

A STUDY OF THE PLANNING AND DEVELOPMENT OF A
MICROCOMPUTER LABORATORY IN AN EDUCATIONAL ENVIRONMENT

by

JOHN PAUL CHAPMAN

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Approved by:

Myron A. Alhoun
Major Professor

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I. INTRODUCTION

The Need for a Microcomputer Lab

The computer has been recognized as a potential source for providing instructional support in an educational environment. A significant obstacle in utilizing that support has been a financial one. Beginning in 1975 with the commercial development of the microcomputer, that barrier has been reduced to manageable proportions. Since 1979, the cost of having a microcomputer has continued to decrease but, more importantly, the cost of acquiring software to run on the microcomputer has been reduced to amounts well within the budgets of many educational institutions. Combined with this is the knowledge that software is available or, if not, is presently being written and developed. If the cost is appropriate, the software is available, and a need exists to be satisfied, then it is reasonable to assume that the primary ingredients for creating a microcomputer laboratory are in place.

A microcomputer laboratory may be defined as a facility containing hardware, software, and various support materials, designed and equipped to satisfy the requirements or purposes of the intended user. When contemplating developmental strategies a logical starting point would be the identification of the needs and requirements of target users.

Once a set of specific goals capable of being accomplished by the use of microcomputers is defined, it is an easier task to analyze the benefits to be gained from using microcomputers for instructional purposes. A clear picture of how microcomputers assist the process of instruction might help to justify their cost, an important issue for educational institutions.

Planning will help determine what needs must be met. A survey of the microcomputer market will identify the quantity and quality of software which is available to meet those needs. Microcomputer hardware suitable for use with the selected software can be found. Acquiring adequate facilities to house the microcomputers and locating a good funding source will complete the process of developing a microcomputer laboratory.

Purpose of This Report

The purpose of this report is to investigate and identify elements which are important considerations in developing a microcomputer laboratory in an educational environment. The main section of the report presents the findings of the literature review. To report the results the literature review is organized into seven major areas:

1. Educational uses of microcomputers
2. Advantages of using microcomputers
3. The planning phase
4. The selection of software
5. The selection of hardware
6. Laboratory facilities
7. Laboratory costs

To illustrate the application of some of the principles suggested in the literature review, a case study of a two-year community college is presented. Appendix 1 is attached which summarizes the development work at two separate universities. Appendix 2 is attached which outlines a suggested list of guidelines in developing a microcomputer laboratory in an educational environment.

II. LITERATURE REVIEW

Major Uses of Microcomputers in Educational Instruction

The purpose of this literature review is to investigate and identify sources which would shed light on issues related to the development of a microcomputer lab in an educational environment. An important element in developing specifications for a microcomputer lab is the identification of the possible uses of microcomputers themselves. In reviewing the literature, numerous articles cited a common classification of such computer uses. Huntington (14), Meierhenry (22), and Thomas (31) serve as typical examples in attempting to formalize that classification. The scheme they constructed consists of the following instructional activities:

1. Drill and Practice - This is a tool for learning and consists of exercises related to some specific topic or procedure, such as mathematical formulas or stimulus-response activities
2. Tutorial - This is a presentation of paragraph-like material with periodic prompts and questions concerning a given text. Progress through the presentation is dependent on mastery of the various concepts presented

3. Simulations - The study of the relationship of variables effecting complex, but real-life situations, especially as they relate to experimenting with the changing of values of any given set of variables

4. Problem Solving - The study of the principles or rules of solving problems. This is done without the student having to spend lengthy sessions computing intermediate results. The entire session is spent on becoming familiar with some underlying principle, and not the algorithms necessary to utilize the principle being demonstrated

5. Programming - The actual teaching of the manipulation of the computer itself by using instructions written in a specific computer language (e.g. BASIC)

6. Word Processing - The preparation of correspondence, or the manipulation of text data for reports or essays. Included in this category is the ability to change, add or delete sections of a given text without the necessity of rewriting the material

7. Testing - This can be a far-reaching category consisting of such areas as test generation, test administration, test grading, reporting results, and summarizing results

8. Computer Literacy - Learning fundamentals of computers, computing and data processing, including familiarization with microcomputer keyboards and the various uses of microcomputers

In addition to these commonly mentioned activities, several other possible uses were proposed. Crovello (8) created a category of general use and labeled it Information Retrieval, Data Accumulation and Analysis. He claims that schools will always have the need to store information and retrieve it in various forms for analytical purposes. This same author suggests Course Review as a legitimate use, as well as Computer Aided Instruction and Computer Managed Instruction, two areas passed up as topics in most articles.

Matthews (21) considers Educational Gaming, Music Instruction, and Data Base Management as three potential areas for exploration. He explains Educational Gaming as a learning strategy whereby the player finds it necessary to continue winning (scoring correctly) in order to progress through a set of topics. Data Base Management is thought of as a special entity whose concepts should be taught, and is not just the manipulation of some particular software package.

Thomas (31) presents a case for allowing data analysis techniques, especially statistics, while employing the microcomputer outside of the statistics class. Johnson (17) argues the case of hand computations versus automated calculations within the laboratory setting, recommending that the microcomputer should replace as much of the existing lab equipment as is possible.

Sandery (27) discusses an alternative instructional activity grouping by introducing seven general headings under which all computer uses might fall:

1. Teaching about computers - This generally includes issues related to computer literacy
2. Teaching/Learning using computers - This encompasses CAI and the concept of the electronic blackboard, a device which allows the demonstration of principles by presenting computer-calculated examples that, by hand, would be prohibitively long or difficult
3. The computer as a general educational tool - This is a catch-all category which incorporates many types of supplementary uses, such as library scans, data base inquiry with graphical results replied, etc., but requires that students or users have a reasonable level of keyboard skill

4. Curriculum support activities - Scheduling, storage and retrieval of subject information, library management, or resource management in general (books, videotape, course outline, etc).
5. Administration - Applications to which the general school user does not have immediate access, such as accounting and planning software
6. Recreational computing - Electronic games of any variety
7. General information storage and retrieval - This area covers telecommunications aspects including public information storage, electronic mail and bulletin board facilities, as well as on-line "talking" to connected users

Benefits Derived From Using Microcomputers in Instruction

Numerous benefits were found to accompany the individual uses of microcomputers in educational environments. Jelden (16) claims that the student is forced to participate actively in the learning process, as opposed to passive involvement. Trump (32) asserts that students are getting more difficult to motivate with standard techniques and that the entrance of the microcomputer will strengthen motivational strategies. In addition, microcomputers will most certainly obsolete other, older "teaching machines". Trump also points out that students have always had the need to spend more time with different and improved environments for educational activities and that the microcomputer will fill this need.

Broussard (4) lists the factor of learning at convenient times (for the student) as important, while Klopping (18) emphasizes that, as a by-product, students will become skilled computer operators, will learn to program (hence will have vocational opportunities provided), and will have the opportunity to have computerized IEP's (Individualized Educational Programs) developed for them. Johnson (17) suggests that a major gain is associated with the potential for students to compare, first hand, the effectiveness of conventional versus computer based methodology.

Thomas (31) analyzes the benefits of releasing the teacher from routine tasks so that more questions from students could be addressed. This could be considered as amplifying a teacher's general effectiveness. Cohen (?) discusses the role of the microcomputer as a surrogate tutor, as well as the apparent lowering of the teacher-student ratio in the learning environment. Crovello (8) introduces the notion of students having the ability to learn at individually determined paces, thus allowing a unique individualized level of instruction. Pertinent to this process is the capability of providing a value-oriented education, where the student must choose the best solution in a situation where each choice is a compromise.

Young (35) concentrates on the individual level, stating that individual students can be monitored, can be diagnosed for specific problems, and can have repeating or reinforcing lessons developed. Furthermore, there is assistance in selecting or presenting materials for these individuals and a provision for giving the bright students more exposure to materials. Finally, Young makes the claim that previously unanswered questions concerning educational theory can be simulated and demonstrated by utilizing computer technology. On a more practical level, Crovello (8) cites the benefit of decreasing the routine jobs in education (letting the computer do it), as well as increasing general student interest in subject matter, while increasing creativity by requiring well-thought-out responses.

