DOCUMENT RESUME

ED 215 093 CE 031 681

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TITLE	Computer Equipment and Curriculum Requirements for Quality Data Processing Instruction. Research and Development. Final Report.
INSTITUTION	Des Moines Area Community Coll., Ankeny, Iowa.; Iowa State Dept. of Public Instruction, Des Moines. Div. of Career Education.
SPONS AGENCY	Department of Education, Washington, DC.
REPORT NO	ISDPI-CE-82-R1
PUB DATE	Dec 81
NOTE	37p.
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Computer Literacy; Computer Science; *Computer Science Education; Course Content; *Curriculum Development; Curriculum Guides; *Data Processing Occupations; *Educational Needs; Elementary Secondary Education; Needs Assessment; Postsecondary Education; *Programing
IDENTIFIERS	Iowa

ABSTRACT

Analysis of the curriculum and hardware needs for data processing instruction in Iowa was undertaken in order to prepare a sample curriculum and equipment recommendations for instruction in postsecondary institutions, as well as suggestions for a K-12 computer literacy program. More than 60 publications on computer-related topics and K-12 computer literacy were reviewed to determine competency requirements for computer programmers and computer operators, as well as six dimensions of computer literacy. In addition, data were collected through visitations to recognized data processing education centers; a telephone survey of two-year colleges to examine the hardware being used in training programs; a mailed survey to employers of computer programmers and operators who had been enrolled in a community college program; and a telephone survey of placement officers at Iowa area schools with programming/operations departments. All four of the surveys indicated the following similar necessary characteristics: the need for current, relevant curricula in step with technology advances; the need for modern equipment used by the industry in the primary service area; the need for modern equipment used by the industry in the primary service area; the need for experience through field study, cooperative study, or other arrangements; and the need for various options for enrollees to satisfy their needs and to take advantage of the employment opportunities available. As a result of the study, a listing of required and optional topics as well as recommended non-computer course work for programmers and operators was proposed to aid postsecondary schools in building their curricula; and a list of proposed topics and hardware requirements for a K-12 computer literacy curriculum was developed. (KC)

Research and Development

Computer Equipment and Curriculum Requirements for Quality Data Processing Instruction Final Report

December 1981

Iowa Department of Public Instruction
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COMPUTER EQUIPMENT AND CURRICULUM REQUIREMENTS FOR QUALITY DATA PROCESSING INSTRUCTION

Final Report

Study Conducted by Staff
of
Des Moines Area Community College

State of Iowa
Department of Public Instruction
Career Education Division
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The activity which is the subject of this report was supported in whole or in part by the U. S. Department of Education under P.L. 94-482, Section 131. The opinions expressed herein do not necessarily reflect the position or policy of the U. S. Department of Education, and no official endorsement should be inferred.

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6300-D87882-2/82

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I. INTRODUCTION

In the late Spring of 1980, the Des Moines Area Community College submitted a proposal to the Iowa Department of Public Instruction in response to an RFP that would result in an analysis of the curriculum and hardware needs for data processing instruction in Iowa.

The proposal was approved by the State Board, and work was begun on the project in late 1980. The principal investigators were Ralph Keul, Ph.D., programming instructor, and Larry Swanson, operations instructor.

An advisory committee was established to review the project direction, the design of the project, progress, and accomplishments. This committee met infrequently during the project, as needed, to achieve its purposes.

One of the outcomes of the advisory committee sessions was to add a dimension to the project which was the inclusion of a component on data processing education in grades K - 12. The discussion of this component appears in the text of the Findings section of the report.

This final report was written by Dr. Ronald McClurg of the Des Moines Area Community College, Research & Development Staff.

II. FINDINGS

According to the specifications in the Request for Proposal, five (5) minimum outcomes were required. This section of the report is structured around those five topics on the following pages.

A. Evaluation of the Review of Literature

Over 60 items were consulted in the literature review. Unfortunately, many of them were of minor contributing value to the purpose of this project because of their age, and because of the rapid technological changes occuring in the field of data processing since their publication. While a number of the components of any curriculum change little over time, because of their foundation in principle, a substantive proportion of the curricula may be antiquated by technological change. This phenomenon is no different for the computer science field and data processing education than for most others, even though computer science occupations are relatively new fields.

Computer Programming

Few of the publications dealing with computer programming were current enough to be relevant. Two citations (Hamblem; and, Howard and Rothstein) addressed the need for and future outlook for programmers. Hamblem determined that post-secondary institutions are currently unable to meet the demand for computer professionals in his 1981 study. Furthermore, that situation was expected to continue in view of a projection for a doubling of the demand for programmers by 1990, according to Howard and Rothstein.

