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UTILIZATION OF COMPUTER FACILITIES IN THE MATHEMATICS AND BUSINESS CURRICULUM IN A LARGE SUBURBAN HIGH SCHOOL.

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*COMPUTER PROGRAMS, *COMPUTERS, DIGITAL COMPUTERS, *MATHEMATICS CURRICULUM, *HIGH SCHOOL STUDENTS, *DATA PROCESSING, STUDENT PARTICIPATION, INSTRUCTIONAL INNOVATION, PROGRAMING, INFORMATION SYSTEMS, INFORMATION RETRIEVAL, CLEVELAND, OHIO, EUCLID

A STUDY WAS UNDERTAKEN TO EXPLORE IN A QUALITATIVE WAY THE POSSIBLE UTILIZATION OF COMPUTER AND DATA PROCESSING METHODS IN HIGH SCHOOL EDUCATION. OBJECTIVES WERE--(1) TO ESTABLISH A WORKING RELATIONSHIP WITH A COMPUTER FACILITY SO THAT ABLE STUDENTS AND THEIR TEACHERS WOULD HAVE ACCESS TO THE FACILITIES, (2) TO DEVELOP A UNIT FOR THE UTILIZATION OF SUCH COMPUTER AND DATA PROCESSING FACILITIES IN THE MATHEMATICS PROGRAM AT EUCLID SENIOR HIGH SCHOOL, (3) TO DEVELOP A CURRICULUM UNIT AND TEACHING METHODS FOR THE UTILIZATION OF SUCH COMPUTER FACILITIES IN THE BUSINESS EDUCATION PROGRAM, AND (4) TO DISCOVER AND IMPLEMENT WAYS TO USE THE COMPUTER FACILITIES IN EXTRACURRICULAR ACTIVITIES AT THE HIGH SCHOOL. AFTER A SATISFACTORY METHOD OF COMPUTER ACCESS WAS ARRANGED THROUGH THE CASE INSTITUTE OF TECHNOLOGY, PROGRAMS WERE WRITTEN AND PUNCHED INTO CARDS BY 70 STUDENTS. THROUGHOUT THE PROJECT ILLUSTRATIONS OF MATHEMATICS WERE EMPHASIZED, NOT DETAILS OF COMPUTERS. ALL PROJECT OBJECTIVES WERE ACHIEVED. THE CURRICULUM UNIT WHICH WAS DEVELOPED WILL BE EXAMINED AND IMPLEMENTED AT THE SCHOOL. (JC)

5-8118

UTILIZATION OF COMPUTER FACILITIES IN THE MATHEMATICS AND BUSINESS CURRICULUM IN A LARGE SUBURBAN HIGH SCHOOL

Cooperative Research Project No. S-232

by

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PROBLEM

Recent developments in the area of computer science and computer mathematics make it expedient that all citizens be aware of the implications of these devices. Little work has been done to apply these devices to the high school cirriculum. Inclusion of topics related to the computer and data processing would add materially to the educational experience of high school students.

Hand methods of data processing are being replaced at a rapid rate. As a result, the men and women who will work with records must become familiar with automatic methods of handling them. Training in logic is provided when students program any problem for the computer. This is particularly true in the subject areas of mathematics and business education. Not only is the preparation of teachers to train the students a matter of increasing interest to the local community, but will eventually become a problem that knows no geographic boundaries. Employment trends in the United States projected to 1970 reveal a continuous growth of white-collar, blue-collar, and service occupational groups. Even today, one out of every six employed persons is doing clerical work. It is clear that this type of training is to play an increasingly important role in American education and is of vital importance to the future economy of the country. The discovery and working out of these applications merits study.

Supplying educational experien[illegible] will help develop these skills in high school students requires careful planning of the facilities and logistics needed to make available the hardware and materials for such a program. Also, attention must be given to the training and organization of staff members to carry out such an educational program.

For some time the influence of digital computers and data processing methods have been apparent in industry and this has been reflected in the college curriculum and vocational training programs. However, relatively little effort has been directed toward the introduction of computer mathematics and data processing methods into the high school curriculum.

The purpose of this study was to explore in a qualitative way the possible utilization of computer and data processing methods in high school education.

