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Demonstration and Experimentation in Computer Training and Use in Secondary Schools, Activities and Accomplishments of the First Year.

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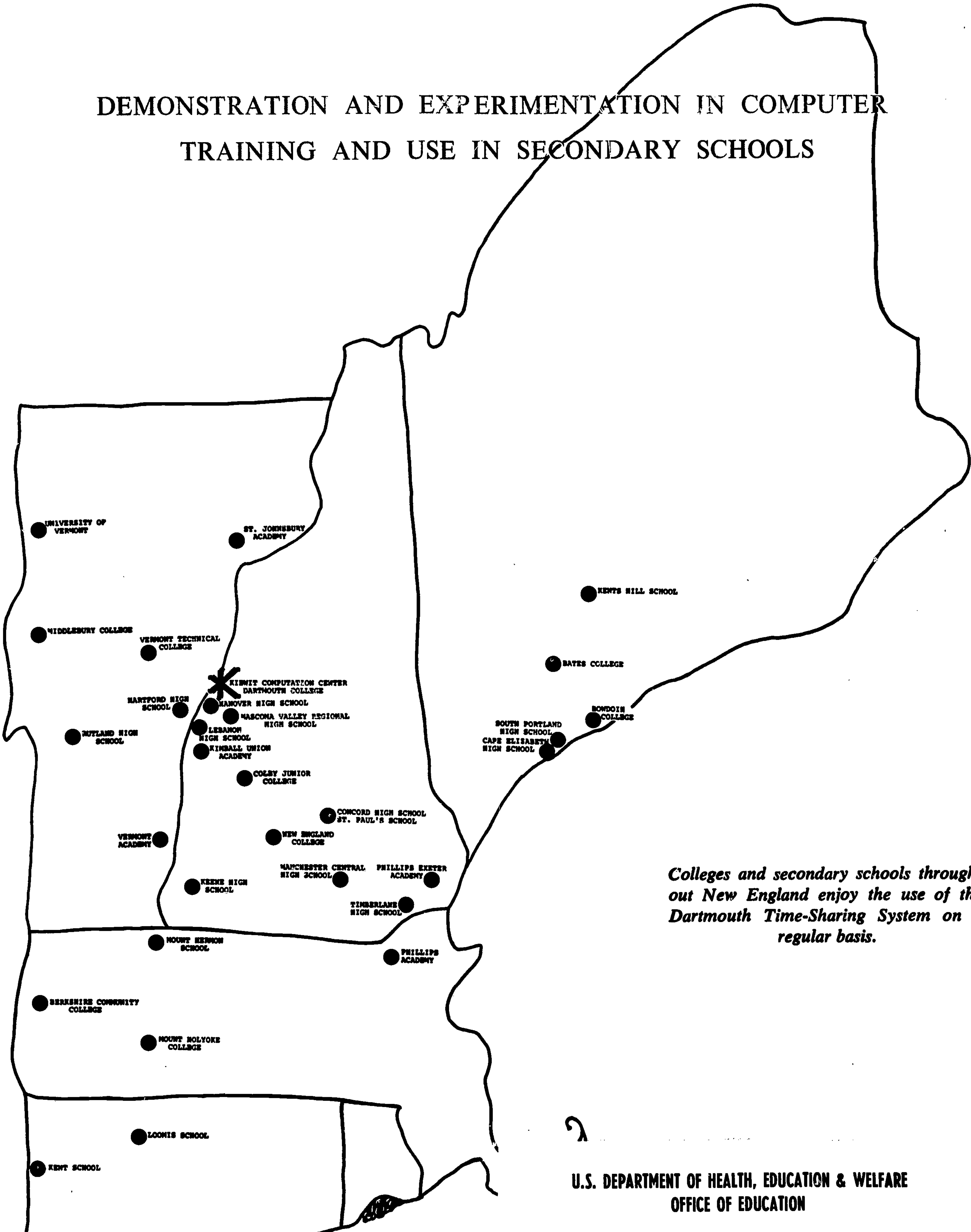
Most of this report is concerned with describing the project and its activities and accomplishments during the first year of its existence. A major goal of the project is to produce units of curricula in which the computer can be used to enhance the teaching or learning of mathematics, the sciences, and other secondary school subjects. Thirty-one units are included in the appendix. Part I of the report describes the regional computer system. Part II describes how the system has been used by the schools. In this section extensive examples of student and teacher activities are given. Feedback on the success of the program is also presented by way of student and teacher opinions. (BC)

DEMONSTRATION AND EXPERIMENTATION IN COMPUTER TRAINING AND USE IN SECONDARY SCHOOLS



Colleges and secondary schools throughout New England enjoy the use of the Dartmouth Time-Sharing System on a regular basis.