In the laboratory setting Engh (10) suggests that the computer will better aid the student in discerning principles of the experiment, will help students to understand the growing role of small computers in the lab, will improve upon usually inaccurate hand made transcriptions, will provide reinforcement value lost when plotting of results must wait for long calculations, will automatically check, recheck and correct spurious data, will automate tedious tasks and free students to examine results, and will eventually replace expensive lab equipment. Holmes (13) considers the microcomputer a solution to the overcrowded classroom and an enhancement of an already effective educational system.

Getting Started

It became evident during the literature review that there were tasks which could be done in the early stages of planning. These tasks were related to the planning phase and sometimes even overlapped into it. The planning phase itself was considered the most important component to the project, one requiring well-thought-out foundations. Before, or during, the planning phase there will be an opportunity to search through already existing sources for ideas relating to the final phase of implementing the plan.

Preparations for Planning

Crovello (8) suggests the following areas to consider or pursue prior to the planning stage: Look for local interested parties or groups which could be joined, formally or otherwise. Members may have gone through similar, if not identical, experiences, or at least would serve as a means of sharing problems and thoughts. Be sure to identify and involve another person (teacher or student) that can provide support or serve as a sounding board for ideas. Visit other sites which have some

actual microcomputers. The primary aim is to learn from those who have already learned. Use existing programs if possible. This means that it might become necessary to survey what is available already. Read journals and attend conferences such as NECC (National Educational Computing Conference). Make preliminary cost estimates to get a feeling for overall costs associated with at least hardware, software and maintenance. Even early in the game it is important to consider housing the microcomputers near the classroom setting. Crovello supplies reinforcement for the importance of a good planning effort by citing his own survey of 1979 which found, of the responding department heads, 48 percent claimed either a lack of teacher training (31 of the 48 percent) or a lack of equipment (17 of the 48 percent) as being the major obstacle to introducing computers into the school. When the same question was asked of the teachers, 48 percent agreed, but cited a lack of time (21 of the 48 percent) instead of a lack of training.

Bell (3) recommended another set of things to do or think about when going about the process of planning for microcomputers. First, realize that it is a cross-disciplinary effort involving many people and requiring strong ties among them. Second, faculty training is a must. Third, avoid piecemeal planning at all costs. Fourth, recognize that there is a special need for four different types of people: someone who has done it before; someone who will implement the program; someone who knows hardware, software,

and courseware; and someone from the physical plant to be in on the meetings with the administration and faculty. Bell says that if these things cannot be done, then go outside (hire a consultant) or even postpone the project.

Pollard (23) suggests five preliminary checklist items: start small - expand gradually; begin with a dedicated faculty member; hire lab assistants to monitor the microcomputers and perform routine tasks; include the training of aids or volunteers wherever you may find them; provide, at a minimum, inservice workshops. Frellman (11) argues for the need to ask for help anywhere along the line from anyone who might be capable of providing it --- if need be, hire a consultant to help define a set of needs.

Wilson (34) prioritizes eight items which represent an administrator's view of the problem:

1. Identify interested personnel
2. Start small
3. Shop and compare - there are many models
4. Assess current facilities for equipment
5. Avoid department exclusivity - don't let one department own the lab

6. Involve additional faculty soon - will aid number five above
7. Become a resource to other departments
(internal or external to the organization)
8. Set ultimate goals early and set limits

Matthews (21), concentrating on a more specific level of action, suggests that the following types of questions should be considered at an early stage: What is the system expected to do? How much money is available? Is speed important? How much memory is needed? Is long term data storage required? How will the system be maintained or repaired? Is personnel available to do programming? What operating system is needed? Will batch or time-sharing be used?

Sadowski (26) points out that the most appropriate implementation model is determined by student needs, the availability of software and hardware, the number of interested and trained personnel, and the goals and objectives determined by the advisory committee. He encourages preliminary actions which include relying on other people's experience, establishing a computer committee to share concerns and expertise, subscribing early to magazines, making contact with professional educational organizations, training teachers in evaluating software to help them define hardware needs, searching for relevant software, planning noncredit as well as credit courses for inservice

training, allocating release time for teachers, planning minisessions for more advanced training of staff, and including other interested parties in training sessions to promote widespread participation and a base of common understanding of goals and objectives.

The Role of Planning

The process of planning was seen as the most important task when considering microcomputer use in the educational environment. Lack of planning was selected as the single ingredient necessary to achieve unpredictable results.

Sadowski (26) begins the planning phase by first instituting a long-range plan. With a long-range plan, short-range goals or objectives can be clearly developed. In this case a three year plan consisted of the following four points:

1. All staff will have computer literacy training
2. All interested staff will have CAI authoring language training
3. All interested staff will have computer language training
4. All students will have computer literacy training

In addition, high priority status was given to achieving both philosophical and financial support from the board of education. The position of the administration should be one of providing necessary personnel, equipment, and materials. The appropriate staff must devote sufficient time to both planning and training, since staff needs are an important part of a needs assessment. A

survey of the interests and training needs of teachers could help to formulate an inservice training model.

Sadowski reports that, as a final step, a computer advisory committee was formed, generating the following fifteen areas of concern or need:

1. Develop overall philosophy
2. Devise a strategy for gathering information and dissemination
3. Organize inservice training of staff
4. Determine what support personnel will be needed for assisting in instruction, for technical assistance, and for inservice training of teachers
5. Establish policy or procedure for selection of software
6. Determine what sources exist for reviewing software
7. Provide for duplications of materials (diskettes, support materials)
8. Respect copyrights
9. Develop a procedure for selecting hardware
10. Initiate a policy or procedure for cataloging, processing, inventory of materials
11. Establish security measures
12. Establish insurance measures
13. Determine what the furniture needs are

14. Create a policy concerning curriculum - who will use the system
15. Address the issue of teaching programming concepts

Lecavalier (19) describes the formation of a task force of administrators and program planners to study uses of computers in education in an area covering 110 high schools and over 77,000 students. Six points were listed in developing a five year plan:

1. Specify scope of computer based education program
2. Identify facility, equipment and maintenance needs
3. Begin to outline a plan for integrating computer technology into instruction
4. Determine needs for staff development
5. Develop process for identification, evaluation, distribution and development of courseware for existing curriculum
6. Study budgetary and logistical implications

Van Dusseldorp (33) offers a model to evaluate the implementation and management of microcomputers for instruction, in the form of twelve questions:

1. Does there exist a clear purpose for using microcomputers?
2. Is that purpose known to teachers and administrators?

3. Is the microcomputer an integral part of the curriculum?
4. Is someone in charge of implementation and management?
5. Does there exist enough money for non-hardware costs?
6. Are the microcomputers of the same type in anticipating cost, maintenance, education, portability factors?
7. Will the microcomputer be located in the proper place?
8. Is the actual use going to be the same as the planned use?
9. Is inservice training available for both teachers and administrators?
10. Is maintenance provided for?
11. Is there software available for teachers?
12. Is software also in readily available and usable form?

Sources Which Can Provide Help

In getting started, possibly even before a needs assessment is performed, there is time to consider the experiences and views of others who have previously acquired microcomputer equipment. In fact, the beginning is often a period when time voids are created, as committees have to be formed and time consuming contacts have to be made. It is appropriate, then, to use this period of relative inactivity to investigate sources which might aid in defining any of those tasks, from planning through the actual purchase of equipment.

Almost every article made some mention of how, or where, to look for help in the early stages. The following sources are representative of the general consensus:

- 1) Local universities or colleges
- 2) Newspapers
- 3) Computer journals
- 4) Educational journals
- 5) Futurist journals
- 6) Major journals
- 7) Libraries
- 8) Direct mail catalogs
- 9) User groups

- 10) Software directories
- 11) Microcomputer vendors
- 12) Professional organizations
- 13) Publications
- 14) Microcomputer resource directories
- 15) Associations

Caravella (5) suggests looking in any of the major periodicals, such as Time or Newsweek, where regularly featured articles dealing with microcomputers may be found. Libraries will carry a significant number of issues of popular periodicals like Popular Computing, where advertisements and reader-response cards may be viewed. Libraries also will have available local newspapers and national newspapers, such as the New York Times.