Both these studies indicated the need for not only more programmers to be added to the employment pool, but also (indirectly) for those persons to be well prepared in their field to reduce turn-over due to inadequate preparation or lack of ability.

By far, the best publication reviewed pertaining to programmer education was a working paper from the Association for Computing Machinery (ACM), Committee on Curriculum in Computer Sciences. That document offered recommendations for a two-year associate degree. Specifically, the program recommended by ACM was directed toward the preparation of an entry-level programmer who could function as a team member in a moderate to large-sized shop.

The task force project, began in 1976 and completed in 1979, presents a recommended two-year college curricula, curriculum objectives, subject matter content, principles to consider for resource requirements, and articulation needs to fully integrate the educational program with industry, secondary schools, and other higher education.

The ACM report is by far the best source document to be reviewed for an impartial statement of principles and planning considerations, and recommends that each institution structure their own curriculum after an analysis of student and community needs.

One other publication, authored by one of the investigators on this project, has summarized the general competency requirements for entry-level programmers in terms of the general time within which the competency should be introduced in the curriculum and the relative degree of importance of the competency. The merit of this particular report lies with the ratings made by data processing employers and the relative worth they placed upon individual items in the total pool of tasks that may be taught in an educational program.

Very little was available regarding the hardware recommendations needed to support a programming curriculum. Those that were available, were too old to be of value for this report.

Computer Operations

The difficulties in discovering relevant literature pertaining to the preparation of computer operators were even more profound than those encountered in programmer education. Historically, operators were trained in an on-the-job (OJT) setting and were basically expected to limit their activities solely to the hardware and related activities.

In today's work setting, operators are expected to not only operate equipment and perform basic maintenance, but more importantly to devote as much as 90 percent of their time interfacing software. Hansen, in a

1979 report, described the current role of an operator to include involvement with complex languages (JCL) with a pre-placement need for training in that capability. Operators, according to Hansen, must also be trained to be problem solvers as a member of the data processing team. Little, et al, hold the position that "home-grown" operators no longer have a place in the industry, and must be individuals with strong educational bases which will contribute to state-of-the-art advances in computing centers.

Again, the major work of value to this project is a model published by ACM in April, 1980. While much of a programmer's training can be equipment independent, the same is not true for operators. Thus, the preparation of operators is, from one point of view, an even more difficult task than for the programmer. This is true because the capabilities will vary from shop to shop with the size of the installation, the brand of equipment, the purpose of the operation, and even the age of the hardware.

The ACM working paper on operations described the various environments in which an operator may be situated, outlined goals and objectives of a model curriculum, examined the opportunities for career paths and advancement, and curriculum content and resources for implementation were reviewed as were teaching methodology.

As with the working paper on programming education, the ACM Committee offered a framework for a curriculum, rather than a specific training program for a specific environment. The ACM went on to recommend that operat s personnel must be prepared to face continual learning needs and to expect continual change in their placement.

A task analysis which outlined the competency requirements for operators was completed by Swanson in 1980. The competency analysis involved an assessment by employers of the point within the curriculum at which the competency should be introduced, and the relative importance of each of the competencies.

The ACM and the Swanson materials appear to be the best available on the topic of operator education in data processing.

K - 12 Literacy

Readings in the literature on the topic of computer literacy are generally relatively new. Most of those available have been published in the past four or five years, with the majority of those having relevance being printed in the last two years.

Two works specifically were selected to deal with the topics of K - 12 computer literacy. They included a report based on a National Science Foundation project authored by Anderson and Klassen, University of Minnesota (1980), and an Association for Computing Machinery (ACM) report by Rogers and Austing (circa 1980).

The focus of the Anderson-Klassen report was that of designing, building, and evaluating a set of student learning modules in science, math, and social studies, using the computer as the central theme -- how it works, how it is used, its impact on the individual and society, and its use for the future.

These authors took the position that public understanding of computers and computer use has not kept pace with their availability. Even those growing up in the computer age are little better informed.

Research conducted in Minnesota showed a general lack of awareness and understanding about the purpose and capabilities of computers in society. Because of this finding, and other similar determinations, a number of groups including the President's Science Advisory Committee, the Organization for Economic Cooperation and Development, and many educational and scientific societies recommended the need to foster formal presentation in "computer literacy" as early as the late 1960s..

More recently, the National Council of Supervisors of Mathematics (1978), the National Council for the Social Studies (1980), and the National Council of Teachers of Mathematics (1980) have recommended that every student be exposed to a computer literacy course.

In the Minnesota study (1979), 87 percent of those surveyed agreed with the need for every high school to have some understanding of computers. These data and others from school boards and parent-teacher groups suggest public support of such training.

While there is some disagreement about when computer literacy instruction should begin, it has been suggested that career awareness education in the lower elementary grades should reflect the fact that many occupations require the use of or support by computers and that actual instruction should occur in the junior or senior high school levels.