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DEMONSTRATION AND EXPERIMENTATION IN COMPUTER TRAINING AND USE IN SECONDARY SCHOOLS

A two-year project being carried out with the support of the National Science Foundation under the terms of NSF Grant GW-2246.

Interim Report

ACTIVITIES and ACCOMPLISHMENTS of the FIRST YEAR

1 October 1968

Kiewit Computation Center
Dartmouth College
Hanover, New Hampshire

FOREWORD

One of the primary goals of this project is to produce units of curricula in which the computer is used in some way to enhance the teaching or learning of mathematics, the sciences, and other secondary-school subjects. So far, 31 "topic outlines", as we refer to these units of curricula, have been prepared in draft form and are included as appendices to this report. The main effort of the second year will be devoted to revising and refining these topic outlines through use in several schools, and to rewrite them in finished form as part of the final report of the project.

The bulk of this interim report is mainly concerned with describing the project and its organization, and with describing in narrative form some of the happenings in the schools when computing in the form of BASIC and the Dartmouth Time-Sharing System was introduced into these schools.

I wish to acknowledge the assistance of these persons:

Prof. William Slesnick, Associate Director
Mr. John M. Nevison, Coordinator (May, 1967, to 15 September, 1968)
Mrs. Jean Danver, Coordinator (1 September, 1968)

It should be added that the project would not have proceeded nearly as well without the enthusiastic and successful efforts of Jack Nevison in harnessing the energies of half a hundred secondary-school teachers and several thousand students into the direction of the project. He also is the principle author of the main body of this report.

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INTRODUCTION

From September, 1967, through June, 1968, 18 secondary schools dispersed across five New England states have each had a teletype installed in their school. The teletype has been connected via telephone lines to a time-sharing computer at Dartmouth College.

For 12 months, the schools and the College have been involved in the first of a two-year Secondary School Project founded by the National Science Foundation. The Project's primary concern is to demonstrate how a computer can best be used by teachers and students in secondary schools.

The following report is a summary of what has been learned this year. The report is organized around two questions. First, how does a college become a regional computing center for surrounding schools? And, once the center is established and a teletype terminal is installed, what happens in the school?

PART I

A REGIONAL COMPUTER SYSTEM FOR SECONDARY SCHOOLS

The Schools

Eighteen schools were included in the project. They are listed below along with the ninth-through-twelth-grade school population, size of the 1967 graduating class, and the percentage of the class that went on to a four-year college.

School	School Pop.	Grad. Class	4-Year College
Cape Elizabeth, Me.	573	116	48.3
Concord, N.H.	1,478	333	37.5
Hartford, Vt.	516	135	24.4
Hanover, N.H.	679	110	61.8
Keene, N.H.	1,415	284	33.1
Lebanon, N.H.	536	152	34.8
*Loomis, Conn.	444	100	100.0
Manchester Central, N.H.	1,616	356	41.6
Mascoma Valley Regional, N.H.	456	61	29.5
*Mt. Hermon, Mass.	620	177	99.4
*Phillips Andover, Mass.	860	242	94.6
*Phillips Exeter, N.H.	789	252	97.6
Rutland, Vt.	1,063	196	32.6
+St. Johnsbury, Vt.	701	149	32.2
*St. Paul's, N.H.	458	95	100.0
South Portland, Me.	1,700	335	50.1
Timberlane, N.H.	830	86	33.7
*Vermont Academy, Vt.	217	65	95.4

*Private School
+Private school considered as a public school in this report.

