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ABSTRACT

An overview is provided of the institutional and technological factors to be considered in designing or updating a computer science curriculum at the community college level. After underscoring the importance of the computer in today's society, the paper identifies and discusses the following considerations in curriculum design: (1) the mission of the college to fulfill both career preparation and transfer functions; (2) the influence exerted by the Association for Computing Machinery (ACM), which has published guidelines for computer science, information systems, vocational-technical, and health computing curricula; (3) the needs of the business/industrial community; (4) the needs and interests of students; and (5) state mandates. In light of these considerations, several conclusions about curriculum design are presented. First, programs should be designed to be viable for several years, given a two-year lag time for program development and rapid changes in technology. Second, no one curriculum will satisfy the needs of all students and the community. Third, the associate of science degree program in computer science cannot differ radically from the first two years of four-year college programs. And fourth, strong mathematics and science backgrounds are advantageous for computer science majors. A sample curriculum, based on ACM guidelines, and sample course descriptions are provided. (EJV)

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DESIGNING A CURRICULUM FOR COMPUTER STUDENTS IN THE COMMUNITY COLLEGE

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Today no one will deny the importance of the computer in our technocratic society. We have come to expect a microcomputer at our work stations, scanners in the grocery stores, and automatic tellers everywhere ready to dispense funds at any hour of the night or day. However it was not always so--just some thirty years ago a department of the United States government had anticipated that ten computers would supply all the computer power needed for our country! And even as recently as twenty years ago the question of whether or not there existed a need for a separate curriculum in computer studies at the college level was still being debated.

As more and more segments of our society became computerized during the sixties and seventies, the need for people with the know-how to direct the processing of data grew rapidly. Colleges quickly implemented programs to satisfy the demand and the New Jersey community colleges, having just been created during this period, also responded by offering career programs in "data processing".

But times have again changed. Much of the usage of computers has shifted from the large main-frame computers to the desk-top models. Application programs that formerly took months to write can now be bought "off-the-shelf" as software packages. College computer studies departments that once used calculus as a

filter to limit the throngs of would-be students are now worried about attracting enough students to keep the curriculum alive. Community colleges have to contend not only with shrinking computer studies departments, but with a decline in enrollment overall.

It is surely time to re-examine the program in light of current trends and update the course of study appropriately.

Factors Affecting Curriculum Design

There are many factors that must be considered in designing or updating a computer curriculum. Especially important among these are the mission of the college, the needs of the business/industrial community, the needs of the student population, the mandates of the state of New Jersey, and the willingness of the college to implement change. Carefully balanced with all of these must be subject matter that is not only fundamental to the study of computer science but also provides the skills needed in maintaining an information-based society.

The mission of the college appears to be the most nearly constant factor of those listed above. The community colleges for the most part are designed to serve the educational needs of the area residents and to provide career training for the business/industrial community. For example the purpose and philosophy of County College of Morris, as stated in the 1986-88 college catalogue, is " dedicated to meeting the needs of area residents and employers for educational advancement and career

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training, and to fostering social and cultural enlightenment within the community it serves" (p. 14). It follows from the college's mission that computer studies should also address itself to the educational needs of the students and also to the training needs of local industry.

Some--but not all--of the two-year colleges have two separate programs in computer studies in order to satisfy the needs of education and the needs of industry; namely, an Associate of Science Degree curriculum leading to a transfer to a baccalaureate institution and an Associate in Applied Science curriculum leading to an immediate computer career. Moreover several colleges have developed "cluster programs" and certificate programs that do not lead to a degree; rather they satisfy the needs of certain populations. For example Bergen Community College offers a certificate in computer science that is designed to give students with B.S. degrees in other fields the necessary background to pursue an M.S. in Computer Science. County College of Morris, on the other hand, is planning a series of "cluster programs" in such areas as COBOL language programming and micro-computer programming that will provide a fixed course of study for data processing personnel who wish to advance their training without completing all the requirements of an A.A.S. degree. (Certificate programs carry 30 credits and are sanctioned by the state whereas "cluster" programs provide about 15 credits and do not need to be approved by the state).

