COMPUTER SCIENCE AT A LIBERAL ARTS COLLEGE

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The Computer Science program at Hope College is described as an example of what can be done at a small, liberal arts college. The department attempts to serve the needs of all students at the college in a flexible and economically feasible way. This includes offering an interdisciplinary, applications-oriented major program.

Introduction

Computer science education has grown very rapidly in the last fifteen years with the development of many academic programs and departments. Most of this growth has occurred in the large universities with relatively little change apparent at the small liberal arts colleges. This report on the implementation of a computer science program at one small college is not intended to serve as a recommendation for others to follow. Rather, it is meant to suggest ideas and provide encouragement for those who are planning to implement or are in the process of implementing such a program at their liberal arts college.

History

Hope College is a Christian, liberal arts college with a tradition of excellence in science education. It's enrollment is about 2100 students. The beginning of computer science education on campus was in the middle sixties when an IBM 1130 computer system was installed and an introductory computer programming course was taught by a member of the Physics Department.

In 1969 a computer scientist was hired by the Mathematics Department to teach courses related to the computer. As more students were able to complete the introductory computing course, demand grew for a second course in computer science. After that there was demand for a third course, and then a fourth, etc.

In 1973, the Mathematics Department discovered that some students who were graduating as mathematics majors had only taken about half of the required number of upper level courses in mathematics, completing the remainder of their major requirement with computer science courses. In order to maintain the integrity of the mathematics major while retaining the popular new courses, the computer science courses were listed separately from mathematics and a new major was established called "mathematics with computing emphasis."

A separate Computer Science Department and a major program were created in 1974 under the leadership of David Marker, who was then Assistant Dean for the Natural Sciences and Director of the Computer Center at Hope College. The faculty of the new department was selected from faculty already on campus and all held joint appointments in Computer Science and some other department. Two were jointly in Mathematics, two in Physics, and one each in Psychology and Business Administration. Also in 1974, the IBM 1130 was replaced by a Xerox Sigma 6. The first major of the new department graduated in 1975.

In 1976 and 1977 five majors graduated and this number is expected to be about 10 in 1978 and the years following. The faculty now includes two full-time members and three with joint appointments. Approximately 200 students are introduced to the computer through coursework each year. This represents about forty percent of the entire student body who take a course in the Computer Science Department some time during their academic career.

Philosophy

The Computer Science Department at Hope College was established with three purposes:

1. To provide all students with an opportunity to become familiar with computers, their applications, and their implications.

2. To teach each student how to make appropriate use of the computer as a tool in his/her chosen career.

3. To provide each student desiring a career in computer science with a major program which is flexible enough to meet his/her individual needs.

A significant problem in a liberal arts college is to accomplish all of this in an effective and efficient way with the limited resources available. The approach taken at Hope College to solve this problem is to make the computer science program interdisciplinary, application-oriented, and flexible.

The interdisciplinary nature of the program is necessary from a practical standpoint since Hope College cannot afford a large staff of computer scientists and hence has to draw on the computer expertise located in other departments on the campus. This is also valuable from an educational point of view since faculty from other disciplines provide needed input in the development of programs for students who wish to learn how to use the computer as a tool. Such a "user perspective" is also useful to the computer science major. The interdisciplinary goal is accomplished on two levels. First, those faculty with expertise in computer science sufficient to permit them to teach courses in the department are given joint appointments. In addition, faculty who are interested in the use of the computer in their discipline are made a part of an advisory group to assist the Computer Science Department in planning and implementing a program.

The program is application-oriented in that all computer science taught by the department is intended to be useful for solving problems. The interdisciplinary nature of the department helps to insure that the program retains this emphasis. This is important because the size of the department makes it impossible to offer separate courses for students majoring in computer science and those majoring in other disciplines. Therefore, the curriculum must be able to serve both simultaneously. In recognition of this goal, efforts are made at all levels to give the students practical experience in the use of the computer

Finally, due to the many diverse areas of computer science and the range of interests of the students, the program has to be very flexible. The prescribed portion of the curriculum is thus minimized and a wide range of elective possibilities is available both within and outside the department.