Figure 1. -- Participating Schools

/It should be noted that St. Johnsbury Academy will be considered a public school in this report because it serves as the sole secondary school for the town of St. Johnsbury and the composition of the student body resembles that of other public

schools. Also, it used the teletype from 8 a.m. to 4 p.m., Monday through Friday. (Private schools use the teletype from 8 a.m. to 8 p.m., Monday through Saturday.)/

Looking at Figure 1., one can see:

* There are 12 public schools and six private schools in the project.
* The schools are dispersed over a five-state region.
* Five of the large city schools have a population of over 1,000 students.
* The remaining seven public high schools all have populations of more than 500 students.
* On the average, less than two-fifths of the public-school students go on to four-year colleges.
* Almost all of the private-school students go on to four-year colleges.

Training Session

In order to prepare for reasonable usage of the teletype terminal, each school sent one teacher to a four-week summer training program at Kiewit Computation Center. Teaching the initial training sessions was Mr. John Warren, an experienced teacher who had used a teletype terminal two previous years at the Phillips Exeter Academy. Mr. Warren not only introduced teachers to how computer programming could be used in teaching mathematics, but he also suggested intelligent ways to administer the use of the teletype. These administrative suggestions included possible ways to remedy teletype breakdowns and poor telephone communications. His anticipation of likely problems forestalled many awkward moments for the novice teachers beginning their first year at a remote terminal.

A short report on the initial summer training program is available upon request from the Kiewit Computation Center.

Outstanding recommendations to those who are beginning regional computing centers and running initial training sessions for school teachers include:

* Have an experienced user of a system similar to the one you will be using talk to the group about likely problems.

* Count on teachers learning elementary BASIC in six one-hour lectures. (two per day.)

* Ensure each teacher ample time at the terminal (at least ten hours in the first five days -- twenty before he will feel completely at ease).

* Problem sessions for extra help should be scheduled.

* Quantities of printed materials should be placed in the teacher's hands. (If it is not read at the training session, perhaps it will be later during the school year.)

Contact with Schools

Once the teletypes are installed at the remote locations and the teachers have been trained and returned to their schools, any problem forces the questions "Where do I go for help?" and "Who do I ask?"

On our system telephone and teletype malfunctions were at first reported directly to the phone company for immediate service. During the year, the procedure was changed, and the computation center began to handle telephone troubles. (The phone company reacted faster to a big customer and the center personnel became familiar with just who to call for each problem.)

Communications and programming problems were reported to members of the Computation Center Staff.

Individual programmers with problems that required the special peripheral apparatus (high-speed printout, card read, card punch, paper tape -- read and punch) could contact a member of the Kiewit Staff who stood ready to assist them.

Financial details were worked out in correspondence with the assistant director in charge of administration.

Problems relating to the Secondary School Project (curriculum development and student programs) were relayed to the Project Coordinator.

Contact among the schools and Kiewit was supposed to take place in several ways. Some ways that failed included:

* A teacher gossip file in the system. (It took too long to LIST it on a teletype and teachers found it hard to get time at the terminal because of the heavy student usage.)

* Voluntarily submitted programs by students.

* Voluntarily submitted programs by teachers.

(The last two failed, because not enough notice was taken of the fact that user time is important and ordinary documentation wastes user time.)

In an effort to solicit a large response from the students, an inter-school contest was begun. An individual submitting a program selected for publication in the Biweekly Bulletin received a printed citation and a small silver abacus charm. The school which amassed the most points in a two-month period won possession of a silver cup.

As a result of the contest:

* Voluntary submission of student programs and

* Voluntary submission of the teachers' uses

were found to work quite well.

The inflow of information from the contest plus answers to

* Questionnaires to teachers

served to supply a sufficient amount of interesting material for inclusion in the

* Biweekly Bulletin

which went out to all the schools in our project as well as a growing number of other schools who became interested in reading the remarkable student descriptions of their own programs. (By the end of the year, the mailing list had grown from 40 to 125.)

In addition to sending out a Biweekly Bulletin to all interested students and teachers, a confidential

* Newsletter for Project teachers

informed teachers of the Project Coordinator's visits to schools and plans for Saturday Teachers' Conferences.