Exactly what courses make up the A.S. or A.A.S. programs depend on many factors. The A.S. transfer programs by their very

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nature must be comprised of courses readily transferable to accredited four-year institutes. Moreover in New Jersey the state approval of a two-year transfer degree assures that students completing the program will have third-year standing at state institutions offering programs in that field. Many two year colleges have enhanced their programs by developing articulation agreements with neighboring four-year colleges and publically market the agreement; for example Camden Community College includes a copy of their articulation agreement with Glassboro State College in the information packet it sends to potential students.

Nonetheless there is still quite an array of programs offered during the first two years at New Jersey colleges, regardless of whether they are two-year or four-year institutions. Perhaps the most sensitive issue is the extent to which a curriculum is career-oriented. For example Bloomfield College has a curriculum strongly based in the COBOL language. (COBOL is the most widely used programming language--a quick scan of any metropolitan newspaper's classified ads will show a predominance of jobs requiring training in COBOL). On the other hand, Rutgers, which is known to be striving for a national reputation in computer science, does little in COBOL, and instead has its students writing programs mostly in Pascal. (Pascal, although it enjoys some limited popularity in the job market, is a language that was designed specifically for the academic environment).

One of the major forces in the design of curriculum is the Association for Computing Machinery, the ACM, an organization

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dedicated to the advancement of computer science. Back in the sixties, when the very existence of such a discipline as computer science was questioned, the ACM created a committee to research what material might comprise the curricula of four-year programs and two-year career programs. The programs have been revised several times and now make up a three volume set published by the ACM: ACM Curricula Recommendations for Computer Science Volume I, ACM Curricula Recommendations for Information Systems Volume II, and ACM Curricula Recommendations for Related Computer Science Programs in Vocational-Technical Schools, Community and Junior Colleges, and Health Computing Volume III. Many colleges use the recommendations as a guide; for example Ocean County College advertises its curriculum as being based on the ACM recommendations.

However the ACM is not the only source for guidelines in curricula. Another view is presented in The Carnegie-Mellon Curriculum for Undergraduate Computer Science. Other notable guides have been published by the Data Processing Management Association (DPMA) and the Computer Society of the Institute for Electrical and Electronic Engineers (IEEE-CS).

The curricula promulgated in these guides are for the most part stringent. With the exception of DPMA's, they are well grounded in the theory of computer science, physics, and calculus.

On the other hand it is possible to have a successful career in computing without a theoretical education: everyone is familiar with the legend of Steve Jobs starting Apple Computer

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in a garage when he was in high school. Furthermore many college computer departments see computing more nearly tied to business applications than to computer science and so have developed curricula along the DPMA guidelines in a field loosely called Computer Information Systems (At least four such programs exist in New Jersey). The requirements in such programs are oriented more toward the file handling and data communications in business applications of computing than toward computer science.

What are the thoughts of the business/industrial community itself? The author interviewed several highly placed personnel at New Jersey businesses such as AT&T, Cieby-Giegy, United Research, and Warner-Lambert. Overall the feeling was that a two-year graduate has little chance of obtaining an attractive job in computing regardless of his/her skills. Apparently there is a sufficient pool of four-year graduates for industry to choose from and the four-year graduates provide a maturity that the two-year graduate does not. Moreover one official expressed a sentiment similiar to that stated in the following paragraph from The Wall Street Journal, November 27, 1987 (p.13):

> "I'd love to have more students with degrees in finance or anthropology or political science," says Stuart Reeves, EDS vice president in charge of recruiting and development, adding that being able to think critically is more important than a computer-science degree. "We'll teach them what they need to know to be a computer professional."

Another interesting observation made during the interviews was when the author described the courses in the present A.A.S. curriculum at County College of Morris and asked whether the courses still represented viable skills; overwhelmingly the

answer was yes. As the present curriculum is very much a traditional computing curriculum, these representatives seemed to be saying that the skills with which they are familiar--skills indeed that have a vintage of some twenty years--have served them well and should continue as the basis of training for the next generation of computer personnel.

When asked what new skills might be added, the respondents answered that training in one of the so-called 4-GL languages--fourth generation computer languages that more nearly resemble English--like Oracle or Natural might be appropriate. Also more training in the theoretical foundations of data bases seemed like a good idea.