Popular computer magazines and educational journals will assist by providing current thoughts and experiences of other people who have already been through the different stages of development. The most frequently cited magazines and journals include:

BYTE	Computers and Education
Calculators/Computers	The Computing Teacher
Creative Computing	Educational Technology
Personal Computing	Classroom Computer News
Popular Computing	Data Training
Interface Age	80 Microcomputing

Infoworld	Kilobaud Computing
Soft Side	Electronic Learning
Electronic Education	Perspectives in Computing
Computer Education	Educational Computer
Kilobaud	Apple Peelings II
Technological Horizons in Education (THE)	
Association for Educational Data Systems Journal	
Association for Educational Data Systems Monitor	
Journal of Computer Based Instruction	
Journal of Educational Technology Systems	
Programmed Learning and Educational Technology	
Chronicle of Higher Education	

Three other magazine and journal sources are: 1) SIGCUE - Special Interest Group Computer Users in Education and SIGCSE - Special Interest Group Computer Science in Education --- both journals are published by special interest groups belonging to the national computer science organization called Association of Computing Machinery (ACM) --- to order either journal requires both ACM and local membership 2) Futurist magazines such as Omni and The Futurist and 3) Magazines which are published by the individual vendors, such as PC World from IBM and Hardcopy from DEC.

Three examples of a microcomputer resource directory are 1983 Classroom Computer News Directory of Educational Computing Resources, Educator's Handbook and Software Directory, and Instructor's 1982-1983 Directory for Schools. Markline and The

Sharper Image are two catalogs which include new products regularly. Local and national professional organizations like ACM, and local computer users groups will provide shared information sources, while EDUCOM requires annual fees for allowing access to a membership sharing network composed of ideas and software. The Computerist's Directory in Forestville, CA, supports what it calls a people network.

Some miscellaneous sources involving associations and organizations include ADCIS (Association for the Development of Computer-Based Systems), AEDS (Association for Educational Data Systems), HRO (Human Resources Organization), MEAN (Microcomputer Education Application Network, and MECC (Minnesota Educational Computing Consortium). Educational software evaluations may be obtained from EPIE (Educational Products Information Exchange), CONDUIT which is located at the University of Iowa, The Journal of Courseware Review, Apple Feelings II, as well as, from local ACM user groups. Not to be overlooked are the individual vendors themselves. Invaluable information may be obtained from them when looking for specific hardware or software products.

Considerations for Selecting Software

Specific citings recommending specific software items were not encountered during this literature review. Occasional mention of packages such as Visicalc were done not to recommend them as software, but more to demonstrate the type of category one could employ in a classification scheme. Abundant references were found which stressed the idea that individual needs assessment was the highest priority during the search for relevant software. Closely related to this was the concept that an orderly approach to software evaluation was essential in obtaining usable products. Although a few mentioned that it was necessary to ensure that the desired software could run on the hardware, the majority of articles encouraged the identification of desired software as a prerequisite to hardware requisition. Throughout this review "software," "courseware" and "CAI" (Computer Aided Instruction) were terms that, at times, were used interchangeably.

Establish Need Factor and Evaluation Strategy

Selden (29) discusses how to avoid the headaches of CAI by drawing attention to the need for long term planning. Considering the complex nature of instructional computing and the long term effects of making mistakes, the call for organized long term planning is a must. Top priority must be given to forming an environment in which all decisions will have a predictable impact and will result in a common direction toward a common goal.

Schwartz (28) presents the argument of evaluating software prior to surveying hardware. If a piece of software seems appropriate, then get a sample printout of an actual run. Jelden (16), although recommending that software will, to a large degree, be defined by the type of hardware that exists, points out that portability is a critical consideration. If there is a need to use software on different brands of microcomputers, then lack of portability will force extensive revisions of programs, will make copying of disks a problem, and will create difficulty in adding boards for software which uses varying amounts of storage.

Castle (6) presents a picture of uncertainty in discussing the software scene. He describes the market as being deluged with new programs, while constantly expanding at the same time. There are several questions, however, that might be useful to ask: 1) Will the software work on my hardware? --- in particular, the language it was written in and its particular dialect. 2) Is it possible to get a program from the manufacturer which can be copied? --- this applies primarily to those with hard disks 3) For any given software piece, does there exist a cheaper supplier? 4) Is it possible to preview specified software at the store, to obtain a thirty day trial, or to serve as a test site for the software? 5) In regard to content and structure: how is the reading level? Are the lessons in black and white, or color? Is the resolution high or low? Is the action sufficient to keep one's attention? 6) Is a community college nearby where student programmers can be recruited? 7) Do there exist any local computer clubs that have free software available?

LeCavalier (19) notes the need for establishing direction for in-house programming as well as purchased software packages. She has constructed a software evaluation form whose purpose is to identify and classify packaged software into one of the following categories: 1) Appropriate software which interfaces well with the curriculum 2) Valuable but needs some modification and 3) Inappropriate.

Doyle (9) supplies a checklist of pertinent items when looking for software: 1) How do published reviews rate the software? 2) Is software documentation available? 3) Are support materials sufficient? 4) Can the software be copied after purchase for further use in the school? 5) Is the software reliable? 6) Is the cost of the software reasonable?

Software, Courseware, and Problems

Cohen (7) defines courseware as instructional software, hence relegating it to a subset of software --- a type of software that is appropriate only within the confines of the classroom. In other articles the two terms are used interchangeably in writing about programs that would be useful in an educational setting. The term courseware seems to be used more frequently by those who are specifically addressing theoretical points of computer aided instruction, and not by those discussing specific packages relating to the presentation of that material.

Schwartz (28) lists a set of qualities that courseware should have: 1) Does the program respect human rights (has a polite tone/easily maneuvered in and out of the session as well as navigating throughout it)? 2) Does it respect and promote originality and individuality? 3) Is the program easy to use? 4) Is the program integrated in an education setting to support the essential social character of human learning and motivation? 5) Is the student involved in evaluating and modifying the program? Jelden (16) lists an additional sixteen qualities of good courseware including such things as the pace being set by the student, liberal use of graphics and the reduction of the length of the presentations prior to eliciting a response from the student.

Jelden (16) also indicates some areas for consideration when beginning preparation. He reinforces the notion that it is important to have a definite instructional model and backing plan when considering writing in-house courseware. When approaching this area, it is not necessary to purchase high cost audio-visual systems. Be prepared to spend as much time on computer prepared lessons as is required for traditional methods, such as films, videos or slides. Be certain that someone is dealing with the physical and psychological factors, such as reading levels, or being "psyched out" by the system.

Dean (3) describes some problems in choosing software. They include 1) Large numbers of software houses 2) Much of the existing software doesn't fit the needs of the teachers 3) Lack of preview arrangements 4) No language exists that is suitable jointly for teachers and CAI, and 5) Some software may only be effective for those who have bought sound or color features.

Roblye (25) explains why teachers write their own courseware and then he presents a case against doing so. According to a 1979 survey there are three reasons why teachers write courseware: 1) They are trying to fill expectations 2) They are saving money (on courseware) and 3) They are filling what they perceive to be a gap in software. The case against writing personal courseware consists of two points: First is the quality issue. Without a tremendous outlay of time investment, teachers will not meet the

high standards of technical and instructional quality. As an example, few provide permanent data collection; error trappings are inadequate; programs are short and limited in scope; and individuals cannot hope to compete with well-funded professional organizations. Secondly, Roblye is afraid that if teachers attempt to do this on a national level, there will be volumes of duplicated efforts and information.

C.A.I. - Goals and Problems

The term CAI was used in two basic ways. One use referred to it in terms of it being something made out of software, or consisted solely of software. The other use of the term was more general in nature, incorporating both software and hardware components. The recommendations for CAI as a potential use for microcomputers included some guidelines for selecting CAI-related offerings as well as a list of problems that might be encountered.