The Coordinator's visits to the schools were inefficient but necessary -- inefficient because one person visiting 18 schools involved an inordinately large amount of time away from the center of activity; necessary for several reasons:

* Schools would seldom ask for <u>ad hoc</u> visits from the Coordinator and some schools chose not to communicate frequently with the Center.

* The visit gave the Coordinator a chance to see first-hand what was going on in every school.

* The visit served to help plan the Saturday Teacher Conferences.

* In some schools the visit was the occasion of a "computer meeting" of all the teachers who were using the system.

* Many teachers would make suggestions and ask questions in person while they remained reluctant to phone or write to the Computation Center.

Two Saturday Teacher Conferences enabled all the teachers to get together and discuss problems of common interest and hear first-hand about new developments at the Center.

Three recommended activities for a Saturday Teacher Conference are:

* Open discussion of a selected topic. (Problem defined by a panel of

two to four teachers in first 15 minutes followed by 30 to 40 minutes of open discussion.)

* Selected presentations of classroom work. (One teacher speaking 30 minutes on how he used the computer in his class.)

* Guest lectures -- College faculty and staff speaking 45 to 60 minutes on topics of interest. For example, "New Developments in BASIC."

One final contact among the schools that worked well was

* the student gossip file,

a commonly available file in the computer to ask and answer questions of students at other schools. One evidence of the high regard the students have for a system they feel responsible for is the continuing existence of this gossip column. Any prankster at any school could have destroyed it. It was a completely vulnerable file. Yet, because the students knew it was theirs, it was successfully used all year with only a few minor mishaps.

The End of the First Year

The first-year usage was largely informal use by students with occasional formal classroom use by teachers. Plans were made to train a larger number of teachers for each school for the second year and thereby increase the formal class use of the machine.

The original plan of bringing back one additional teacher from each school for a four-week training session was scrapped. Instead, two two-week sessions were planned, the experienced teacher and one new teacher attending the June session and two additional new teachers attending the August session.

The following considerations played a part in this change of plans:

* Teachers were better trained in the summer at the Center than during the school year in the schools. (The training session at the Center

provided each teacher with ample teletype time without having to compete with students for time on the single teletype at the School.)

* An increase to four (as opposed to two) teachers for the second year would mean a much more significant increase in the use of the computer in the classroom.

* Four teachers in each school form a core that can more strongly influence local school policy.

* In some cases a larger number of users in the mathematics departments would generate enough enthusiasm to seriously interest their fellow teachers.

* Four teachers in some schools will serve to spread the usage across science, math, business, and on occasion into history, English, and foreign languages.

Conclusion

Establishing a regional network of secondary schools involves three steps. First, a summer session to train at least one person from each school on how to use the system. Second, on-going contact with this person as he works with the computer during the first year in the school. This contact can be maintained by letters, contest entries, biweekly bulletins, personal visits, and Saturday meetings. Third, a second summer training session where the object is to train as many teachers as possible for each school.

PART II

THE SCHOOL

Introductory Comments

At the heart and core of the NSF-Dartmouth Secondary School Project resides the lone figure of a high-school student seated in front of a teletype terminal. Our project belongs to him. It belongs to him because the worth of the time-sharing system is measured by the worth of the tasks the students set for the machine; not the worth of the tasks a machine sets for the students. In short, in our system the student teaches the machine and only if a student intelligently and creatively uses this new tool will it work productively.

Dr. William Huggins of Johns Hopkins University eloquently describes what goes on at a terminal when a student teaches the machine:

> 1. The unique and supreme significance of the computer within our educational context is that it serves as a catalyst in unleashing the inquisitive and exploratory intellectual energies of the high-school student.
> 2. The actual content of what the student writes a program about is relatively insignificant compared to the experience of encountering for the first time a physical system over which he has complete understanding and control; a system that follows the rules exactly, but which is ruthless in demanding a corresponding conciseness and rigor of formulation in the instructions that he gives it.
> 3. The extent of this involvement and the rate at which the catalytic action is brought about is in direct proportion to the freedom the student has in following his own interests and inclinations (rather than those dictated by the lesson of the day).
> 4. In the end, for a given expenditure of computer resources, there will be more achievement and progress toward real understanding . . . if the student is encouraged to explore problems of his own creation.