OBJECTIVES

1. To establish a working relationship with a computer facility so that able students and their teachers will have access to the facilities of a large-scale computer and to auxuliary equipment such as card sorters, collators, card punches, key punches, accounting machines, and magnetic tapes.
2. To develop a unit for the utilization of such computer and data processing facilities in the mathematics program at Euclid Senior High School.
3. To develop a curriculum unit and teaching methods for the utilization of such computer and data processing facilities in the business education program at Euclid Senior High School.
4. To discover and implement ways to use the computer facilities in the extracurricular activities of a comprehensive high school.

PROCEDURE

The first step was to obtain access to a computer facility. Arrangements were made with Case Institute of Technology to use the Andrew Jennings Computing Center which has a Univac 1107 capable of processing and executing programs in Fortran, Algol, Cobol, and Sleuth II. The system is card oriented and has ten tape drive units. This particular configuration has been specifically designed for easy access by students and therefore was ideal for small-time use by high school students.

Two possible methods of operation were apparent. Either the students could be transported to the Computing Center and thereby have essentially hands-on experience with the system or the student's work in the form of programs on punched cards could be carried to the Center by a courier service and the printout returned to the student. Initially, the transporting of students was attempted, but this proved to be too expensive and time consuming for regular operation. Later, the students were taken to the Center at least once and then subsequent programs were run via courier service. The majority of student runs were made by a teacher who acted as courier and machine operator.

A schedule was arranged for collecting student programs, carrying programs to the center, running the programs, and returning the printout to the student. For a group of 70 students, two trips per week were sufficient for steady progress. A set of 50 student programs would constitute about 1,000 cards, would take about ten minutes of computer time, and would yield about 200 pages of printout. The printout and the original program cards were then bundled by a secretary and returned to the student. The logistics of this operation is by no means trivial. Any high school that wants to give a large number of students direct access a computer must make provisions for this.

By this procedure, about 70 students were able to work on computer projects related to their regular class work. However, progress by this method is slow. With only two passes possible per week and an average of four passes necessary to debug a program, it often took as much as a month for a student to write, debug, and check a given program. This clearly points up the advantage of an on-site installation where the student could make multiple passes and do immediate debugging.

In order to communicate with a computer by any means other than console input, the student must have some method of preparing programs and data for input. This preparation may be done via keypunch or punched paper tape. The Case installation is card oriented so it was necessary for students to have access to a keypunch machine. This proved to be a prime necessity. The Euclid Board of Education approved the rental of an IBM keypunch machine which was made available to the students before school, during lunch periods, during study halls, and after school. A log of student use of this machine shows it was used by approximately ten students per day and showed almost continual use for nine hours per day during some peak periods. This heavy, voluntary use of the keypunch by students on their own time was a clear indication of the enthusiasm for the work.

Before students can keypunch programs, they must have some introduction to the keypunch machine. Some students in the business curriculum had experience on the machine, but students in math courses are mostly college preparatory and had no prior keypunch training. These students were given a short (20 minutes) introduction to the machine in small groups (5-7 students). This proved to be sufficient introduction, and students could thereafter punch their own programs and data. Some attempts were made to arrange for business education students to punch programs for the math students. This was not successful.

Students were introduced to the basic elements of computers and to the ALGOL language at the outset. The objective was to give a minimum of instruction concerning the nature and operation of the computer and to proceed as directly as possible to the compiler language (ALGOL). A short course (one week) was sufficient to acquaint students with the abbreviated ALGOL and to write simple illustrative programs. During this time all students were given a short introduction to keypunch operation. After this introduction to techniques, some simple programs were written by the students. These first programs were designed to help the student gain familiarity with the ALGOL language and to illustrate the connection between computer oriented mathematics and algebra. Programs illustrative of this phase include the evaluation of a function, the ordering of a set of numbers, and the determination of square roots by Newton's method.

Upon completion of the introductory phase, a test was given to measure the students mastery of the basic elements of the ALGOL language. This test is reproduced in Appendix I.