Broussard (4) provides a list of qualities to look for, in either designing or choosing a CAI system:

1. The system should be easy to use by nontechnical instructors
2. The system should be easy to use by students
3. The system should have extensive self-monitoring facilities (including student and session statistics)
4. The course must be easily modifiable by the instructor
5. The CAI package should be one whose programs and courseware are easily transportable from one computer system to another

Holmes (12) supplies a set of items which supports the use of CAI in education (some of these are identical to those listed as benefits of using microcomputers): 1) Individual learning 2) Two-way interaction 3) Increased student-teacher interaction 4) Aid in remediating lessons 5) Potential student performance improvement 6) Improvement of student motivation 7) Obtainment of feedback on performance and 8) Release burdens of teaching routine tasks.

Holmes, in the same article, lays out a set of problems that must be given consideration: 1) Cost should be carefully evaluated, as well as issues of cost effectiveness 2) Routine maintenance 3) Regular or periodic replacement of equipment 4) Eventual replacement of entire system 5) The courseware options of pre-packaged, templated, or in-house developed programs 6) Don't plan on sharing any hardware with administration 7) Choose hardware only after deciding upon the software 8) Leave open the option of obtaining multiple brand computers 9) Be warned that resistance to change will be a major obstacle 10) Prepare for simultaneous support from three groups: administrators, teachers and students.

Considerations for Selecting Hardware

Closely aligned with the idea that planning is essential in determining what software will be used is the idea that hardware specifications must be integrated and matched with software specifications. Once the software specifications are well defined, then selection of the microcomputer vendor(s) becomes an orderly process. By avoiding some common mistaken notions, the specific equipment choices will more adequately satisfy the needs.

Establish Need Factors

It is not enough to establish a needs assessment for software. Once it has been decided which software will be used, it is then necessary to ensure that available equipment exists to service that need.

Auten (2) summarizes some research efforts of the past by stating, simply, that it is necessary to first define needs. Sandery (27) asserts that hardware should be considered as a consumable, and software and expertise in the classroom should be considered as capital investment --- thus slanting the philosophy behind the needs assessment. Schwartz (28) insists on locating pertinent software first, then gathering its technical

specifications, and finally purchasing the hardware which will run the chosen software.

Thomas (31) conceives a three point approach in the sequence leading up to hardware acquisition. First, the key to an effective needs assessment is the recognition of having to do a careful analysis of the instructional problem. Second, there must be a determination of the instructional requirements. Third, it is necessary to create specifications of the required computing capability which should be followed by a survey of the market, in order to locate the proper equipment. Castle (6) proposes that once the need is identified, and long before the equipment is purchased, a check should be made to insure that there is adequate software available, both written in the appropriate language and capable of satisfying those identified needs.

Choosing a Vendor

Within the educational arena, there are a limited number of brand name microcomputers commonly used. Apple, Atari, Commodore, Ohio Scientific, and Radio Shack were the popular choices for instructional computing on the microcomputer level. Three potential vendors (DEC, IBM and Texas Instruments) have apparently not established a sufficiently solid software base to attract attention in the current literature. In considering the different vendors, the deciding factor of all those reviewed was the availability of usable software. Beyond that, there were ideas about what to look for in choosing equipment.

Jelden (16) advised the purchaser to look for plug-in capability, such as memory expansion, vector-interrupt boards and standardized disk drives to enable interchangeability of floppy disks. He recommended CPM/MPM due to its purported machine independent features. In addition, terminals should be RS232C compatible with both a "clear," and a "home," cursor control buttons. Should different vendors be chosen, ensure that all CRTs have identical ASCII patterns. Be certain that the manufacturer is willing to give technical information associated with the hardware and be absolutely certain that the vendor has a reputation for being good and reliable. If the proposed

configuration is a time-sharing system, split among 4 users (as is Jeldens), then 64k is the minimum required memory. Finally, if program development is likely, the purchase of a hard disk is recommended, considering that a floppy disk's life is around 5000 hours of use.

Bell (3) suggests that the final selection of equipment should be made jointly by the instructors who will use them and local people who know hardware and software. Bell lists twenty seven key questions which should be considered when looking at different microcomputer brands:

1. Does it have a standard keyboard?
2. Is the screen easy to read?
3. How many graphics and text characters per screen line and how many lines?
4. How are the graphics?
5. What are its disk and internal memory capabilities?
6. Does it have sound and color?
7. Can it do word processing?
8. What are the add ons and what do they cost?
9. Does it have standard BASIC?
10. What special BASIC functions does it have?
11. Are other programming languages available?
12. Is courseware available?
13. How portable is it?
14. What start up support is available?

15. How and where is service available?
16. How much is a service contract?
17. What are the warranty terms?
18. Are cables, connectors, etc. included?
19. What is the quality of the manuals?
20. When will it be delivered?
21. Who can be called for help and advice?
22. What is the educational discount?
23. What are its special strengths?
24. What are its quirks?
25. Can the microcomputers be networked?
26. Can you talk to someone who is using these machines?
27. Is this really the microcomputer for your needs?

Bell concludes his article by suggesting that a printer is a must purchase, and that disks are necessary for anyone who will be doing "serious" work.

Johnson (17) describes an ideal system setup, used to introduce undergraduates to computer-based data acquisition. It must be readily interfaced to existing lab instruments, programmable in a familiar language, capable of allowing software control of data reduction and display techniques, capable of storing data, portable, inexpensive, reliable, and able to withstand the rigors of use in chemistry labs.

Frillmann (11) solicits the interested to research hardware capabilities and suitability for ones specific needs. Drawing upon information supplied in an AEDS Special Report of 1979, important items associated with instruction include: ease of use, documentaion, memory size, storage, character set, display graphics, color, programming languages and ease of connecting a good selection of peripherals. Highlighted are service options, capability for upgrading, portability, educational software availability, and the matching of hardware and educational purposes.

Thomas (31) suggests that at least one disk should be used for floppy disk backups. The minimum graphics resolution should be 128 by 128 addressable points. The length of your warranty should be ascertained. In developing an instructional requirements matrix, he found that of the eleven major instructional uses, nine of them required the capability of interaction and hardcopy; six of them required large data sources or large amounts of text were required, while three of the nine required lower case, specific languages, and statistics programs.

Matthews (21) deals on a more technical level in presenting what he considers the minimum system for a classroom. It must have: a high speed processor; a power supply to support al least five more boards; sophisticated operating system with editor and BASIC(8-12K); 16K incremental memory; memory expansion to 64K; S100 bus structure for ease of system expansion; standard

keyboard and video; and CP/M as an operating system due to its national usage. Matthews added nineteen more characteristics in attempting to define the ideal system. Included in this list are such items as memory mapped and managed boards, one-half megabyte memory or more, sixteen bit processors, high speed printing such as DECwriter III, a daisy wheel printer, and phone answering modems (costs seemed to have no practical consideration in this ideal system).

Ricketts (24) establishes guidelines in the area of documentation. He notes that manuals generally seem to serve the experienced rather than the naive. There seems to be incomplete information in several areas of documentation. Missing, but crucial to the understanding of even the simplest of concepts, are indexes, maintenance or troubleshooting sections, glossaries, listings of relevant source code and annotated bibliographies. Ricketts constructs a documentation checklist, dividing it into three major headings (general, hardware and software):

General Documentation

- 1) Statement of intended audience
- 2) Clear table of contents
- 3) Quick reference sections
- 4) Clear illustrations and examples
- 5) Tables or charts where needed
- 6) Readable text and format

- 7) Glossary of all terms, commands, and statements
- 8) Bibliography to include related materials,
references to other documentation or places to get help
- 9) Terms defined on first appearance
- 10) Complete index, including key words
- 11) List of prices and specifications - list of vendors
- 12) Durable binding, manual should lie flat when open

Hardware Documentation

- 1) Clear maintenance directions, with illustrations and
troubleshooting guide
- 2) Clear sections on interface options and how to proceed
- 3) Clear schematics

Software Documentation

- 1) Description of programming language with at least one
example for each feature
- 2) Programming techniques that take advantage of the
language capabilities
- 3) Listings of source code
- 4) Lists of PEEK and POKE addresses
- 5) Exercises and question with answers, if appropriate
- 6) Descriptions of programs available on tape or disk,
including prices and sources.