The rest of this report is a summary of what happens in a school when a computer is installed with the idea that it is up to the student to use it well. If

he uses the computer well, it can serve as a creative extension of his intellect.

Start-up

Upon returning to their respective schools in September of 1967, each teacher began to instruct his students in the elements of BASIC programming. These introductions were accomplished in a variety of ways:

* Five lectures in one week to ninth graders beginning Algebra One. (See P. Pitney's Topic Outline, Introduction of the BASIC Language, Teletype Usage, and Elementary Programming.)

* Six lectures (two/week with time in between for TTY usage).

* Lectures for interested students during activity periods.

* Visiting series of three lectures to other math or science classes (with the regular teacher learning along with his students).

* Brief discussions in regular math lectures (See L. Hoitsma's Topic Outline, BASIC in Ten Minutes a Day, and R. Bolduc's Topic Outline, Junior High School Uses of a Time-Shared Computer).

* Lectures supplemented with the "High School BASIC Manual" (See F. McPhetres' Topic Outline).

Several lessons were learned from these introductions:

* First, provisions must be made for each student to get at least one 20-minute period on the machine for each one hour of lecture, or a grand total of at least one hour and 20 minutes as he learns to use the machine.

* Second, if a teacher happens to be included in the group, allow him at least one hour of terminal time per hour of classroom lecturing or five hours for a five-lecture course. (A teacher is slower to learn than his students and should be allowed an additional fifteen hours on the teletype upon completion of the first five lectures.)

* Third, programming courses are obsolete for most people who wish to simply use the computer as a tool. With the BASIC language and a time-shared terminal, developing the ability to program is a matter of hours and days; not a matter of weeks.

* * * * *

Item -- Mr. G. Lewis at Concord High School walked into the teletype room one day during the first week of classes and found some of his math students (who had only two lectures on the computer and BASIC) excitedly showing their physics teacher how they could use the computer to do laboratory calculations in physics.

* * * * *

Teacher Introduction

Teachers were harder to introduce to the system. They were reluctant to use a terminal already mobbed by students and they needed, but often could not find, lots of "hands on" time at the TTY console.

The few public-school teachers who did learn to program at their school and made significant use of the machine in their courses, all gave themselves several hours of "hands on" teletype practice. They found their time either by staying late in the afternoon or by coming in on Saturday. In private schools, it was much harder for teachers to find time on terminals which were saturated with student users from 8 a.m. to 8 p.m., Monday through Saturday.

* * * * *

Item -- At South Portland High School, students rapidly filled up the available time on their two teletypes. (The school received additional funds for a second teletype through a Title III grant.) Not only was the official eight to four period filled, but also the late afternoon, after four, when students would return to spend a few additional minutes on the machine. Students left the building with the last janitor at five or five-thirty. The two teachers using the machine decided to get their own time in on Saturdays. The second Saturday they were there, a student passing by in his car noticed one of the teacher's cars parked by the school. He shook on one of the locked school doors until one of the teachers heard him and let him in. The student asked "Is the computer running today? Can we use the teletypes today?" The teacher couldn't say no. The work was out. From then on the two teachers used the machine in between the students who came in on Saturday to have one hour periods at the teletype to do jobs they couldn't do in the weekday twenty-minute slots.

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Teletype Scheduling

As has been suggested above, the demand for a chance to use the teletype was high. In order to equitably distribute the usage, the following plan was generally adopted:

* A sign-up sheet with the school day broken into 15- to 20-minute periods is posted by the teletype two days in advance.

* Students can sign up for a convenient time.

The below example is typical of the rules evolved at most schools.

MOUNT HERMON SCHOOL SIGN-UP PROCEDURES

The large number of users of this terminal necessitates a few rules which must be observed by all users to assure efficient use of the facilities.

1. Sign-up sheets are provided to reserve time in 15-minute blocks. Sign in pencil only.

2. From 8:00 a.m. to 4:00 p.m.: Only those boys having "project" user numbers and faculty may reserve time. Others may use the machine if it is not being used at this time, but should relinquish it to the above people upon request.