The literature suggests that there are six dimensions of computer literacy. Field studies have validated these dimensions and added two others. The list includes: Applications, hardware, impact, limitations, programming/algorithms, software and data processing, usage, and values and feelings.

Regardless of the differences in approach, content, or level of instruction, there was little disagreement but that computer literacy was needed and as a part of the public education system.

B. Evaluation of Survey Results

This project involved the collection of data through four different survey processes. They included a survey of recognized data processing education centers by visitation and inspection, a telephone survey of two-year colleges to "examine" the hardware being used in training programs, a mail-out survey to employers of computer programmers and operators who had been enrolled in a community college program, and a telephone survey of placement officers at Iowa area schools with programming/operations departments.

Visitation Survey Results

The first visitation was made to Florida Junior College at Jacksonville, Florida. Florida Junior College utilizes an IBM 370 and a Prime 300 instructional mini-computer system. There is a limit of 25 students per class, and all are pre-tested prior to admission.

Four program options are offered for students at Florida Junior College: computer operations, certificate in programming, A.S. in data processing, and A.A. in data processing.

Two visitations were made in June, 1981. The first was to Orange County Community College, Middletown, New York. Using an IBM 370/148, this college starts two classes of 30 students annually on a first come - first served basis. It is essentially a full-time, four semester program. Students may enter employment as programmers upon graduation, or continue their education elsewhere in computer science or information management. Each student is required to complete a field project in an on-the-job setting with an approved off-campus installation. This was brought about by the close rapport with the community in the curriculum design stage of setting up the program.

The third inspection trip was to the Boulder Valley Vocational Technical Center, Boulder, Colorado. The Boulder Valley program is one of the more innovative centers available for data processing instruction. The program is designed for high school juniors and seniors but admits post-secondary students on a space available basis.

While the district computation center controls the mainframe computer, the VM operating system makes it appear to the students that they are in command. Hardware is extensive. It includes an IBM 370/145, thirteen disk units (IBM and CDC), five tape units, two printers, and a wide variety of consoles, CRTs, dual station keydisks, and other typical peripheral equipment.

High school students devote half of each school day for four semesters to the training program, and, depending on the career option, play the roles of entry level through lead positions in each of four options. An evening post-secondary program is available also.

The career options include Computer Operations, Business Programming, Data Entry, and Computerized Accounting. Most of the equipment used and instructional content is oriented toward specific uses and needs of businesses and industry in the community.

Relatively small classes are enrolled, with a maximum of twelve in the hands-on courses. Placement runs high, with percentages of between 90 and 100 for each of the options available.

Visitation Summary

In summation of the visitation approach at data collection, three factors stood out. First, the equipment used was modern and typical of that used in the business and industrial community served by the institution. Secondly, the two more progressive of the centers involved students in field projects (co-op setting) or in direct team work situations with real-world operations. Finally, the curriculum at each center offers options and is tailored to the needs of the community, thus providing training directly related to post-graduation employment settings.

Hardware Survey

To analyze the hardware and equipment used by two-year colleges in data processing education, a stratified sampling design was used. A random sample of 40 colleges was drawn from a roster of schools known to offer programming and/or operations training outside of Iowa. Half of the schools were selected from the five states generally recognized for leadership in data processing education (Florida, New York, Colorado, Texas, and Minnesota). The other half were selected from the other states (excluding Iowa, Hawaii, and Alaska).

Within each group, the schools were further stratified by size, with a full time enrollment of 3,000 students being used as a criterion for being "small" or "large". Roughly half of all schools with data processing education programs were in each of these two stratifications. A data collection instrument was designed for use in a telephone-type survey. Contact with the department chairperson was made with 28 of the 40 colleges. Half were from large and half were from small school categories. Seventeen of the 28 were from the control group and eleven were from the five leading states.

A brief summary of the findings follows. First, 26 of the 28 colleges use on-site computers for training. Of the 2 who do not, one used mini-computers only, and the other used minis as remote job entry terminals to a large off-site computer made available by a local business concern.

The type of mainframe computer used varied; however, IBM had 14 units in use, DEC had 7, and seven other models had one or two units in use on college campuses. Other major equipment (disk drives, tape units, printers, etc.) tended to be of the same brand name as the CPU. Twenty-three of the 28 colleges used mini- or micro-computers in programmer training or for RJE to the mainframe computer.

Thirdly, colleges were asked for the basis for selecting the hardware. Six small and four large schools selected computers because of what was typical in local use or because of what local business recommended; three small and five large units were acquired based upon competitive bidding and cost variables; five small and six large schools made selections on the basis of versatility, adaptability, and time sharing capabilities.

