERING INSTRUCTIONS

To order additional copies, please use order number and title. Orders of $10.00 or less should be prepaid. Make remittance payable to the National Center for Research in Vocational Education. Mail order to:

The National Center for Research
in Vocational Education
National Center Publications, Box F
1960 Kenny Road
Columbus, Ohio 43210–1090

Prices listed are in effect at the time of publication of this book. All prices include postage and handling. Prices are subject to change without notice.

Quantity Discounts

Orders of five (5) or more items, as listed by publication number and title, with a total dollar value for the order of:

$ 50 to $100, the discount is 5%
$101 to $200, the discount is 10%
$201 to $300, the discount is 15%
$301 to $400, the discount is 20%
$401 and above, the discount is 25%

International Orders

All orders, in any amount, from outside the United States and its possessions are to be paid in U.S. currency. Additional postage and handling charges may be added for foreign shipments if necessary.