3. From 4:00 p.m. to 8:00 p.m. may be reserved by all students or faculty having a user number on a first-come-first-reserved basis. Please do not sign for periods more than 48 hours in advance.

4. All users are limited to two reserved periods in one day. These should not be consecutive periods.

5. The person who reserves the computer shall have exclusive use of the room for that period. PLEASE DO NOT DISTURB!

6. A person may not "donate" his reserved time to another.

7. Productive use of the teletype is seriously impaired by that person who fails to use his reserved time.

8. From time to time the teletype may be required for use in mathematics classes and special events. Periods deleted from the sign-up sheet are for such purposes and will be kept to a minimum.

9. Since the teletype room is frequently seen by visitors, users of the room are requested to see that it is neat when they leave.

Figure 2.

Several interesting features may be noted in this set of rules:

* Mount Hermon, being a school that makes active use of the machine in math classes, has reserved a block of time expecially for these users.

* There is a large block of free time open to all. (At most schools the whole day was open to all.)

* Rules 4 and 6 are designed to prevent the takeover of the computer by a small group of "hard core" users.

* Provision is made (in Rule 8) for occasional classroom teletype demonstration.

* * * * *

Item -- One of the pleasant by-products of encouraging students to feel responsible for the computer was Mr. W. Smith's honor code at Lebanon High School. Every morning he would sign a pad of blank passes and leave them on the desk in his classroom. Any student who wished to be excused from a study hall to use the computer would simply take a pass and fill it out for the appropriate time and give it to his study hall teacher. This honor system worked well the whole year.

* * * * *

Classroom Teaching -- Subjects

One of our project's objectives this past year has been to demonstrate that the computer can be a significant aid to regular class work already found in existing school curricula. Because most of our first-year teachers taught either mathematics or science, most of the Topic Outlines (see Appendices B and F) are from math and science classes. Next year it is expected that there will be a significant increase in the number of applications in high school business courses as well as extensive write-ups of computer applications to science.

In the past year the following class-usage patterns have emerged:

* Mathematics usage is heavy. The computer does numerical calculations, executes algorithms of varying complexity, and yields convincing demonstrations for classroom use. There is a very immediate transfer of enthusiasm generated by having written a successful computer program to becoming interested in the mathematics involved in the programming.

* * * * *

Item -- Miss Ann Waterhouse, a teacher at South Portland High School, describes what has happened at her school:

> I think that having a computer has done wonders for the morale of the school. Teachers and administrators are very interested in how it can be used and take pride in the fact that South Portland can lead in educational innovations. Of course, the students reap the biggest benefits. Their enthusiasm has been most apparent. It gives many a chance to shine in an intellectual area and receive recognition they would not have otherwise. Parents have commented that these children are much more interested in their school work this year as a result of having access to the computer. (The sign-up sheet for Christmas vacation was completely filled within four hours.) They are willing to do more than what is required in a course. They experiment and discover for themselves, which is the best kind of learning.

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* Science usage is medium to heavy. The computer is an excellent tool for performing tedious calculations. Use of the computer yields extra time for more laboratory work and better approximations to the theoretically predicted value when the class average is computed.

* * * * *

Item -- Mr. C. Stinchfield, a chemistry teacher at Mount Hermon School for Boys, has the computer do all the calculations for the chemistry study labs. Some of the programs he wrote, some his students were expected to write. Most of the programs printed out the results for each student and then the average result of the whole class. Finding the class average was one good way of checking to see if, as the number of trials increased, the results agreed more closely with the theoretical prediction.

* * * * *

Classroom computer demonstrations in the sciences often suffer from the artificiality of having been generated from laws known in advance. Occasionally, however, an immediate response time-shared computer provides

a versitility in demonstration not otherwise present in a school (See S. Laramie's Topic Outline, Free Falling Bodies and Projectile Motion: Three Simple Examples of Computer Use in a Physics Laboratory).

* Business usage has yet to be explored. With only a couple of exceptions (See Ann Waterhouse's Topic Outline, Computer Course for Business Students), what can be done in high school business courses remains to be demonstrated. It goes without saying that all areas of business courses that deal with numerical calculations should be dramatically affected by the introduction of the computer.