At the conslusion of this introductory phase, the classes then proceeded to study the regular course content which in this case was advanced algebra. Throughout the remainder of the year, topics in algebra were continually related to computer mathematics; and students worked on computer programs that illustrated the algebra. Many of these problems were long-term projects for the students and, thus, only a limited number of programs could be run by each student. During the course of the year, each student wrote an average of 12 programs. Most of these problems were carried out on an individual basis, and there was a wide variation in student success as measured by the number of programs run successfully. A set of problems illustrative of this phase is included in Appendix II.

During the senior year, the students were given a brief refresher in the computer language. These students take analytic geometry and calculus. The process of using selected computer programs to illustrate the mathematics was continued in this course. A set of sample problems for this phase also appears in Appendix II.

Consideration was given to the introduction of basic computer and data processing techniques in the business education curriculum. Specifically, an attempt was made to introduce the ALGOL or COBOL language into the bookkeeping course. This venture proved unsuccessful. The teacher of bookkeeping concluded that the ability of the students in this course would not allow for the introduction of the abstract concepts necessary in programming.

Trips to the Case Computer Center were an integral part of the operation. All students involved in the program were taken to the Computer Center at least once. It was found better to arrange for a series of small groups to visit the Center rather than taking the whole class at once. Small groups were given a personal tour of the Center and had an opportunity to put cards through the machine and otherwise participate in the operation. These trips were scheduled after school in the late afternoon. After students had visited the center, they had a beginning notion of what happened to their programs and thereafter were willing to send their programs by courier service and receive only the printout. Business students who were not actually writing programs were also taken on these trips. This proved to be a valuable experience for these students. They could thereby gain some appreciation of the nature of a modern high speed computer installation. Indications are that such a trip would be a valuable educational experience for any high school student. Trips were also arranged for members of the teaching and administrative staff. This served to give professional employees some indication of the possible uses of a computer in high school education.

A questionnaire was sent to a group of local industries inquiring concerning the future employment opportunities in data processing and computer technology in this local area. The questionnaire used was adapted from the "Des Moines Story." The questionnaire is qualitative but serves to give basic information concerning the needs for workers in this area. The questionnaire is reproduced in Appendix III.

The Math Club made extensive use of the keypunch and computer access during the project. Weekly meetings of the club were replaced by a continuous activity built around the computer problems. The

Math Club thus became an extension of the regular math curriculum rather than a separate entity. The emphasis upon computer mathematics resulted in a much wider student interest in the Math Club. A computer program was written to determine from extensive numerical criteria which students were to be inducted into National Honor Society.

RESULTS

A satisfactory method of computer access was arranged. Basically, programs were written and punched into cards by the students at the high school and then were carried to the computer and run by a teacher. Other methods of operation were studied and evaluated:

1. Transport students to a computer center. This process seems feasible for small groups of students but becomes very cumbersome when large groups are involved or when attempted on a regular basis. Scheduling of students, mode and cost of transportation, disruption of other courses, and imposition on the computer center are some of the problems that arise with this method.
2. Purchase or lease of computer for use in high school. A wide range of computers are available in a wide price range ($10,000 up). A low priced computer will use machine language only, and so considerably more time is necessary to bring the student to the place where he can

write meaningful programs. Altogether too much time is spent learning the machine language and coding problems into this language. More expensive computers will process algorithmic language programs and thus are much better suited for teaching computer oriented mathematics. Obviously, the cost of such a system may be prohibitive for a local school system. However, if the computer can be used for other purposes within the school system, such as student scheduling, payroll, inventory, and student records, the cost may be justified.

3. Telephone access to computer. Various devices are available which transmit programs via telephone lines to a remote computer. At least two companies (IBM and GE) already offer this service. Under this system the student has direct access to a large scale computer and can communicate in an algorithmic language. The cost of such a system is about $500 per month.

Extensive use of computer mathematics was successful in college preparatory math courses (Advanced Algebra and Calculus). An abbreviated ALGOL language was used. This consisted of a minimum set of symbols and statements with which the students could write meaningful programs. An outline of this abbreviated ALGOL is shown in Appendix IV. Students were also issued the complete ALGOL manual for the Univac 1107 system. This approach was very successful. Students could write their own programs after a very short time and a minimum of time was used in learning the language. As a result, more time could be devoted to the mathematics. Throughout this project the illustration of mathematics was emphasized, and the details of computers and computer language was not emphasized.

