ABSTRACT
        The state of California and System Development
Corporation have developed, implemented, and evaluated a training
program in computer programing for the blind and visually impaired.
Students are selected according to general aptitude, interests,
general intelligence, previous educational achievement, health, and
personal qualities. The eight-month course in programing involves 120
classroom hours per month. The curriculum is modular to allow
flexibility in introducing new computer technology and languages as
they become available. Students record lectures on tape recorders.
Closed circuit television systems for low-vision persons and the
Optacon for the totally blind are also used. Recorded and brailled
reference materials are available to the students, and classroom
handouts are reproduced on a braille duplicator. Student retention in
the program and job placement and performance have been successful.
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TRAINING BLIND AND VISUALLY HANDICAPPED COMPUTER PROGRAMMERS

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In 1966 System Development Corporation was tasked by the California Department of Rehabilitation to develop a pilot program to test the feasibility of training the blind and visually handicapped to become computer programmers. The success of the pilot test resulted in establishment of the first such on-going training program in private industry. The Department of Rehabilitation is responsible for the screening and selection of candidates for the training. System Development Corporation conducts the eight month training program, using their professional staff and facilities. The students record the class lectures on tape or take notes in braille. The instructors are very concise and explicit in presenting the material. During the study periods the students utilize the CCTV readers, the OPTACON, and brailled material to help them study. Student retention and placement have been very successful. Job performance of graduates has been highly praised by employers.

During the past decade, the State of California, in conjunction with System Development Corporation (SDC), has developed, implemented, and evaluated a training program in computer programming for the blind and visually impaired. Although programming is generally thought of as a field that requires vision, it is chiefly an analytical task, and is well suited for either sighted or blind persons with intelligence and an interest in problem solving. SDC's program has demonstrated that qualified blind persons can be trained as programmers in much the same way as sighted students are trained.

The success of the program over the past ten years has been due primarily to intensive screening and realistic selection of candidates for the training, high standards in the conduct of the training, and professional ethics in the placement of the students.

In the summer of 1966, System Development Corporation enrolled a blind person in one of its regular programmer training courses as an experiment. With little additional assistance beyond those aids generally available to the blind, he met the same demanding standards, followed the same curriculum, and used the same instructional materials available to the sighted students. After successful graduation from the four-month program, he was employed by a well-known computer company in the Los Angeles area, and is still employed in the computer programming field. The experiment definitely worked, and in the

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fall of 1966, under the sponsorship of the California Department of Rehabilitation, SDC began a programmer training course for 14 visually-impaired persons.

During the next ten years over 120 persons were enrolled in the course. About 85% of the students completed the training, and about 76% of the graduates have found employment as computer programmers.

Selection of Students

The selection of students to participate in the program is primarily the responsibility of the California Department of Rehabilitation. Rehabilitation Counselors throughout the state are continually looking for clients that may qualify for the program. Students are selected from the candidates screened. The criteria are:

1. High scores on a battery of general aptitude and reasoning tests;

2. Acceptable keys on an interest inventory;

3. A range from bright normal, and above on the WAIS intelligence test;

4. Two years of college or equivalent, with courses taken in mathematics, science, or business preferred;

5. Reliability;

6. General good health; and

7. The ability to make an acceptable impression on employment interviews.

Other prerequisites include training in all areas of mobility, the ability to read and write large print or Grade II braille, and the temperment to cope with the detail and attendant frustrations normally associated with the programming task. Though qualification is difficult, selection is flexible, and candidates having outstanding ability in areas other than the required criteria may be considered. Further screening is done in a personal interview with the instructional staff. This interview also allows the client to evaluate the program in terms of his expectations and needs.

Curriculum

The eight-month course involves approximately 120 classroom hours per month at a rate of six hours per day. The curriculum has been modularized to allow flexibility in introducing new computer technology and new languages as they become available. The first module of the program (the general Programming Module) introduces the students to the basic concepts of system analysis and design. A description and review of computer hardware is given. The techniques of problem solving, stressing logical reasoning and sequential

thought, are given in-depth consideration to prepare the students to work, easily with computers. This module also teaches program design, data organziation and manipulation, retrieval techniques, and complex data structures. Flow diagramming and numbered statements are used to indicate program logic.

Following the general programming module the student is ready to learn a computer assembly language. The second module covers the IBM 370/158 hardware and the assembly language for this machine. The student codes, runs, and debugs computer programs at the machine-language level, thus developing a strong basis for learning other computers and higher-order languages. This module also includes an introduction to operating systems, concepts, and facilities. Emphasis is placed on the role of operating systems in the present-day computer system networks to make it easier to program and use computers.

In the next module, the students learn COBOL and PL1 and are introduced to other higher-order programming languages. Programs are written, compiled, debugged, and tested. A major student project, which must be completed by every student, is to code and run a payroll accounting application.

The final portion of the course is devoted to a workshop where each student either selects or is assigned a project to pursue individually. This project experience prepares the student for a realistic work environment and strengthens independence and self-assurance. The workshop is interspersed with a series of seminars based on the state-of-the-art topics. Subject matter specialists are solicited from the computing industry to lead the various seminars. The course ends with a comprehensive review of all the material covered.