In addition, Ricketts presents a short comparison on six different brands, consisting of Apple, CompuColor, Heathkit, Pet, Sorcerer, and TRS80. The Apple scores highest, but each of the other types has its own individual merit, depending on the ultimate use of the equipment.

Huntington (14) reviews the characteristics of printers and summarizes his results. Thermal printers have costly paper requirements. Good printers, in general, have speed, quality print, good line lengths, graphics capability, and adapt easily to various micros. The most flexible are dot matrix, but have lower quality print. The daisy wheel or impact printers are slow with no graphics, but are high quality printers. The recommended educational use is the dot (7 by 9 or 9 by n) matrix due to its low cost, flexibility and ease of use.

Huntington (15) proposes a microcomputer system recommended for university teaching, one permitting drill and practice, tutoring, test administration, and computer managed instruction (CMI), as follows:

1. A processor with 32K memory (minimum)
2. Keyboard approximating the standard IBM Selectric
3. Diskette storage
4. A printer
5. An extended version of BASIC

Mistaken Notions

Bell (3) discusses four common misconceptions that people have when searching for microcomputers. The first is "Buy it where it's cheapest." What this does is to ignore valuable sources of help, such as vendor assistance in setting up hardware, assistance with training, and, possibly, fast and reliable service. Buying the cheapest also may mean having to buy components from other manufacturers, which may mean having to deal with more than one repair or service shop. The second is "Get all the options." If sound and color are not an important part of the curriculum needs, don't buy what is not needed. This could be costly as well as a possible distraction to the user. The third is "Buy bottom of the line systems." Four thousand bytes of storage is not enough for anything in instructional computing. Buy enough memory to run your software on. The fourth is "Too much of the same." If your needs happen to be quite diverse, don't buy all identical models of the same brand. It is possible that if you have 5 different and separate needs, 5 different microcomputers might better satisfy your requirements.

Bell also warns against the two for one deal where you might purchase two business oriented computers when you needed educational types. Be aware, also, he says, of the possibility that you might have 12 brand X computers with great color

graphics, but somehow have purchased black and white monitors.

Frillmann (11) adds to the list of warnings by indicating that its not just an issue of money --- that is, don't buy based on money all by itself. Just because it's cheap doesn't make it the right purchase, nor on the other hand, does the highest priced item guarantee that it is the best purchase. Thomas (31) supplies a warning to not assume that microcomputers can do the same things as minicomputers or main frames, nor should the use of a microcomputer be extended to applications beyond those initially intended by the designers.

Specific Choices and Rationale

Castle (6) chose the Apple II with 48K. Key rationale included its performance, dependability, high resolution graphics and the availability of color. A 10MB (megabyte) Corvus hard disk was obtained because it was the fastest external media available and was more practical for lab "reuse" --- practical in the sense that: 1) it would have cost \$5000 per Apple for each pair of floppy drives; 2) they would have had more wear and tear; and 3) the speed of the hard disk held the students attention longer. Even with the hard disk which was equivalent to sixty-seven separate disk drives, there was the need to maintain two floppy drives for "loading" purchased software, for backing up important files from the hard disk, and for software products that were restricted from being loaded onto the hard disk. Two printers were bought --- one, an EPSON MX-80 was used strictly for reports, word processing and straight listings of student programs; the second, an Apple Graphics Tablet, was used for development work with color graphics, and was not considered essential for the lab. Some of the miscellaneous products included: one Apple Integer card per Apple (he recommends the more versatile Applesoft language card); one Corvus interface card per Apple; one Softape light pen; one set of Apple game paddles; one Amdek Color-I thirteen inch monitor; one Apple Pascal language card; and one clock card.

Klopping (19) chose the Apple II based on its having low resolution graphics with sixteen columns and the dual disk configuration. LeCavelier (19) discusses the purchase of 140 Apples for a school district in Colorado, citing its hardware integrity, special features (especially graphics), and the good software available. Alty (1) decided upon the Commodore Pet due to the following reasons: 1) good cost 2) it was desktop 3) it had a plastic case and 4) it was a complete system --- criteria that almost any microcomputer could meet. Alty chose tape cassettes over disk drives solely because no one on the staff was threatened by their simple use and installation!

Sircar (30) developed a microcomputer lab consisting of fifteen TRS-80 Model I processors with 32K, one disk drive per station, one Integral Data Systems 400 Impact Printer (ninety-two ops dot matrix), one TRS Model I Impact Printer (fifty ops dot matrix), and an extra disk drive (making two floppy drives at a single station). The lab is used for a Business Data Processing course in the College of Business Administration and services two thousand students a year (eight hundred maximum a semester) and is open seventy hours a week for student use. This introductory course requires the completion of four assignments per student each semester.

Sircar selected the equipment based upon its low cost and popularity (over one-half of those sold were sold to professionals

and businesses). Reliablity, maintenance concerns and number of personnel needed to run the lab were other factors influencing this decision. Problems which were encountered include weekly downtime on disk drives, four week repair periods on the out-of-town brands, and non-support on other out-of-town brands. Other problem areas involved having under-estimated the number of terminals required and having to write in-house software to facilitate the use of the printers which were purchased.

Johnson (17) uses a Commodore PET 2001 processor with 8K RAM and 14K ROM. This was chosen because it could be interfaced with lab instruments. After its purchase, the low resolution needed to be increased from the 25 by 40 resolution, to 200 by 300 which, in turn, made the additional acquisition of 24K necessary --- 32K memory is now the recommended size. Problems have generally been in the area of having to do all of the software programming in-house.

Facilities

Lopez (20) makes the only reference to the physical layout of a microcomputer laboratory. He suggests cubicles of four feet by four feet, with an L-shaped counter. This will provide space for the microcomputer, books, supplies, and a workarea. Other points of advice include: 1) Place the power switch in a position where it is not accidentally reachable 2) Use a swivel chair for easy movement around the cubicle 3) Use a single power switch to control all devices in the cubicle 4) Put all the microcomputers (2-3 amps each) on an independent thirty amp line to avoid power spikes created by other appliances from other parts of the building 5) Air conditioning requirements will vary depending on the size of the room and the number of people that will be in it and 6) If programming will be taught, remember that a social environment requires adequate space for interaction between students and between teacher and students.

Bell (3) advises locating equipment in a secure area, one reserved exclusively for computer activities, out of any traffic area and capable of having adequate supervision. Castle (6) uses eleven microcomputers for 350 students and describes the duties of the single lab manager as being: 1) Equipment selection 2) Security considerations (locking micros to the table top, etc) 3) Class laboratory scheduling 4) Equipment upkeep 5) Program

modifications and 6) Software selection. Sircar (30) located the Microlab in a single room in the building housing the College of Business Administration. It is managed by a faculty member whose primary duties include staffing, maintenance and operation of the lab. The staff is composed of three graduate assistants and three work-study students. The lab is open seventy hours a week, Monday thru Saturday.

Costs

Cost factors are hard to determine given the variety of things which may influence them, such as inflation, price differences between similar machines, and price differences between various models within a single vendor. Jelden (16) quotes a \$10,000 price tag on four Altair 8800, two floppy disk drives, and a single printer. Bell (3) itemizes several things relevant to equipment purchases. Thirty five percent of the original purchase price will be spent on such things as service contracts, paper, ribbon, dust covers, stands, tables, cords, switch boxes, floppy disks, cassette tapes and electrical work. He warns of the need to plan for locks and bolts, lab manager and assistant pay, and magazine subscriptions. Another potential source includes consultant fees of \$2000 for teaching teachers how to use the equipment (twenty to thirty teachers at \$300 a group). Color monitors, expansion budget allowance, eventual upgrading, and paying teachers to learn about microcomputers are all possible expenditures. For every \$20,000 of equipment purchased, Bell recommends an additional \$10,000 be allocated for security, electrical work and minimum furnishing; \$10,000 be allocated for personnel; \$5,000 be allocated for supplies, upgrading equipment, service contracts, and courseware --- this all is assuming that space and overhead has been accounted for.