* Humanities and Social Science usage has been, and probably will remain, sporadic. A student can write a teaching machine for any subject -- be it a foreign language or history. But, except for the value of having a student learn how to write a teaching machine, these computer drills are almost worthless. Teletype time is too precious to be wasted by using the computer as a teaching machine. Other than a few brief flurries into teaching machines, the application in the social sciences and humanities all appear to be excellent special projects for small groups of students rather than major contributions to the ordinary classroom teaching.

  One special area of computer applications especially amenable to the social sciences is games. Games with intelligent sets of rules simulate a simplified real world (for example, Monopoly or Tactics II). Students who know how to program have the potential for developing highly sophisticated simulations of anything from a horse race to an economic system. The programming is relatively easy. The only limitation is the imagination employed by the student in devising rules for his game.

Classroom usage of the computer pays unexpected dividends. Several teachers commented that writing a program increased understanding of a mathematical algorithm and saved more time than was taken to teach BASIC.

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Item -- Miss A. Waterhouse at South Portland High School was worried about how she would make up the five days she used to teach BASIC to her senior calculus class. Using the computer to illustrate difficult points in her calculus course helped students understand so much quicker that she found she had covered more, not less, calculus by the end of the year.

Item -- Mr. R. Bolduc at Cape Elizabeth High School recalls his experience in teaching a group of slow algebra students. They were reviewing the derivation of the "quadratic formula". After working the derivation through on the board, he asked if anyone has any questions. Silence. The homework assignment was given and the class dismissed. The next morning, before school, one boy in the class came up to

Mr. Bolduc. "Sir, yesterday in class I didn't understand what you did." "Well, why didn't you ask?" "Well, I figured all the other kids knew what was going on and I didn't want to be the only one to ask. But last night I wrote a computer program to do it, and now I understand what you did in class yesterday. And I know what a person has to figure out before he can make the machine calculate." A puzzled student, an accessible computer, and a creative extension of the human intellect.

* * * * *

Other computer projects also discovered that BASIC could save time and help teach math faster.

* * * * *

Item -- Mr. G. Zakem of Altoona High School writes about his project:

> Naturally, there has been some reluctance and opposition by a few of the teachers to introduce a new chapter in their respective courses. The biggest question which arose was "Where are we going to find the time to cover all the required material and still teach programming?" However, through actual experience with a test group, it was found that less time had to be spent on drill work to reinforce a difficult concept since the student had to analyze completely his problem before programming. It was found that more material could be covered since less time was required for the tedious calculations. Also, problems that were by-passed before because of their complexity and lengthiness, were now tackled with success. It didn't take long to convince teachers that, as a matter of fact, more material could be covered than before.

* * * * *

Course Work -- Grades

The computer is used in a wide variety of courses and, in addition, at a number of different grade levels.

* * * * *

Item -- Mr. G. Smith of the St. Paul's School writes:

> The computer has been used almost entirely by the boys and men in mathematics. There has been some use by boys in science courses, but only for computation, and in the end they do not have enough statistical information to warrant its use.

The Registrar also uses it for ranking and other statistical grouping.

In classwork we have varied. The seventh grade arithmetic uses it as part of their course in the area of factoring, etc. The eighth and ninth grade algebra use it for solving equations and finding coordinates for graphing purposes. The tenth grade geometry has used it for Pythagorean triplets and other spot topics, but it is rather forced and not a basic part of the course. The course is synthetic, deductive in the main. The eleventh grade algebra and trig has used it more for solving polynomials, estimating Pi, working out cosine tables (see John Warren's scheme of last summer), working out series for logs, and one or two graphing programs have been written.

The twelfth grade calculus (with analyt for the 'average' sections) has used it for finding tangents to curves as limit of secants -- will certainly use it next term for area. Also used it for straight limit exercises approaching e, Pi, and various sequences with infinite and finite limits on the variable.

In general, every teacher has some familiarity with programming. We had an 'in-service' training last year and share new ideas this year with each other. If a man has a bright idea for a program and it works, he makes a spirit master of it and puts copies around -- we keep a file of the spirit masters.