It was found that the computer serves as a useful tool to illustrate many of the ideas of algebra and calculus. Further uses were found in physics and chemistry. Student interest grew rapidly in many forms of computer utilization. In addition to programs illustrating mathematics and science, students wrote programs related to English, language analysis, language translation and simple games. Students also wrote programs which were useful for administrative purposes.

As an outgrowth of this program, computer mathematics will continue to be used in the mathematics and science courses. Attempts will be made to involve more students. However, this expansion is limited by the cost of making facilities available and the ability of the students. Starting in 1966, a full course in computer mathematics will be offered. Basic statistics and numerical analysis will serve as the subject matter base, and the computer will serve to illustrate the developments. A study is already well under way pursuant to the purchase of a small computer which could be used in an administrative and data processing capacity as well as within the curriculum.

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APPENDIX I

<u>What does each program fragment do?</u>

1. A(1) = 1$ A(2) = 1$ I = 3$

   TEST.. A(I) = A(I-1)+2(A(I-2))$

   WRITE (A(I))$ I = I=1$

   IF I LEQ 100 THEN GO TO TEST$

2. FOR J = 1 STEP 1 UNTIL 100 DO

   IF A(J) GTR 0 THEN S = S+A(J)$

3. FOR K = (1, 1, 100) DO

   S = S+(A(K))*(A(K))$

   S = S/100$

   WRITE (S)

4. WRITE COMPLETE PROGRAM to find and write out the average of the first 100 square roots of natural numbers.

5. Given that the expression LN(x) denotes the natural log of x, write complete program to write out $\log_{10}$ (100!)

6. Write a program fragment using a FOR statement which simplifies the program in problem 1 above. Make sure that exactly the same answers are to be output.

APPENDIX II

The following set of projects is taken from a wide variety of mathematics.

I. Projects related to algebra

a. Write a computer program in ALGOL which will compute and output N factorial for values of N from 1 to 10.

b. Write a program which will: 1) find all the prime factors of any N ($N \leq 1000$) which is to be input as data; 2) will print the original number N followed by its prime factors with repeated factors repeated in the printout.

c. Write a program which will output N followed by its square root which is to be computed by successive approximation or Newton's method using values of N from 1 through 200.

d. Same as above except that cube roots are to be approximated rather than square roots.

e. Write a program which will output a compound interest table where T varies one year at a time from 1 to 50 and R varies from 3 percent to 5 percent in intervals of 0.25 percent.

f. Write a program which will output the first 100 terms of the recursive sequence specified by A(N) = A(N-1) + A(N-2) starting with A(1) = A(2) = 1. Also compute A(100) formula:

$$A(N) = \left(\left(\frac{1 + \sqrt{5}}{2} \right)^N - \left(\frac{1 - \quad 5}{2} \right)^N \right) \Big/ \sqrt{5}$$

g. Write a program which will input coefficients A, B, and C for general quadratic equation $Ax^2 + Bx + C = 0$, determine whether the equation specified is meaningful, and output roots or message describing nature of equation if roots fail to exist.

h. Write a program which inputs coefficients for a cubic equation, determine that the equation specified is cubic, approximates a first root by regula-falsi method, finds coefficients of the depressed quadratic equation by synthetic division, computes the two roots of the depressed equation, and outputs original coefficients and the three roots.

i. Write a program which inputs coefficients for a cubic equation, solves cubic equation specified by method of Cardan, and outputs original coefficients followed by the three roots.

j. Write a program which will input N followed by an N by N matrix, compute the determinant, and output original matrix and its determinant.

k. Write a program which will input a matrix and output the original matrix and its inverse or a message that the inverse does not exist.

l. Write a program which will output a table of base two logarithms of numbers from 1 to 10 in steps of 0.01 printing 10 values on a line.

m. Write a program which will input N followed by N items of data and output the data followed by mean and standard deviation.

n. Write a program which will input N followed by N items of data and output the data in original order followed by the items in ranked order from largest to smallest.