Castle (6) spent \$32,000 for 11 Apples, a 10MB Corvus hard disk, 2 floppy drives, and 2 printers. Klopping (18) mentions the need to budget for a full time programmer and a CAI coordinator. Brumbaugh illustrates a sample school district budget as follows:

1.	1 fulltime and 6 parttime	=\$46,000
2.	Rent and equipment repair	=\$ 7,000
3.	Printing	=\$ 1,000
4.	Consultants	=\$ 3,000
5.	Postage and telephone	=\$ 700
6.	Travel	=\$ 5,000
7.	Memberships and tuition	=\$ 500
8.	Supplies	=\$ 1,300
9.	Software	=\$10,000
10.	Equipment and furniture	=\$76,000
	TOTAL	=\$150,500

Sircar (30) divides his costs into two parts. The first is the initial investment consisting of fifteen Radio Shack Model I microcomputers (\$1200 each), two printers (\$750 each), and six floppy disk drives (\$450 each) for a total of \$26,700. The second part is operating expenses, and consists of personnel costs (\$19,800), maintenance (\$2,200), and supplies (\$600) for a total of \$22,600. Sircar is planning on a four year life from the equipment and an annual depreciation cost of \$6,675.

III. CASE STUDY

Maple Woods Community College

This is a case study of Maple Woods Community College, a small two-year institution in Kansas City, Missouri, which planned and implemented a microcomputer laboratory in 1982. The purpose of this case study is to provide a specific example which might serve to illustrate the steps involved in developing a microcomputer lab.

Background

In the summer of 1981, Maple Woods was notified of the possibility of obtaining state funding for the purchase of computer equipment. Since this was money which required local matching funds, the district, of which Maple Woods is a part offered to provide the necessary support. The administration notified the data processing department which, at the time, consisted of a single full-time faculty member who also served as the department chairman.

The data processing department had recently upgraded to an IBM 4331 mainframe, but no interactive facility was implemented for instructional purposes. Therefore, no practical knowledge

could be gained from the experiences with its batch processing style. The department chairman was going through his first semester as a full-time teacher when he was notified of the availability of the state funds. Part of the reason that he was hired by the college was to institute a program with a microcomputer component. The department had been teaching a BASIC programming language course for three semesters, using a full-time faculty member from the psychology department. The equipment that was used for the course belonged to the Physics department and consisted of ten TRS-80 Model I microcomputers, each with its own tape cassette, and four line printers.

Planning

The planning effort began with the full support of the school's administration. The administration was interested in supporting any approach which would take advantage of the state's matching funds and would bring the use of microcomputers to its school. The data processing department chairman set three long-range goals:

- 1) Provide instruction in the computer languages BASIC and Pascal
- 2) Provide instruction in the business and science areas and
- 3) Incorporate microcomputers as an integral part of the introductory data processing course, a required course for a two-year degree

The primary impetus for planning was the availability of state matching funds. The funds were to be approved and the equipment purchased by January 1982, in time for the beginning of the spring semester. In addition, there was evidence that more matching funds would be available in the summer of 1982. Therefore, the planning phase was divided into two separate steps. Step one consisted of establishing a laboratory to be used for two BASIC courses and six introductory courses by January 1982. Step two consisted of adding to the laboratory, by January 1983, any items necessary to teach Pascal and other designated topics in the business and science curriculum. The ultimate benefit in using

this strategy was threefold. First, the project began on a small scale where the tasks were reduced to manageable proportions. Second, things which were learned in step one could be applied to step two development. Third, an additional year allowed for a wider range of software and hardware products from which to choose.

Software Selection

The instruction of BASIC in the programming language classes and the introductory classes were the first needs to be satisfied. Choosing which BASIC language to use was not an isolated decision. Other factors which would influence this decision included the type of operating system under which the BASIC language would run and the extent and availability of additional software which was scheduled to be purchased the second year. The department chairman had been working independently in the field of microcomputers for the past five years. This experience provided him with a good working knowledge of microcomputers and allowed him to maintain contact with the sales force of several local microcomputer retail outlets. In addition, he kept current with new software and hardware developments by subscribing to BYTE, Infoworld, and Creative Computing magazines.

Even though choosing software was the first priority, the identification of a subset of vendors for that selection was performed first. Experience had dictated that long term purchases (five to ten years) required dealing only with established companies. Apple, IBM, and Radio Shack were top selling microcomputers with reliable and strong reputations. Radio Shack was eliminated from contention, however, based on the prior experience with the ten TRS-80 Model I microcomputers. Two

fundamental problems had been encountered. First, Radio Shack had designed their computers to use only other Radio Shack components and hence had no plug compatibility. Any upgrading of this equipment would restrict purchases to Radio Shack products. Second, the Model I's were no longer being manufactured and hence were obsolete.

IBM was eliminated from consideration due to its recent entry into the microcomputer market. Based upon much of the literature coming out at the time, it was thought that IBM's version of BASIC, as well as its operating system, would undergo modifications during the first year or two. This combined with the fact that there was very little software available prevented it from being a final candidate for step one planning. By the second year IBM would make substantial gains and would be reconsidered. The final choice then was limited to the Apple company. As it turned out, Apple also had the largest and best software from which to choose. Therefore, Apple was selected as the microcomputer to be used in the programming classes. The Radio Shack computers were to be only used for the introductory courses, thus reducing the need for replacement computers.

Apple Integer BASIC and Applesoft (with floating point capacity) were the two BASIC interpreters used for instruction in the programming language classes. No other versions of BASIC were reviewed since both of these came free with the Apple II Plus microcomputer and satisfied the requirements of flexibility and

ease of use. Omninet was chosen as the networking software package to interface the Apples to the hard disk that was being considered. Omninet was chosen because it provided a level of independence from having to use a particular microcomputer brand. It could interface different brands of microcomputers to the disk including Apple, IBM, and Zenith. It allowed multiple CPU's to be attached to the disk, multiple operating systems, and up to a maximum of sixty four users simultaneously. It seemed ideal for use on the small campus, since any of the microcomputers could be physically located up to four thousand feet away from the disk. Mirror was the software package purchased to do automatic and rapid copying of the files on disk onto the video disk. This was a one command restoration system which would back up the entire disk without the inconvenience of using several floppy diskettes.

By the next year it appeared that the CP/M operating system from Digital Research would closely approximate an industry standard for microcomputers. The instructor who had been teaching BASIC wanted to start using CP/M which meant that CP/M's MBASIC would be taught instead of Apple's Applesoft. CPUNET was the only other networking software package available to interface the Apples to the hard disk, and the only one which would allow CP/M to be run from the Apples. Unfortunately, CPUNET was a recent product and was loaded with software bugs. This fact combined with the inability to get service from the-out-of state provider forced the discontinuance of using CPUNET. Fortunately, Omninet announced their version of networking which supported CP/M on the

Apples and it was purchased.