There was little excitement when the author suggested that CASE technologies be added to the curriculum. CASE technology (computer assisted software engineering) is the name tagged on to recently emerging software that aids in the development of software systems, including the actual generation of code. On the other hand much of the literature touts the CASE technology as ringing the death knell of the professional programmer that we know of today (Yourdon).

A defense of the traditional curriculum has recently been made by Leonard Kleinrock, professor of computer science at UCLA and president of Technology Transfer Institute, in an interview published in the Communications of the ACM. He maintains that

> the concern of the university is not to provide training narrowly directed toward a particular industry's special requirements, but rather to

> educate our scientists in the basic tools, methodology, understanding, and approaches that will survive the short five-year life of today's generation of computers (p. 254).

Not everyone however is satisfied with the current state of computer education. One major critic is James Martin, author of 33 books on computers and/or communications and a consultant to top management of federal agencies and the Fortune 500. In the interview cited above, he dismisses the current curricula as totally inappropriate.

> Neither the business schools nor the computer science schools have gotten anywhere near understanding what's happening [in computing today], let alone teaching it....Many of the subjects relate to the 1970s, a few to the 1990s, but virtually none relate to the 1980s (pp. 253-254).

What of the needs of the students? It seems appropriate to examine the makeup of the student body in relation to this question. In the statistics of County College of Morris describing the incoming freshman in Fall 1987, it is given that the average rank in the high school graduating class was in the 30-39 percentile with only 26% ranking in the upper half of the class (Facts & Figures, p. 2).

In an informal survey of computer students, most students listed their reasons for enrolling at County College of Morris as being pleased with its reputation and as feeling inadequately prepared academically and/ or psychologically for a four-year school.

Furthermore students who enrolled in the computer program with a commercial emphasis did so because they either enjoyed business-related studies or preceived the program as being

academically easier. Those students who enrolled in the program with a technical emphasis did so because they enjoyed the scientific aspect and because they preceived the program as more challenging.

It is also of interest to examine what happens to students after graduation. Of the graduates in the part of the program with a commercial emphasis, 65% are employeed full-time whereas 27% transferred and attend school full time. Of the graduates in the part of the program with a technical emphasis, 50% are employeed full time and 43% transferred and attend school full time (Graduate Survey Class of 1986, p. 8).

Another significant factor in creating curriculum is the mandates of the state of New Jersey. The Department of Higher Education's influence is two-fold: it specifies requirements for the various degrees and it specifies a procedure for implementing changes or implementing new curricula.

The degree requirements are themselves separated into two catagories: general education requirements and major requirements. The minimum general education requirements for the degrees appropriate to a two-year college's computer studies are:

(1) Associate in Science (A.S.) degree: not less than 30 credits in an array of courses in each of the following catagories: communications, mathematics and sciences, social sciences, and humanities;

(2) Associate in Applied Science (A.A.S.) degree: not less than 20 credits in an array from the communications category and at least one course from each of the three following categories:

mathematics and science, social sciences, and humanities.

The interpretation of the requirements is at the institutional level. For example County College of Morris interprets "an array of courses" to mean two from each category. Morris considers history to be a social science whereas Bergen Community College considers it a humanities course.

Besides providing specifications for general education, the state also sets a limit on the number of credits that a student can accumulate in the major area. For an Associate in Science (A.S.) degree the maximum is sixteen credits.

The process of developing a new curriculum from its planning stages to its approval by the state is described in great detail by Dean Judith F. Raulf and Dean Marilyn C. Ayres in The Challenge of Curriculum Development: From Idea to Reality. After the needs and format of the program have been developed at the institutional level, a document called the Preliminary Program Announcement PAA, describing the program, is submitted to the state's Department of Higher Education. The department circulates the document to the state's colleges and, acting upon the feedback from the colleges, sends the proposing institution an advisory letter. If the institution wishes to pursue the establishment of the new program, then it develops a Program Approval Document (PAD) which presents complete information on the proposed program. The PAD is sent to the Department of Higher Education for review. As part of the review, the department hires an out-of-state evaluator who, along with a representative from the state department of higher education, visits the submitting institution and prepares a report. The report is ultimately

reviewed by the state's curriculum coordinating committee which can approve it, reject it, or send it back for possible revisions.

It has been estimated in County College of Morris Manual for Developent of New Degree Programs that the establishment of a new program according to the process outlined above will take approximately two years (p. ii).