It was also considered important to assess the nature of the software used by the schools. While the type of software varied considerably, smaller schools tended to use OS (operating system) whereas the larger colleges tended to use DOS (disk operating system) and VS (virtual system) software. These were not mutually exclusive categories, however.

The fourth category of inquiry was to ascertain when the curriculum was designed in relation to when the hardware was acquired. Five schools designed their curricula after hardware was on site, 9 before hardware was obtained; and 14 before hardware was obtained, but later modified.

Twelve of the 28 colleges give their students direct access to the computer mainframe and peripheral equipment while the remaining 16 give access via CRTs only. Smaller schools tended to allow their students greater access to the computer than larger schools did. In all schools surveyed, the lab time varied, but the mean hovered around 50 percent, regardless of size of school.

Twenty of the 28 colleges shared their equipment with administrative uses -- probably the factor that limited student access to the computation center.

Summation of the Hardware Survey

Computer hardware acquisition decisions are not always based upon what may be of greatest value to the employer or even to the student as a prospective employee. Cost and multi-purpose utility were more often used in the acquisition decision. Only three of the colleges surveyed indicated that their equipment was seriously out of date, and each was contemplating acquisition of more modern hardware in the near future.

Employer Survey

One method of assessing the impact of an instructional program is to obtain employer evaluations of the students who have been enrolled in a program and who are working in the field. Thus, a survey of 72 employers of former DMACC data processing students was designed and conducted as a part of this project.

The approach followed was to build a questionnaire based upon clustered competencies (or, categories of competencies) was designed following the ACM models reviewed in the literature.

Employers were asked to identify the types of competencies for which former students in programming and operations were <u>inadequately</u> prepared at the point of job entry. A relatively short time for the survey process resulted in only 21 of 72 surveys being returned. Six of these had notes attached indicating that because of the size of staff they had no time to evaluate individuals adequately for our purposes. Therefore, only 15 surveys (21 percent) were useable.

Employers of programming students tended to indicate the following problems at the job entry level: problem analysis; use of problem-oriented language; use of pre-programmed routines, JCL, and documentation; and, effective communication.

Operations students tended to have difficulty in operating the hardware and peripheral equipment and in understanding the software used.

Many more areas of inadequate preparation were stated, however, with the limited sample size and with the extreme variance between shop operations, one or two frequency items were considered not to be trend indicators and are not discussed herein.

Summation of the Employer Survey

The results of this survey must be guardedly interpreted because of the limited sample size. It has two values for this project, however. First, it exhibits a model that can be followed to obtain an outside assessment of a program, and secondly, it illustrates one method of opening communication lines between employers and the institution.

Survey of Iowa Area School Placement Personnel

A telephone survey of Iowa Area Schools with data processing education departments was conducted to assess three factors related to this project. These included: (1) the enrollment capacity of the programs, (2) the attrition and placement levels at each institution, and (3) problems related to placement. It was hypothesized that these data items might contribute to the scope of the data processing education investigation, particularly with the problems related to placement variables.

Eight area schools are involved in data processing education to some extent. All eight schools have programmer courses, seven with limited enrollment, and one with an open enrollment basis. In the seven schools, approximately 700 new students are admitted each year. These school officials reported approximately 215 graduates per year, for a completion rate of 31 percent. This program completion rate appears relatively low on the surface. Unexplained, however, (and not investigated by this project) is what happens to those who do not graduate. It is suggested by some that students frequently terminate for the purpose of obtaining related employment. Others switch programs (perhaps to operations), some enter continuing education in the field, many do not use their training for any immediate benefit, and the status of some others is unknown.

Of the 31 percent who graduate, about 81 percent are placed in an occupational setting related to their preparation. This appears to be an acceptable level, given the general status of the economy in the past two years.

Placement problems were shared by placement staff at the colleges, but reluctantly. Reports indicated that programmers tended to start at salaries of $13,000 to $15,000; that most students were reluctant to relocate (thus perhaps inhibiting their employment potential), that many employers were no longer recruiting on campus and were looking for more experienced programming personnel. Nearly all placement staff reported a tight job market for programmers and that some often opted for operations jobs.

Only two area schools reported having operations training programs per se and both reported that 65 - 75 percent of their students completed with around three-fourths of those being placed in operations jobs in a typical year. The sample is too small to draw any concrete inferences.

The employment problems related by placement personnel led to the identification of several issues that were not tested in this project. The first was that of the attrition rate. Could it be that more rigorous selection standards are needed? It may well be that valuable resources are being wasted on persons who may have little chance for completion and success.

Is it possible that curricula are improperly designed? It may be necessary to redesign training programs to incorporate co-op experiences to provide the experience that employers seem to be seeking. Maybe programs are too intensive for entry level needs and students leave for employment opportunity at less-than-degree points in time.