II. Calculus

a. Write a program which involves a limiting technique to determine an approximate value for each of the following:

1. $\lim_{x \to 0} \frac{\sin(x)}{x}$

2. $\lim_{x \to 0} \frac{e^x - 1}{x}$

3. $\lim_{x \to 0} \frac{\ln(x)}{x}$

4. $\lim_{x \to 0} (1 + x)^{1/x}$

b. Write a program to determine the least integer k such that $\sum_{n=1}^{k} 1/n \geq 20$

c. Approximate the slope of the tangent line to the curve $f(x) = e^x$ at $x = 1$ by finding $m_2 = \frac{f(1 + \Delta x) - f(1)}{\Delta x}$ and $m_1 = \frac{f(1 - \Delta x) - f(1)}{- \Delta x}$ for smaller values of Δx until m_2 and m_1 differ by .00001 or less. Also printout f(1).

d. Write a program to output a table of natural logarithms for x = (.1, .01, 10) with values to be found from definition of ln(x) using trapezoidal approximation.

e. Compute a table of functional values for the function defined by $f(x) = \int_0^x e^{-x^2} dx$. Approximate $\lim_{n \to \infty} f(x)$.

f. Approximate $\int_0^1 \frac{dx}{1 + x^2}$ using larger values of n until abs (inscribedsum - circumscribedsum) is less than 0.00001.

g. Solve $x \cdot \log_{10}(x) = 1.2$ by using Newton's method.

h. Find the central angle of a unit circle which subtends an arc whose length is three times the distance from the center of the circle to the chord of the arc.

i. Express the length of arc of the segment of a parabola $y = x^2$ between the vertex and P(1, 1) by a definite integral. Use n = 100 to approximate this integral.

III. Trigonometry

a. Write a program which will read in three pair of coordinate numbers and output the perimeter and angles of triangle specified or a message stating coincidence or collinearity of the points.

b. Given series expansion formula sin(x) and cos(x): 1) determine the value of π and 2) output values of sin(x) and cos(x) with x ranging from 0 through 90 degrees.

c. Write a program which will output a table giving range of a projectile as muzzle velocity varies from 1000 to 3000 ft/sec and angle of elevation varying from 0 to 90 degrees.

d. Write a program which will output a graph of a damped sine curve specified by $y = e^{-kx} \cdot \sin(x)$ using values of x from 0 to 150 with increments of 0.2. Determine k so that the half-life is approximately one page of print and center the graph on entire page.

IV. Physics and Chemistry

a. Write a program which will output a table of position and velocity as a function of time for an object dropped from a height of 100 feet. Use time intervals of 0.01 sec.

b. Same as above except that a retarding force = -kv is to be included. Use k = 0.01, 0.05, 0.1 and 0.5.

c. Write a program which will output a table of period and velocity as a function of altitude for a satellite in a circular orbit.

d. Write a program which will output a table of volumes and pressures for a one mole sample of ideal gas at temperatures 200 - 350° kelvin.

e. Write a program which will output temperature and volume as a function of time for a sample of liter of water at T = 0°C in a 2 liter container if 100 drop or 10 ml of water at 95° is added every second. Note that the volume increases to 2 liter during the first 100 sec and that after 100 sec, 10 ml of water at the present temperature overflows every second.

APPENDIX III

1. What type of DP employees have you added to your staff in the last year?

A. Key Punch Operators?	How Many?	______
B. Machine Operators?	How Many?	______
C. Supervisory Assistants, Methods Analysts, etc?	How Many?	______
D. Supervisors?	How Many?	______

II. What was the source of these additions to your staff? (state number)

	Direct Hiring	Transfers from Other Departments
A. Key Punch Operators?	______	______
B. Machine Operators?	______	______
C. Supervisory Assistants, Methods Analysts, etc?	______	______
D. Supervisors?	______	______

III. In general, was difficulty experienced in finding qualified personnel?

Yes______ No______

To what degree? Great/ Above Average/ Average/ Little/ None

IV. What functions have these new employees performed? (Check functions in each category)

	Key Punch Operators	Machine Operators	Supervisory Assistants	Supervisors
1. Card Punching	______	______	______	______
2. Card Verifying	______	______	______	______
3. Sorting	______	______	______	______
4. Auxiliary Machine Operation	______	______	______	______
5. Accounting Machine Operation	______	______	______	______
6. Control Panel Wiring	______	______	______	______
7. Forms Design, Procedure Planning, Flow Charting		______	______	______
8. Computer Programming			______	
9. Clerical			______	

V. If you foresee a computer installation, what type of staff are you planning?

A. Machine Operators How Many? ______

B. Programmers How Many? ______

C. Systems Analysts - Methods How Many? ______

D. Systems Supervisors How Many? ______

What will be your source?