Curriculum

The curriculum has been developed to meet the needs of three types of students: students desiring an exposure to computers, students who need to use the computer as a tool, and computer science majors.

One of the great difficulties has been that of finding a suitable way to introduce all three of these groups to the computer in an efficient way. Thus far we have tried offering one course for all students, offering three versions of one course, and offering three separate courses. None of these approaches has been satisfactory. We are currently in the development stages of another approach, a modular, multi-path introductory computing course which would allow each student to progress at an appropriate pace and learn the techniques and languages which will be most useful. The new course will be able to do this within the staffing constraints of the small, liberal arts college. A report on this course will be forthcoming after some experience is gained in its use.

A list of all courses currently offered by the department is found in the Appendix. All of these courses have been designed with the needs of the non-major in mind. For example, the Computer Program and Organization course is appropriate for students in all areas who want to add to their understanding of computers and problem solving. Numerical Analysis is designed with the applications of scientists and engineers occupying a prominent place in the course. Applications are stressed similarly throughout the curriculum.

The major program in computer science does not follow exactly any of the many recommended curricula, but much helpful input has been derived from several sources. These are listed in the Bibliography and are important resources for anyone considering the implementation of a computer science curriculum at a small college.

The Hope College major in computer science is divided into four components. Each student must complete each of the four components and contracts with the department on the manner in which each of the last three will be fulfilled. The four components are described below.

1. Core Component: This component consists of four courses beyond the introductory computing course and is required of all majors. The courses are Computer and Program Organization, File Management, Data Structures, and Programming Languages.

2. Elective Component: A minimum of four additional computer science courses are required. These are chosen to match the student's needs and interests. Choices can be made from any of the computer science courses not included in the core and the Electronics course offered by the Physics Department. At least two special topics courses are offered each year in computer science to meet the special needs and interests of the students. These courses may be retaken as often as desired with different topics. They provide an important method of attaining the desired flexibility.

3. Application Component: Each major must complete a sequence of courses outside of computer science which constitutes a strong preparation in an area to which the computer can be applied. This is normally six courses, but this may vary with the student's needs. These courses may all be from one department's offerings, but frequently span several departments. Common choices are business, mathematics, physics, and chemistry.

4. Experience Component: This component has four phases. The first is in computer operations which the student usually begins during his/her Sophomore year. In this phase the student gains experience by serving as an operator in the college computer center.

In the Junior year, the student begins the consulting phase of the experience component. This consists of doing programming consulting work with other students, faculty, or off-campus computer users.

No credit is awarded for either of the first two phases of the experience component, but the students are paid for their work. The last two phases both result in academic credit. The first of these is the Independent Study/Research phase in which the student completes a project of his/her own design under the supervision of a faculty member.

The fourth phase is the Internship. The student works in a computer installation off the campus for approximately 10 hours a week for a semester. Both the Independent Study/Research and Internship phases are completed during the Senior year and the projects are chosen to be suitable for each individual student.

Conclusions

The program has been successful from several points of view. First, the students have been enthusiastic in their enrollment and participation and graduates have reported their experience at Hope appropriate for their later work. Although preparation for graduate school is not one of the primary goals of the program, three graduates in the last two years have performed very well in computer science graduate programs. In addition, many graduates go on to study for graduate degrees in other fields, such as the M.B.A.

The second group for whom the program is a success is the faculty. They find their work very challenging and rewarding. The interdisciplinary nature of the department helps to promote faculty growth in new areas of computer science.

The college also is pleased with the program because it is attractive to prospective students, it strengthens the offerings of other disciplines, and it is one of the most cost-effective departments on campus.

The final group to rate the program a success is the prospective employers who offer fine opportunities to our graduates each year.