Some placement personnel indicated that training competition was reducing the employment potential for graduates. It is entirely reasonable to expect that a better program, taught on modern equipment would soon reduce this inhibiting factor to placement success.

Summary for the Survey Component

The surveys conducted as a part of this project each served to answer a portion of the questions raised in the Request for Proposal. Perhaps of greater value were the surveys of hardware used and of employer reactions to graduates.

All four of the "surveys" indicated similar necessary characteristics, at least in principle. These were: the need for current, relevant curricula in step with technology advances, the need for modern equipment used by the industry in the primary service area, the need for experience through field study, co-op, or other arrangement, and the need for various options for the enrollee to satisfy their needs and to take advantage of the employment opportunities available.

C. Recommended Curriculum for Business Programmers

The surveys conducted as a part of this project and the review of literature, each in its own right, highlighted several factors that should be considered in the development and presentation of a curriculum. Briefly stated, these factors include items such as the needs of industry and business (i.e., the employers), the type of student clientele and their previous background, the expertise of the faculty and staff, the academic calendar administered by the college, the resources available, the degree of innovation desired by the institution, and even factors related to where students go for employment when they are placed (specific industries, relocation, various sized and located shops, etc.).

All of these elements should be carefully reviewed in the process of building a curriculum.

As a result of these findings, the research staff has been hesitant to propose a single model curriculum. Instead, an alternative approach has been devised. That which is used is a topical listing of required and optional business programmer topics and non-programmer oriented topics needed for general competence in the industry. Each institution should then integrate the topics into their own structure, considering the design factors listed above, in order to build the curriculum that would be most appropriate for them. Similarly, this presentation does not specify the weight or time that should be devoted to each topic.

The general structure for business programmers is organized as follows:

1. Required computer related topics

2. Local option topics and elective topics

3. Required non-computer topics

4. Student options in an application field

5. Institutional degree requirements

Required Computer Related Topics

Principles and Techniques of Programming

This is the heart and core of the programmer curriculum and should include the following topics:

a. Characters, fields, records, and files
b. Data representation, coding, and conversion
c. Types and format of data input and output
d. Use of structural programming constructs and extensions
e. Routines: initialization, end of file, end of job
f. Multiple level control breaks
g. Use of parameter data, sentinel fields, program switches
h. Validation and control features
i. Compound logical functions
j. Test data creation
k. Debugging methods
l. Program correctness
m. Program efficiency, timing, and style
n. Internal and external documentation
o. A problem-oriented procedural language
p. An assembler level language
q. An additional specialized language
r. Use of language reference manuals
s. Basic computer architecture
t. Overview of operating systems
u. Job stream control and language
v. Use of utility programs, text editors, functions
w. Storage and use of program modules
x. Input/output routines
y. Compilation - linkage - execution routines
z. Resource accountability
aa. Use of assembler routines by non-assembler languages

Programmer Environment

1. Computer Equipment and Function

   a. Internal function of the CPU
   b. Storage devices
   c. Peripheral devices
   d. Computer configuration
   e. Hardware comparison

2. Programming Language in Organizations

   a. Compilers; interpreters; assemblers
   b. Generators; file management languages
   c. Languages relative to equipment
   d. Languages appropriate to the application
   e. Mode of processing: Demand vs Batch

3. Computers in Organizations

   a. Evaluation of computers and their use
   b. Computer center in the organizational structure
   c. Computer centers: structure, staff, job descriptions
   d. Relationship of programmers to the computer center structure
   e. Statistical data and trends
   f. Software and hardware costs

4. Overview of an Existing Applications System

   a. Necessary reports
   b. Source data
   c. Systems flowcharts
   d. Process flowcharts
   e. Necessary programs
   f. Equipment needed
   g. Proper documentation

5. Overview of the Systems Cycle and the Programmer's Role in the Project

   a. Analysis phase
   b. Development phase
   c. Implementation phase
   d. Production phase
   e. Evaluation phase
   f. Program maintenance

6. Documentation

   a. Using systems documentation
   b. Using systems flowcharts
   c. Using process flowcharts
   d. Evaluation of documentation

7. Data Elements and Files

   a. Collection, forms, and coding
   b. Mode and format
   c. Data validation and control
   d. File valuation and control
   e. File structures
   f. File security
   g. Concern for privacy

8. Report Requirements and Forms Control

   a. Survey of business forms
   b. Input forms
   c. Output forms layout
   d. Output forms distribution and control

9. Quality Programming with Structured Approach

   a. Fundamentals of structured analysis and design of programs
   b. Top-down programming/debugging/testing/implementation
   c. Program analysis for improvement
   d. Review of control structures
   e. Determining logical equivalence of differently written programs
   f. Comparing the efficiency of two differently written programs
   g. Conversion from unstructured to structured code