Still another factor that must be considered in the designing of a computer curriculum is the willingness of the institution to support the program. Change inevitably reaches beyond preceived needs and into the political structure. Physical resources, such as classrooms and computer equipment, and personnel, including faculty, may have to be reallocated. It rests with the administration to balance the need for change with the short-term and long-term goals of the college.

Some Conclusions

An obvious conclusion that one reaches when examining the above factors that affect curriculum development in computer studies is that time is of the essence. With a two year lag from the beginning of program development to its implementation and with the rapid changes in computer technology, one had better design a curriculum that will still be viable for the next several years.

Another apparent conclusion is that no one curriculum will satisfy all the needs of the students and the community. The fact that so many of the students use the community college as a

maturing ground and do eventually enroll in baccalaurate programs underlines the importance of offering an associate in science program; moreover such a program is also supported by the fact that the business/industrial comunity prefers the four-year graduate to the two-year graduate.

The associate of science program cannot differ too radically from the programs offered during the first two years at possible transfer institutions. Overwhelmingly in New Jersey, those institutes base their programs on the ACM guidelines.

Furthermore in such programs the primary language offered is Pascal. Professors have found that teaching through the use of one primary language advances the amount of information that can be presented; after acquiring a proficency in Pascal, a student can then take an over-view course in a practical computer language such as COBOL or Fortran. Also Pascal is the language of choice in the majority f computer science texts.

Unfortunately, the two-year transfer program has several drawbacks. As the state limits the number of credits that a student can acquire in the major area to 16, a student is limited to taking five three-credit courses; however in a non-transfer program, the student would take ten or eleven courses in the major. Thus the amount of information that can be taught is severely curtailed. Moreover the transfer program must be strong in both math and science; for example two semesters of calculus and two semesters of calculus-based physics are often required (or preferred) by the four-year colleges. However many of the students are using the community colleges as a maturing ground

and are not ready to tackle so heavy an academic load.

Also one must consider the impact of the transfer program on the computer studies department. The reduced amount of computer courses could play havoc with the resources already dedicated to computing; many colleges had expended large sums of money on computer equipment and laboratory space, expecting these to become cost effective in time. Also there may be less demand for the services of the computer department faculty.

On the other hand it has been the experience of at least one community college which instituted an A.S. degree program that enrollment increased once the fact became known that its graduates easily transferred to desirable four-year colleges.

A sample curriculum that is strongly based on ACM recommendations is presented in Attachment I. A cursory glance shows a plethoria of electives; however the degree of freedom is really not that pronounced as the electives must be carefully chosen to assure transferability. Thus the electives in the humanities and the social sciences must be selected with an eye toward the transfer institute; a list of courses in each discipline that are most likely to transfer is usually available at the counseling office in the community college.

The mathematics electives must also be chosen carefully. It may be that the entering freshman is not ready for calculus; in such a case the student should select a pre-calculus course, which may or may not be transferable. After taking the calculus series, the student should continue with high-level mathematics--a third semester of calculus, discrete mathematics, linear programming, and statistics are all desirable selections.

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A strong science background is definitely advantageous for a computer science major. Eight to twelve credits of calculus-based laboratory physics is certainly highly desirable (The free elective credits could be used for the additional credits). However eight credits of physics that is not calculus-based may be a more realistic choice for some students. Also there are transfer institutes that accept two-semester sequences in chemistry or biology as the science requirement.

Course descriptions for Computer Science I and Computer Science II are presented in Attachments II and III, resp. These descriptions strongly follow those presented by Koffman, Miller, and Wardle in the report of the ACM Curriculum Committee Task Force for CS1 and Koffman, Stemple, and Wardle in a similiar report for CS2. The courses are taught using Pascal; moreover they embody the computing precepts of structured code, careful documentation, and block processing that are the foundation of software engineering. These courses are so fundamental to information processing that they should be listed among the general education selections of a college.

The course in Machine Organization and Assembly Language is perhaps the most controversial in the sample curriculum. A short time ago the information presented in such a course was highly regarded and its mastery went hand-in-hand with computer expertise. More recently however the trend in computing has been in the creation of software that is machine independent and so assembly language (which is machine specific) is looked upon as a dinasaur. Nonetheless, many four-year colleges still require the

course; however they emphasize the machine organization more than the assembly language. Moreover several institutions require two semesters; when transferring to such a school, the two-year college student should use the computer elective to take the second semester at the community college.