Teaching Techniques and Aids

The six-hour classroom day usually starts with homework review and continues with lecture presentations for the rest of the morning. Afternoons are generally devoted to practice problems that provide an opportunity to implement the new information. The classroom environment used is the same as that for sighted students. The wall-to-wall chalkboards are used by the instructors to keep themselves oriented and to help maintain continuity of presentation. (One of the instructors who taught the first class started writing notes on the blackboard, making very large letters so that everyone could seem them. At the break-time, one of the students walked up to the board and began to trace the shapes of the letters with his magnifying glass.)

During the lectures, the instructors must over-verbalize the technical material presented. When specific language formats are discussed they must be explicitly stated, including all punctuation. The lecture material is recorded on tape by the individual student and becomes his primary reference source.

Originally, the students had only reel tape recorders, which were bulky and hard to transport back and forth between home and school. With the appear- of the tape cassette recorders about 1971, tape recording became much easier.

Cassettes are easier to use and to edit, and are much more portable. Students are allowed to braille their notes during lectures if they wish, but they are encouraged instead to record the lectures and then braille them as they edit the tapes.

One of the major means of communication among programmers is the flow chart showing the logic of the problem solution. In the early days of the program flow charts were prepared by imprinting the symbols on braille paper with a stylus. This procedure became very laborious, so numbered statements were introduced to communicate program flow. The numbered statements also proved helpful in teaching higher-order languages.

Early in the school year, partially-sighted students who have not had a low-vision evaluation are scheduled by the Department of Rehabilitation to visit the low-vision clinic. Students are provided with such individual aids as monoculars for use in reading the chalkboard, lighted magnifying glasses, and appropriate changes in their eyeglass prescriptions to help them to see their work better.

The large volume of reference material and program documentation involved in programming is difficult to handle even for sighted programmers. (There was a cartoon in Datamation magazine showing two men looking at a large and small box. . . . The caption said, "You're wrong, the small box contains the computer, the large one contains the documentation.") How does the visually-impaired programmer cope with this problem? Two recent developments have done much to aid the visually handicapped in handling printed material: closed circuit television (CCTV) systems for low-vision persons and the Optacon for the totally blind.

The CCTV systems are used to enlarge printed or other material and transmit it onto a TV screen. Most systems are equipped with the reversal reading modes for black on white (positive) or white on black (negative). Most of our students have preferred the negative, white on black. A reader board with x/y movement is available. A recently-developed feature is the electronic-window. This is an adjustable device on the TV monitor for limiting viewing to one horizontal line or sentence at a time. Students in the SDC program found it useful in reading computer printouts and making corrections, because they could zero in on the line with the mistake and hold it until the correction was made.

Some students who have thought they did not have enough vision to use a CCTV system have learned to use one while attending class. A student with "travel vision" tried out the CCTV: Although he could ready only a letter or two at a time, he found that using the system helped him tremendously in debugging his programs. He now uses a CCTV on the job and also has one at home.

We are aware of experimentation with another way to utilize the CCTV in the classroom. The camera is tilted or hand-held and used to read from the chalkboard. Although we have not experimented with the idea yet, research

has been done on the use of a monitor at each desk with a teacher-controlled camera. The reports of this work were very encouraging and of interest to us. (Sam Genensky, RAND Corporation.)

For the totally blind there are many tactile devices. One such device that has proven quite satisfactory is the OPTACON, made by Telesensory Incorporated. The OPTACON consists of a hand-held electronic scanner and a sense box. The fingers are placed on the sensor and the outlines of letters are transmitted to the finger tips. The letter height and width can be adjusted on the scanner. Because computer printouts are usually all in capital letters or numbers, and because the characters are uniform, people have been able to use the OPTACON rather easily to read printouts. Students have acquired reading speeds from 25 words per minute to over 70 words per minute, with practice. The OPTACON can be used to read printouts from a terminal, and a special attachment is available for use with video display equipment.

Recorded and brailled reference materials are also available to students, as are the services of readers to assist them in studying.

To prepare input for the computer, students initially design their programs using numbered statements coded in braille. Students can then keypunch their own programs, record their programs on tape for later keypunch, or type them and send them to a keypunch installation. Some keypunch operators prefer the clarity of a typed program to the squiggles done by most sighted programmers on a codeing sheet.

Instructor supplied classroom materials are developed for the class in several ways. Student handouts can be prepared in large print for those who have sufficient vision to use them, or brailled by means of an IBM electric typewriter with standard keyboard and brailled hammers. Multiple copies of brailled material are reproduced on a braille duplicator called a Thermoform. Instructors may also tape-record information before class. Reference books are available from Recording for the Blind.

Because of the ever-changing requirements on the computer industry, dependency on pre-recorded and brailled references is minimized. The technical reference manuals may be updated 2 or 3 times before the original recording can be completed. The sheer bulk of brailled and recorded information also creates a storage and retrieval problem.

Summary

The training of visually-handicapped persons in the field of programming has been an exciting and worthwhile endeavor. Thanks to the energy and intelligence of the students, the resourcefulness of the trainers, and the growing number of aids and materials available, visually-impaired and blind people are making their talents available to the computer field.

ABOUT THE AUTHORS

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Mr. James P. Sigl is a Computer Programmer Analyst, Sr. at System Development Corporation. He is a graduate of Visually Handicapped Programming Class conducted 10 years ago and has been employed at SDC since that time. Mr. Sigl is the principal instructor for the course. Having gone through the training himself, he serves as an outstanding example for each new class. Mr. Sigl has a Bachelor of Science Degree in Economics from Sacramento State College.

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