10. Programming Projects Concept

   a. Evaluation for good structure
   b. Team approach
   c. Project coordinator role
   d. Standards
   e. Project management methods

11. Programming as a Profession

   a. Career paths
   b. Ethics
   c. Licensing/certification
   d. Societies
   e. Continuing education needs

<u>Optional Computer Related Topics</u>

1. Additional Programming Skills

   a. COBOL, FORTRAN, PL-1 or other procedural language not included
   b. APL, BASIC, or other interactive language
   c. Advanced assembler language
   d. RPG
   e. DBMS inquiry languages
   f. Micro-processor based languages

2. Operating Systems and Job Control

   a. Monitors and executives
   b. Multi-programming, processing, accessing
   c. Virtual storage and paging
   d. New advances in OS theory

3. Data Communications and Teleprocessing

   a. Overview of data transmission theory
   b. Coding systems and compatability
   c. Overview of error detection and correction
   d. Transmission methods
   e. Transmission equipment
   f. Terminals
   g. Computer access and processing

4. Data Base and its Management

   a. Concepts
   b. File structures
   c. DB management systems
   d. Software sources
   e. Costs and benefits of software
   f. Administration
   g. Standards for use

5. Computer Operations/Operations Management

   a. Operation of peripheral devices
   b. Console operation
   c. Job stream language
   d. Job scheduling
   e. Control checks
   f. Dispatching and disbursing
   g. Routine production operations
   h. Record-keeping and statistical data
   i. Billing

6. Computer Hardware and Services

   a. Microprocessors and microcomputers
   b. Programmable calculators
   c. Stand-alone systems (diskette or cassette)
   d. Terminals and leased services
   e. RJE stations
   f. Time sharing systems
   g. Service bureaus

7. Applications Software Packages

   a. Sources of packages
   b. Costs of implementation
   c. Evaluation of product
   d. Legal implications
   e. Contracts

8. Systems Analysis for Information Systems

   a. Systems planning

b. Feasibility studies
c. Development of systems
d. Evaluation of systems

9. System Design for Information Systems

a. Specification of logic
b. Suggested implementation into physical system
c. Evaluation of design based on user needs

Recommended Non-Computer Topics

Communications Skills

It is highly recommended that English grammar, English composition, technical writing, and/or speech or specially designed courses in oral and written communications be included in the curriculum to enhance communication expected of programmers.

Business

Programming students should have access to at least an overview course such as Introduction to Business to give them a general frame of reference for their applications work.

Math

The extent of the student's math background may effect their career path. Those with an interest in scientific applications should perhaps consider the calculus sequence. Business oriented students should complete a course similar to Finite Math; all should have completed at least one introductory level course in statistics, also, as a part of the math background.

Application Area

Programming students should complete at least one sequence in an application area. For business programmers, this may be in accounting, finance, banking, or even marketing.

General Education

Institutions offering an associate degree must also provide room in the curriculum for courses that will satisfy the degree requirements. Such courses may include additional communication skills, humanities, social sciences, natural sciences, and others.

D. Recommended Curriculum for Computer Operators

The principles used to devise a recommended curriculum in Computer Operations follow the same line as for Computer Programming. Instead of specifying a precise, rigid curriculum, a set of required and optional topics is presented as well as recommended non-computer course work. The rationale for using this approach parallels that presented for the business programmer curriculum.

This topical outline was devised on a model that considers the potential that an operator has for moving up the career ladder from an entry level position such as peripheral equipment operator or console operator trainee through the level of operations manager or even corporate data processing manager.

It is also founded on the realization that some data processing operations units employ only one or two people (and who thus must be well-versed in a wide variety of skills) while others may have a large staff of persons with very clearly defined task limitations (who need skills only in limited areas at job entry).

Required Computer Operations Topics

Principles and Techniques of Computer Operations

a. Components of a data processing system
b. History and development of today's systems
c. The data processing department: organization, responsibilities, flow of data
d. Operations areas: data entry, scheduling, data control, librarian, documentation, computer operations

e. Software development: program languages, program execution, operating systems, utility programs, multi-programming, common packages

f. Data handling
   1. Types of files: sequential, indexed, direct
   2. Types of processing: batch, random, real-time
   3. Processing problem areas: timeliness, accuracy, completeness
   4. Security: confidentiality, access limitations, equipment, back-up, external/internal labels, passwords
   5. Data bases

g. Operators' tools
   1. Manufacturer reference manuals
   2. Installation reference manuals
   3. Run manuals
   4. Logs
   5. Standards manuals

h. Hardware maintenance

Required Computer Operator Environment (Hardware)