Other software selections included the following:

- 1) Apple Pascal compiler/operating system - an Apple could connect to Omninet with either CP/M or Pascal O.S.
- 2) Constellation - a data management system for files accessed by Omninet (free with Omninet)
- 3) CP/M - one per Apple (free with Z80 boards)
- 4) Wordstar - a wordprocessor for faculty development work
- 5) Visicalc - spreadsheet program to be used with business courses
- 6) COBOL compiler - because it cost only \$30
- 7) Ada compiler - to develop an ADA programming course
- 8) DB Master - to develop a Data Base course using relational data base concepts
- 9) Personal Filing System - data entry/formatting and report producing package to be used for business courses

Hardware Selection

Apple microcomputers were the original choice based on the fact that Apple's available software far exceeded any other vendor's supply. This was supplemented by Apple's strong and reliable reputation. Ten Apple II Plus microcomputers with 64K were purchased. This involved buying ten 16K expansion boards to upgrade the standard 48K versions. The department was interested in getting the best available so that any future use of the microcomputers would not be limited. It was known that many software packages required a minimum of 32K, while some required in excess of that. Each Apple was equipped with one 80-column card board to convert the standard 40-column screen to a width more appropriate for programming tasks. One Integral Data Systems dot matrix printer was purchased and connected to a single Apple, with future plans to locate software which could spool from a hard disk. Two floppy drives were obtained to download certain student files as well as upload purchased software. Two drives were chosen over one strictly for the convenience of manipulating two files simultaneously. A hard disk was decided upon due to its cost, durability compared to floppies or cassettes, and ease of use on a classroom basis. A single Corvus hard disk could store the equivalent of seventy pairs of floppy drives at a cost savings of \$65,000 (\$6,000 vs \$1,000 per pair). The Corvus disk was chosen because it was the only one which could run the Omninet

networking software. The twenty megabyte model was selected to allow for future growth.

Second year additions included ten Apple II E's which came standard with 64K memory, ten Z80 boards containing CP/M logic, ten transporter cards required for interfacing CP/M to Omninet on the Corvus disk, twenty combination power supplies and fans, and another Integral Data System's dot matrix printer. The printer is used mainly for faculty curriculum development work, while the fans provide a single power switch for multiple components being plugged into a single Apple. An additional twenty megabyte Corvus was purchased to serve as backup in case one hard disk required repair and to reduce the number of disk users on any one disk. Future plans are to trade ten Apples to the business department when they get their ten IBM PC's. The business department then will use the data processing department's lab, with established (Apple) systems, while the data processing department becomes familiar with the PC's, including interfacing them with the school's IBM mainframe.

Facilities

There are two rooms which are used for the laboratory. A twenty by thirty foot room is used for the ten TRS-80's and seems to have adequate space. Each microcomputer is on a separate six foot table facing a wall. The tables are arranged in a u-shape around the long end of the room. On the opposite end of the room is a blackboard which is useful for instructional purposes. Every other table has a Radio Shack line printer so when the student is ready to get a listing, the printer is nearby. This room has exterior windows which have been broken into and are the main reason that the Apples are in the other, smaller room. There is insurance for such losses, a seeming necessity for an open lab. The microcomputers are not bolted down to the table tops primarily because they are frequently moved for a variety of reasons. The table tops are twenty-eight inches from the floor in order to get the monitors at eye level, or slightly below (as if a typist were looking down at the typewriter paper). The chairs all have casters for ease of movement. In sending out bids on the furniture it was necessary to specify exact requirements. Since the bids are awarded to the lowest bidder, the exact measurements and specifications are the only guarantee that furniture needs will be satisfied.

The second room is twenty-five feet by twenty-five feet and contains the twenty Apples. Each wall has four six foot tables against it, three of which hold a single Apple each, while the fourth holds two. In addition, one of the sixteen tables holds a printer and two floppy disk drives. All of the Apples are wired to the two Corvus hard disks which are located across the hall in the laboratory room used by the mainframe. This is a location safe from students and climate. Twisted pair wire is carefully strung through the ceiling away from florescent fixtures which will create interference on the wires.

Lab assistants are available during the seventy hours the lab is open during the week, but are also responsible for taking care of the lab used with the mainframe computer. The assistants are all data processing students who also are on the student financial aid program called "Work Study." When purchasing new software or hardware, the documentation which accompanies it usually requires some amount of technical expertise to install it. Although the lab assistants do not have sufficient knowledge, a trial and error process, guided by an instructor, will get the job done. Any knowledge of the use of a soldering iron, basic electricity or electronics, or experience with operating systems is a helpful aid with installation or maintenance of equipment.

Cost

		# OF	
RADIO SHACK EQUIPMENT	PRICE	UNITS	TOTAL COST
TRS-80 Microcomputer Model I	\$ 900	10	\$ 9,000
Tape cassettes	\$ 60	10	\$ 600
Line printers	\$ 600	4	\$ 2,400
TOTAL			\$ 12,000

APPLE EQUIPMENT - YEAR ONE

Apple II Plus with 48K	\$1,000	10	\$ 10,000
16K Memory expansion.....	\$ 100	10	\$ 1,000
80-Column cards.....	\$ 250	10	\$ 2,500
Disk drive for floppy disk.....	\$ 375	2	\$ 750
Interface card for disk drive.....	\$ 150	1	\$ 150
IDS 560 Printer.....	\$ 760	1	\$ 760
Interface card for printer.....	\$ 140	1	\$ 140
Corvus hard disk.....	\$5,600	1	\$ 5,600
TOTAL.....			\$ 20,900

APPLE EQUIPMENT -YEAR TWO

Apple II E with 64K.....	\$1,000	10	\$ 10,000
Z80 Cards.....	\$ 150	20	\$ 3,000
80 Column cards.....	\$ 250	10	\$ 2,500
IDS Printer.....	\$ 760	1	\$ 760
Interface card for printer.....	\$ 140	1	\$ 140
Corvus hard disk.....	\$4,200	1	\$ 4,200
Transporter cards for Omninet.....	\$ 370	20	\$ 7,400
TOTAL			\$ 28,000

SOFTWARE	PRICE UNITS	TOTAL COST
Apple Integer BASIC.....	INCLUDED	
Applesoft BASIC.....	INCLUDED	
Apple Pascal.....	\$ 140	
Constellation.....	INCLUDED	
CP/M.....	INCLUDED	
Omninet - first year.....	\$ 900	
Omninet - second year.....	\$ 600	
Mirror disk backup.....	\$ 600	
CPUNET.....	\$ 3,000	
Wordstar.....	\$ 300	
Visicalc.....	\$ 140	
COBOL compiler.....	\$ 30	
Ada compiler.....	\$ 360	
DB Master.....	\$ 300	
PFS.....	\$ 100	
TOTAL.....	\$ 6,470	
EQUIPMENT TOTAL.....	\$ 61,000	
SOFTWARE TOTAL.....	\$ 6,470	
GRAND TOTAL.....	\$ 67,470	

APPENDIX 1

Two Case Summaries

Southern Illinois University

Laboratory Planner:

Jim Legacy (618) 536-7733

Department of Education and Mechanization Department

Southern Illinois University at Carbondale

PLANNING:

Three purposes of the microcomputer lab:

- 1) To teach computer literacy (using the BASIC language) to agriculture students including hands-on experience with the microcomputer keyboard, disks, and printers
- 2) To teach the use of the microcomputer in solving equations common in agriculture and
- 3) To show how to store data and information using the microcomputer

THE MICROCOMPUTER LABORATORY:

The Beginning lab:

- 1) Six VIC-20s microcomputers with 16K and
six TRS-80s microcomputers with 16K

Reason for selecting:

- i) They did not want to "waste" the power of a
microcomputer like the Apple, when 16K
microcomputers would suffice
 - ii) They were the cheapest possible to buy and
 - iii) They wanted students to be familiar with two
different keyboards
- 2) One floppy disk drive (Radio Shack)
 - 3) One line printer (Radio Shack)

The Advanced laboratory:

- 1) Twelve Apple II Plus microcomputers
- 2) Twelve pairs of floppy disk drives
- 3) One line printer

Reason for selecting:

- i) Apple had the best and biggest selection of
software available
- ii) Visicalc would be used
- iii) Apple's Superpilot authoring system would be used
- iv) File manipulations (create, access) were easy to
use

FACILITIES:

Twenty by twenty foot room houses twenty-two microcomputers. Twenty-one face the four walls with one placed in the center for the teaching assistant.

This arrangement was chosen so students could get help from behind without the TA having to walk around the station.

Two additional microcomputers are located at the lab learning center where students may sign up for their use. Each student is allowed two hours a week to complete assignments.

The lab is used by 250 students during a two-semester year. No lab sign-up sheet is necessary to share the equipment. Relying on a single graduate lab assistant was sufficient primarily because all student materials for the course were self-instructive.

An emergency backup power source was built by an engineering student and donated to the lab.

The lab equipment did not require special air conditioning.