The data structures course examines complex ways of organizing and processing data efficiently through the use of both ancient and recently discovered algorithms. It is here that the student will begin to develop a maturity for designing computer programs.

The remaining computer course, designated as an elective, should again be chosen carefully. It may be that the student will use the elective for a second course in machine organization and assembly language as indicated above. Otherwise the student may prefer to take a course in a "practical" language such as Fortran or COBOL, or a 4GL, or a database language. C and Unix, and teleprocessing and networking are also important areas in which the selection can be made.

The sample curriculum outlined above is obviously very demanding. An alternative to the ACM based associate degree program is one that emphasises file structures and data mangagement rather than computer science. However such programs are not presently commonplace at four year schools although a working group representing ACM, DPMA, and IEEE-CS recently presented some guidelines for such a program at the Nineteenth SIGCSE Technical Symposium on Computer Science Education (p. 88). Furthermore some of these programs that have been in place for some time are heavily oriented toward COBOL programming, but the

demand for COBOL is slowly dying. (It is interesting to note that the career-oriented computer program at Bergen Community College did not have the day students to fill a single section of COBOL in the Spring 88 semester).

In contrast to the Associate of Science programs, the Associate of Applied Science programs can become more sensitive to the needs of local industry as they are not accountable to four-year institutions. Despite the claim that only graduates with bachelor's degrees are being hired, statistics show that the two-year graduates are still being placed in industry and indeed some do very well. In fact they may again be an important source of computing personnel if some of the predictions of a dire shortage of computer scientists come true (The Wall Street Journal, November 27, 1987). The skills needed in such programs seems to be toward micro-computers rather than main-frames. Software packages, fourth generation languages, C and Unix, and telecomunications seem to be areas of growth.

Summary

The design of the curriculum in computer studies involves many factors besides the actual computer knowledge that one wishes it to impart to the students. The curriculum must meet the goals of the mission of the college and be strongly supported by the college. Also it must satisfy the mandates of the New Jersey Department of Higher Education. If it is to be a viable transfer program, it must bear a strong resemblance to the

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programs at four-year institutes. On the other hand, if it is a career program, then it must be sensitive to the business/industrial community which, in a way, does not give the graduates top hiring priority. It must do all of these things while focusing on the special needs of the community college student.

Proposed Computer Science Associate of Science Degree Transfer Program

Area/Courses	Credits
Communications	
English Composition I	3
English Composition II	3
Humanities	
Elective	3
Elective	3
Social Sciences	
Elective	3
Elective	3
Mathematics	
Calculus I	4
Calculus II	4
Elective	3/4
Elective	3/4
Sciences	
Physics I (recommended)	4
Physics II (recommended)	4
Physical Education	
Fitness Concepts	2
Major Computer Information Systems Department	
Computer Science I	3
Computer Science II	3
Machine Organization and Assembly Language I	3
Data Structures	3
Computer Elective	3
Free Electives	
	3
	3
	63/65

Attachment I

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Computer Science I (3 credits; 3 lecture, 1 lab)

Computer Science I is an introduction to computer systems and structured programming. Programming logic and design are implemented through the use of a modern, block-oriented programming language. Topics include:

- the development and components of computer systems and software technology
- problem-solving methods emphasizing algorithmic procedures
- data typing and declarations
- input and output techniques
- sequence, decision, and repetition structures
- procedures
- array processing
- file processing
- character and string processing
- program documentation
- programming style
- testing and debugging

Attachment II

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Computer Science II (3 credits; 3 lecture,1 lab)

Computer Science II continues the study of developing structured programs through the theory and implementation of important computer algorithms and their underlying data structures. Concepts are illustrated through the use of a modern, block-oriented programming language. Topics include:

- recursion
- searching and sorting techniques and their analysis
- multi-dimensional arrays
- records and files of records
- sequential and random access of files
- sets
- various implementations of linked lists and other data structures
- design, coding, testing, and documentation of large, modular software systems implementing the above techniques and structures

Attachment III

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