a. Central processing unit
   1. System structure: data flow, console file, control storage, main storage, registers, channels.
   2. CPU characteristics
   3. Channel characteristics: selection channels, multi-plexor channels, bus structures, channel-less CPUs
   4. Console system control devices
   5. Multiple and attached processor configurations

b. I/O and storage devices
   1. Card punch, reader, and other devices: physical characteristics, codes used, terminology, types of devices, advantages and disadvantages, operating procedures, operational aids.
   2. Printer: characteristics, types, advantages and disadvantages of hard copy, operating procedures, operational aids.
   3. Tape drives: general characteristics, types of drives, advantages and disadvantages, operating procedures, operational aids
   4. Direct access storage devices (disk drives, others): general characteristics and properties, types, advantages and disadvantages of each, operating procedures, operational aids

c. Console system control device: general characteristics, operating procedures, operational aids

d. Teleprocessing and RJE Hardware: modems, multi-plexors, transmission link and methods, terminals

Required Environment (Facilities, Control, Organizational Relationship)

a. Facility characteristics: storage, raised floors, limiting access, structure security, power sources

b. Resource control: inventory practices, security

c. Organization of DP services

d. Operations staff functions

Required Environment (Documentation)

a. Functions of documentation
b. Methods of documentation
c. Types of documentation: applications systems, reference manuals, departmental record keeping, computer produced documentation

Required Environment (Operating Systems and Job Control)

a. Supervisor or monitor
b. Job control program: command formats, syntax, commands, and options
c. Partitions and multi-programming
d. Spooling facilities: types, format, commands, and options
e. System control panel and console device: system preparation, console procedures
f. Interrupts
g. Software features

Required Environment (The Operations Profession)

a. Work environment
b. Career paths and opportunities
c. Ethics
d. Continuing Education

Optional Computer Related Topics

1. Advanced topics on mini- and micro-computers: applications, hardware, software
2. Programming: RPG-II, BASIC, COBOL, FORTRAN, PASCAL, others
3. Data communications and teleprocessing: analog and digital transmission, modems, rate categories, leased/private lines, carriers available, characters and codes, line errors, software
4. System analysis and design (for continuing education)
5. Software application packages

Recommended Non-Computer Related Topics

Communications

Coursework should be integrated into the curriculum to provide operators with communication skills, both oral and written. Operators are part of a team and must communicate with them. They must be able to read and comprehend manuals, written instructions, and technical materials through an interactive terminal.

Thus, coursework in composition, technical writing, and speech should be a part of the curriculum.

Business

Operators should be familiar with fundamentals of business and the functions of a commercial organization. A course such as Introduction to Business is appropriate.

E. Recommended Curriculum for Computer Literacy (Grades K - 12)

As was stated earlier, the growing use of computers throughout society in a vast array of applications suggests that computer literacy should be integrated into the total school curriculum.

Awareness of computer use can be introduced in the lower elementary grades in the study of what parents do and what kinds of jobs exist. Certainly many youngsters have video games and electronic toys from which computer applications can be drawn as a point of reference.

Middle schools can further promote the computer literacy concept, as many presently do, through the introduction of computer assisted instruction (CAI). Many schools are using CAI in introductory and exploratory courses on personal sized computers.

Formal instruction, however, in regard to computer literacy should be presented in the upper grades of senior high school. The purpose of such a course, probably of one-year duration, should be to teach problem solving in a general sense.

The objectives of such a course should include:

1. To provide the student with practice in making use of the computer as a tool for problem solving.

2. To provide the student with a realistic concept of the power, usefulness, and limitations of computers.

3. To provide the student with knowledge about the role of computers in information processing.

4. To provide the student with a context from which possible future computing use can be based.

The study topics appropriate for a one-year course in the secondary school should include:

1. Problem solving: defining a problem, the concept of an algorithm, graphic presentation of a solution

2. Programming methods: structured techniques, style, documentation, manual reading, debugging

3. Programming language: language syntax, control structures, functions and subroutines, user interface, simple data structures, simple sorting and searching, simple files, file manipulation

4. Computer environment: types of systems, languages, communications networks, micro-electronics, hardware components, software, data storage

5. Areas of application: education, research, fine arts, government, health, business, libraries, etc.

6. Application examples: models and simulations, storage and retrieval, process control, calculations, fund transfer, word processing, personal computing

7. History of computing: from abacus to modern, people and events, trends and predictions

8. Social and ethical implications: user benefits, economic effects, privacy and security, computer crime, careers

Most students should have completed an algebra course (for the logical thinking rather than the math). The course should work with a single language such as BASIC. BASIC is both simple to use and powerful enough for real applications, and yet works well on a personal sized computer affordable for most schools.