Plans for the future, in addition to the modular introductory course, include the establishment of a minicomputer laboratory for use by students in hardware, software, and application experimentation. New courses which will be added in the near future are Business Information Systems, Hardware and Software Systems, Data Base Management, Modeling and Simulation, and Computer Graphics.

Bibliography

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4. Committee on the Undergraduate Programs in Mathematics (CUPM) Recommendations for an Undergraduate Program in

Computational Mathematics CUPM, Berkeley, California, 1971.

5. Curriculum Committee on Computer Science "Curriculum '68, Recommendations for Academic Programs in Computer Science" Communications of the ACM 11,3(March, 1968), 151-197.

6. Curriculum Committee on Computer Science "Curriculum Recommendations for the Undergraduate Program in Computer Science: A Working Report" SIGCSE Bulletin 9,2(June, 1977), 1-16.

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APPENDIX

Hope College Computer Science Courses 1977-78

180. Introduction to Computer Science - Introduction to problem solving. Introduction to computers. Fortran programming language. Programming style and technique. Experience solving problems by computer. Interactive computing and BASIC programming language programming.

280. File Management - Overview of data processing. COBOL programming. File organization. Internal and external sorts. Report design. Common data base concepts. Analysis of specific problems and their solutions. Prerequisite: Computer Science 180.

282. Computer and Program Organization - Structured programming. Debugging and testing. Introduction to machine organization and assembly language programming. Advanced programming techniques. Introduction to a second higher level language. Prerequisite: Computer Science 180.

295. Studies in Computer Science - A course offered in response to student interest and need. Deals with topics in computer science which are not included in regular courses. Recent topics have been The Psychology of Computer Programming and Artificial Intelligence.

331. Process Control - Control of experiments and processes using microcomputers. Theory of discrete and continuous sampling methods of control. Experience programming microcomputers to illustrate problems of control, data manipulation and data analysis. Skill will be developed in assembly language programming and an understanding developed of the relationship between assembly language and hardware. Prerequisites: Computer Science 180 and one year of science laboratory.

332. Process Control Laboratory - Application of control methods in Computer Science 331 to actual systems. Interfacing microcomputers with terminals, displays, analog to digital converters, and other input-output devices. Application of microcomputers to data acquisition and on-line data analysis. Prerequisites: Computer Science 331 and Electronics.

372. Numerical Analysis - The source and analysis of computational error. Finding the solution of an equation. Systems of linear equations. Interpolation and approximation. Numerical integration. Ordinary differential equations. Prerequisites: Computer Science 180 and Calculus.

375. Operations Research - Decision making using mathematical modeling and optimization theory. Linear programming. Network analysis. Dynamic programming. Game theory. Computer programs will be written to implement these techniques. Prerequisites: Computer Science 180, Calculus, and Linear Algebra.

381. Data Structures - Description and use of data structures. Software and programming language implementation. Storage allocation and management. Searching and sorting techniques. Applications of data structures. Prerequisite: Computer Science 282.

383. Programming Languages - Survey of programming languages. Programming language syntax. Theory of computation. Control structures. Recursion. Language extensibility. Application languages. Specific languages Fortran, ALGOL, APL, and PL/I will be treated in detail. Prerequisite: Computer Science 282.

490. Independent Study and Research in Computer Science - Independent study or research project carried out in some area of advanced computer science or in the application of the computer to another discipline. This project will be carried out under the supervision of one or more designated staff members.

491. Internship in Computer Science - This program offers the student an opportunity to work on a project or an experience approved by the department as being of significance in computer science. This is usually done off campus and the student will

have a qualified supervisor at the site of this experience in addition to a faculty advisor. This course is normally open only to senior computer science majors.

495. Advanced Studies in Computer Science
A course designated for junior and senior computer science majors which covers an advanced topic in computer science. Recent offerings have been Systems Programming and Business Information Systems. This course is offered at least once each year and may be repeated for additional credit with a different topic.