Hire Generally Trained Personnel Yes____ No____

Present Tabulating Personnel Yes____ No____

Promote Other Employees Yes____ No____

VI. What type of training have your new DP employees had?

IBM school? Has it been adequate? Yes____ No____

On the job? Has it been adequate? Yes____ No____

Previous experience? Has it been adequate? Yes____ No____

If any training medium has been inadequate, how could it be improved?

VII. Would you be interested in hiring carefully selected high school seniors on a part-time or Cooperative Program Basis if they had received thorough training on Unit Record Machines and were well versed in computer concepts and programming?

Yes_____ No_____ How Many Per Year?_____

In what area would they be utilized? (Check)

Key Punch Operator________

Machine Operator? ________

Programmer? ________

VIII. If a group of carefully selected high school graduates with a 1 1/2 year training background equal to an advanced knowledge of wiring principles, computer concepts and computer programming, a knowledge of basic applications (payroll, accounts receivable, accounts payable, inventory control, etc.), and four months of on-the-job practical experience were available, would your hiring practices be affected?

How?

Any sex perference?

Comments?

The results of this study will be handled in a professional manner. A summary of the results will be made available to participating organizations. In order to protect the privacy of your opinions, company names will not be used in the summary statements.

Do you want a copy of the summary sent to you? Yes_____ No_____

We are studying a proposed data processing curriculum in our high school. The suggested curriculum might include variations of at least four units:

1. Introduction to unit record equipment
2. Keypunch operator
3. Introduction to electro-mechanical accounting machines
4. Introduction to computers

The equipment that we plan to have available for teaching this curriculum consists of the following:

keypunch	verifier
sorter	reproducer
collator	interpreter
tabulator	small computer

1. What do you think Euclid's business education department should provide for its students in business education in the way of Data Processing education?

____

____

____

____

2. Same as above but: for its students in the college curriculum

____

____

____

____

3. Would you be interested in students with prior experience in the operation of unit record equipment? Computers?

Yes________ No________

4. What do you think the future requirements of workers in the field of Data Processing will be?

____

____

____

____

5. Do you think Euclid should provide its graduates with a workable skill in Data Processing (keypunch operators, tab operators.)

Yes________ No________

6. Do you feel that unit record is here to say and that there will be long-term career possibilities and specific occupational opportunities available for our graduates?

Yes________ No________

7. If a student applied to your company with two years in Data Processing curriculum, would you find it necessary to provide additional training in that area? (How can we avoid the re-training period that many graduates go through when they are first hired?)

Yes________ No________

____

____

____

8. In your opinion is there enough of a demand in the community to justify the expense of: 1. Unit record 2. Computer

Yes________ No________

APPENDIX IV

Outline of abbreviated ALGOL

Characters:

Letters: A - Z

Numerals: 0 - 9

Special: + - = ( ) . , $ / * &

Numbers:

Constants: string of digits and decimal point

Ex. 3.197, 0.0016, 1.7 & 5

Variables:

Simple: A, B, ALPHA, D5

Subscripted: A(1), B(2, 3), M(I, J)

Expressions:

Arithmetic:

Add + A + B

Subtract - A - B

Multiply * A*B

Divide / A/B

Exponentiation ** A**B

Library:

Absolute value ABS ( )

Square root SQRT ( )

Exponential EXP ( )

Logarithmic LN ( )

Sine SIN ( )

Statements:

Assignment: <variable> = <expression>

Ex. A = B/C + 12 + 12*SQRT (9)$

Grammar:

Delineation: statement$

Compound: BEGIN S $ S_2 $ END$

Labeling: Label.. S$

Control:

GO TO Label $

IF B THEN S $

FOR statement

Declarations:

REAL, INTEGER, ARRAY

Input - Output:

READ ( )$

WRITE ( )$