Each student should receive hands-on experience of about two hours per week and should not be denied access outside of school hours if the physical plant is open and supervision available.

III. CONCLUDING REMARKS

This report consists of a review of the literature pertinent to data processing education at both the secondary and post-secondary levels. Without a doubt, the proliferation of electronic information handling and processing in today's society strengthens the case for the availability of relevant, flexible, and thorough instruction for those interested in a career in the field.

The curriculum recommendations included herein are derived heavily from the task force reports published by the Association of Computer Machinery. The structure has been one of presenting the required minimum topics that should be included, the recommended options that round out a preparatory program and which may also be made available as continuing education offerings, and non-computer related courses that are necessary to help the professional function in an employment setting.

The final format, structure, and organization of a given institution's curriculum should be determined not only from the topical listing provided, but also after having determined the local needs, hardware in use, procedural language used, and other variables as discussed in preceding sections of this report.

The Computer Career Preparation Committee recommendations for objectives, languages, and institutional flexibility were reviewed and are concurred with as leading principles in the design of a functional, relevant curriculum.

The issue of hardware is a most frustrating one. Throughout the literature, a number of references were made to the need for providing access to current, state-of-the-art machines for instruction to be of greatest value. This concept was supported and re-inforced through the equipment survey and the employer surveys that were conducted as a part of the project. Local institutions must determine the nature of equipment most prevalent in their service area, and must plan to provide access to that type of equipment if their student consumers are to obtain optimum employment in the field for which they have prepared. The frustrating aspect of this lies with the cost of acquiring such hardware. Options to having an on-site computer for instruction may have to be considered, including such possibilities as co-op arrangements, off-site training agreements, field exercise components, and even service bureau leases in order to give students the optimum experience possible.

In conclusion, this report has not provided a detailed, model curriculum for business programming, for computer operations, nor for computer literacy in grades K - 12. Instead, it has presented those topics important to a curriculum, but leaves the flexibility needed to tailor the program to a specific area.

APPENDIX

GUIDELINES FOR PROCEDURES TO FOLLOW IN REVIEWING AND MODERNIZING A POST-SECONDARY COMPUTER PROGRAMMING OR OPERATIONS CURRICULUM

I. INTRODUCTION

The following are some suggested guidelines that may be followed in reviewing, evaluating, and planning for an area school computer education curriculum revision. These guidelines are based upon past experiences, some limited field test experiences, and in a large part, on common sense.

A. Use of the Program Advisory Committee

The lay advisory committee should be one of the primary consulEative resources used by the area school in reviewing the curriculum. Few others are as aware as they of the changes in technology and industry needs, of the relevance of the curriculum to the performance expectations in the field, of the career ladder opportunities that exist, and of the needs for continuing education.

Advisory committee personnel should be encouraged to visit classes, inspect course outlines and references, and to otherwise keep abreast of what is happening in the program.

They should be encouraged to recommend areas of emphasis and to highlight needed areas of change. Advisory committees should be used as a resource, but, obviously not "take charge" of the program. Use them, they are professionals.

B. Follow-Up of Graduates

Periodically, institutional research staff, or program faculty, should conduct a follow-up survey of working graduates of the program. The primary type of information sought should include data about the type of related job they are holding in order to learn more about the kind of business or firm for which they are working; and, the former students should be queried about the relevance of their curriculum to their job. Included should be a response to aspects of the program that are not relevant or which are not emphasized in their job setting, parts of their job for which they could or should have had better instruction, and which part of the curriculum presented them with particular strengths or abilities that were essential in the job.

The graduates should also be questioned about their aspirations and the advancement potential as they see it.

C. Employer Surveys

Employers should periodically be surveyed to obtain their contributions and "evaluation" of the training program and of the graduates they have hired.

Employers should be particularly questioned about the parts of their job assignments that do not seem to have been met by the training institution. Their responses can highlight various training components that may need improved attention or modification due to technological change. They can also contribute greatly to the identification of continuing education needs of their total programming/operations staff that are not being met through vendor resources.

Employers are key components in the curriculum modification process and the first line supervisors are key information sources about former students and their capabilities.

D. Use of Research

The use of research should be considered in the review and evaluation of curricula. While many staff have a vested interest in their program, because they may have prepared the curriculum, or been a part of it "from the beginning", the findings of research should not be ignored nor overlooked "because we already know what is needed". It is important that an open mind be kept in evaluating the curriculum. If nothing else, the use of other information in matching it against the existing syllabus for the program may do no more than validate what already exists.

E. Program Faculty

Finally, some of the greatest resources available are to be found among the teaching faculty. These persons should be involved in curriculum review, should be given an opportunity to visit vendors and operating shops in the area, and should be given consideration for their recommendations for changes that are necessary to make the curriculum as pertinent and viable as possible.