COST:

Beginning lab: \$300 per microcomputer and \$1,500 combined
for printer and disk

Total: \$5,100

Advanced lab: \$1,000 per microcomputer and \$1,000 per
pair of disk drives and \$1,000 for printer

Total: \$25,000

Maintenance : miscellaneous repairs

Total: \$500 a year

UNIVERSITY OF MISSOURI

LABORATORY PLANNER:

Elaine Reber (314) 882-4327

Department of Agricultural Economics

University of Missouri at Columbia

PLANNING:

Four purposes of the microcomputer lab:

- 1) Teach computer programming in a hands-on environment
- 2) Provide Computer Assisted Instruction literacy for faculty
- 3) Encourage the development of CAI programs for current
and future courses
- 4) Provide a facility where students, faculty, and staff can
develop programs to satisfy research, teaching and
extension needs.

THE MICROCOMPUTER LABORATORY:

1) Fifteen Apple II Plus microcomputers

Reason for selecting:

- i) Only other option was TRS-80s
- ii) More reliable
- iii) Popular with farmers
- iv) Wanted to use Apple software products

2) Paper Tiger graphics printer

Reasoning for selecting:

Was best at NECC computer faire

3) Hiplot plotter

Reason for selecting:

Reasonable cost

4) Two Graphics Tablet digitizers

Reason for selecting:

Previous knowledge

5) Corvus 20MB hard disk

Reason for selecting:

- i) Visted Springfield site using Corvus
- ii) Could hook Apples up to it
- iii) Cheaper than buying floppy drives
- iv) Less management and less "messy" for classroom use
- v) Provided superior system to teach with
- vi) More reliable than floppy disks

6) Four floppy disk drives

Reason for selecting:

Loading and backup of Corvus

7) One D.C. Hays modem

Reason for selecting:

To upload and download to and from Amdahl mainframe

8) Two Epson printers

Reason for selecting:

Original Paper Tiger broke down frequently

9) Software:

- i) Visicalc
- ii) CCA - Data base manager
- iii) Supertext - Text editor
- iv) Apple Plot - Useful for developing courseware
- v) ASCII Express II - Upload/download to/from Amdahl
- vi) Young Farmers Record Keeping System - and other statistical programs
- vii) Fortran
- viii) BASIC
- ix) Pascal
- x) PFS - Data base system

FACILITIES:

Twenty by thirty foot room holds fourteen microcomputers on five foot tables.

A U-shape arrangement places all within fifty feet of the Corvus and all face a blackboard.

The center of the room has three tables for lab assistants.

One Apple is used for teaching in the classroom which has two large monitors attached to the Apple.

A video cassette serves as backup to the Corvus.

For security, the Apples are bolted to the tables and only four keys exist. The room is not accessible to maintenance crews.

The lab is open seventy hours a week and a sign-up sheet is posted giving students unlimited hours.

Each semester 250 students use the lab.

One full-time lab assistant and three to five TA's manage the lab.

COST:

Initial cost: \$50,000

Yearly cost: None budgeted

APPENDIX 2

A Suggested Set of Guidelines for Developing a
Microcomputer Laboratory in an Educational Environment

Planning:

- 1) Form a computer advisory committee to share concerns and expertise
- 2) Begin with a dedicated faculty member
- 3) Visit other microcomputer laboratories
- 4) Use sources of information such as:
 - i) Computer journals and magazines
 - ii) Computer and educational conferences
 - iii) Professional organizations
 - iv) Microcomputer retail stores
- 5) Develop an overall philosophy including the scope of the educational program
- 6) Define both long-range and short-range goals and objectives
- 7) Consider faculty and staff training needs
- 8) Determine support personnel requirements including technical support and instructional support
- 9) Establish procedures for selecting software
- 10) Establish procedures for evaluating software

- 11) Establish procedures for selecting hardware
- 12) Establish who will use the system
- 13) Solicit support of the administration
- 14) Assess current facilities for equipment needs
- 15) Identify who will be in charge of implementation and management
- 16) Start small and expand gradually
- 17) Ensure that there exists a clear purpose and that purpose is known to all involved
- 18) Promote widespread participation and provide a base of common understanding of the goals and objectives

Software selection:

- 1) Evaluate software's capability to satisfy planned needs
- 2) Collect sample listings of actual computer runs
- 3) Obtain existing reviews of software from magazines or organizations that review software
- 4) Verify that software will run on appropriate equipment
- 5) Determine if backup copy accompanies purchased copy
- 6) Determine if software can be copied to hard disk
- 7) Determine if color, sound or graphics is integral part of software
- 8) Investigate condition of documentation
- 9) Investigate reliability factor
- 10) Verify ease of use of software
- 11) Establish necessity of in-house programming of software

Hardware selection:

- 1) Use technical specifications from software
- 2) Shop and compare
- 3) Look for plug-in compatibility
- 4) Give preference to equipment which conforms to existing industry standard:
 - i) Standard disk drive
 - ii) Processor running a machine independent operating system
 - iii) RS232C compatible terminal
 - iv) Standard keyboard
 - v) Standard eighty column, twenty-four row video display
 - vi) 16K incremental memory
 - vii) Standard printer and printer interface
 - viii) Standard power supply
- 5) Verify reputation of vendor
- 6) Consider service options on equipment
- 7) Investigate condition of documentation
- 8) Identify delivery dates
- 9) Ensure memory size is sufficient to run designated software
- 10) Consider the necessity of using a printer
- 11) Confirm sound, color and graphics capability
- 12) Purchase at least one floppy disk drive to load purchased software

- 13) Consider tradeoffs in obtaining a hard disk
- 14) Analyze need for using microcomputers with different keyboards
- 15) Chose from popular brands such as Apple, Atari, Commodore, DEC, IBM, OSI, Radio Shack, Texas Instruments, and Zenith

Documentation:

Features of good documentaion include:

- 1) Statement of the intended audience
- 2) Table of contents
- 3) Quick-reference section
- 4) Abundant illustrations and examples
- 5) Readable text and readable format
- 6) Glossary of all terms
- 7) Complete index
- 8) Durable binding
- 9) Clear maintenance instructions
- 10) Instructions on interface options
- 11) Listing of source code

Facilities:

- 1) Four by four foot work station area
- 2) Swivel chairs
- 3) Single power switch for each microcomputer
- 4) Maximum of ten microcomputers per thirty amp line
- 5) No special air conditioning requirements
- 6) Some type of security measure
- 7) A lab manager
- 8) Tables to hold the microcomputers

Cost:

Costs are variable but include the following considerations:

- 1) There will be regular or periodic replacement of equipment
- 2) There will be eventual replacement of entire system
- 3) Service or maintenance of equipment will be required
- 4) Cables and connectors may not be included in the original price
- 5) Educational discounts may be available
- 6) Maintenance costs may be as high as thirty-five percent of the original price of the equipment
- 7) Supplies will be a monthly expenditure
- 8) Lab assistants pay should be budgeted
- 9) Consultant fees may have to be paid
- 10) Upgrading of equipment may be necessary

11) Electrical wiring or air conditioning installation
might be needed

12) Insurance might be a monthly cost

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A STUDY OF THE PLANNING AND DEVELOPMENT OF A
MICROCOMPUTER LABORATORY IN AN EDUCATIONAL ENVIRONMENT

by

JOHN PAUL CHAPMAN

B.S., University of Missouri at Kansas City, 1972

AN ABSTRACT OF A MASTER'S REPORT

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KANSAS STATE UNIVERSITY
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A literature review was conducted to identify elements which are necessary in planning the development of a microcomputer laboratory for educational uses. The investigation included findings on the various educational uses of microcomputers, the advantages of using microcomputers, the planning involved in setting up a microcomputer laboratory, the selection of software and hardware, the laboratory facilities, and cost factors. A case study is included demonstrating a specific application of the findings of the literature review. An appendix is attached which summarizes development of two microcomputer laboratories in the Agriculture departments of two different universities. A second appendix is attached which lists a suggested set of guidelines for developing a microcomputer laboratory in an educational environment.

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