Each teacher has taught his classes the rudiments of using the computer, and followed up in most cases with exercises to be done for credit of one sort or another. We throw out suggestions in class and support the energetic and interested souls who follow through on them.

There have been other uses outside the classroom -- the most ingenious is probably the program for planning the make-up of the school newspaper which I sent you.

Our 'hardest-corest' boy this year on his own, for reasons I am not sure other than the fact that the machine was here and he has an inventive mind, worked out a program for 'best line' line. He had had no training along these lines whatsoever. He presented this program in our Math Society and had the group work it out under his guidance -- it made a good exercise for such a group. He is now working on curve fitting.

* * * * *

Several public schools as well as St. Paul's found it practical to introduce programming to seventh graders. (See R. Bolduc's Topic Outline.) One conclusion of the first year of the project was that <u>the average student can learn to program in seventh grade</u>.

In addition to teaching average junior high students, two schools' experiences suggest that BASIC programming is well within the grasp of clever grade-school children. Thirty Hanover grade-school students have passes to the College public teletype room. At Lebanon High School, Mr. William Smith taught elementary programming to fourth graders in four lectures (see his Topic Outline).

The main advantage of teaching programming early is the freedom it gives to both the student and teachers. The students have a powerful tool at their disposal to help them explore certain ideas. The teacher in the upper grades doesn't have to waste precious class time instructing students on how to use the tool. He is free to expect the students to know how to use it, and he can call on its use whenever it can help him to teach his class better.

Thirty-one topic outlines have been prepared this year by the teachers in the Project. Appendix B lists their titles and the grade of the class in which they were used. A glance at this list should help give some idea of how the computer can be used in the secondary school classroom.

The Students

In and out of classes the students used the computer. Every now and then one entered one of his programs in the Kiewit Cup Contest. Appendix A lists the entries in the contest. The entries are roughly sorted out into high school subjects. It is interesting to note that the contest entries probably cover only one-tenth of the interesting work that students have done this year.

Looking at the first category in Appendix A, one discovers that "Number Theory" is in large measure the province of junior high school students. Time and again, when teachers spoke of their junior high user, happy adjectives kept appearing.

Something about the crossword-puzzle-like challenge of the logical design of a computer program holds a special fascination for this group. Mr. Ralph Bolduc at Cape Elizabeth High School began to work with his junior high students in late November and reported, "The kids are easier to teach. They seem to catch on quicker than the senior high kids." Mr. Spencer Laramie at Mascoma Valley Regional High School has a large group of seventh and eighth graders who use the machine during an hour reserved for them. He describes his group as "happy, enthusiastic programmers." Mr. Bill Faulkner at St. Paul's School talks of his seventh grade program as "going merrily along."

Moving on from "Number Theory" to "Algebra" in Appendix A, one notices that the grade levels move into high school. Especially interesting in this section are occasional groups of very similar programs such as the four beginning with an evaluation of 2x2 and 3x3 determinents. The next two programs do similar operations. But the three programs were each written by different students at different schools.

What is interesting about this concurrence of three programs is they each represent a very personal attack on a common problem. Each of the three programmers approached the problem the way he wanted to, named his own variables, had his program work in his own way, and ultimately arrived at his own working program and a solution. Each had made something he could call his own. Each had used the machine as a creative outlet, a creative extension of his own intellect. One notices continuing down the list a similar overlapping of interest in the roots of polynomials. Again, a variety of students, a variety of definitions of the problem, and a variety of approaches. (Grades eight through twelve.)

In "Analytic Geometry and Calculus", one finds exclusively senior high

school students writing programs that provide graphic demonstrations of a variety of subtle topics in high school mathematics.

"Geometry" picks up many programs from trigonometry as well as the expected collection of area or perimeter programs.

"Probability and Statistics" should serve to whet the appetite of any teacher. For the first time, a way to throw a thousand dice in two seconds is at the disposal of every student. Several students have taken advantage of this new power to devise some interesting and clever applications (look ahead to the "Games" section).

"Physics" and "Chemistry" should encourage the science teacher to try and stay up with his students. If he can, they will show him a wide spectrum of computer applications to science and suggest ways he might profitably use the machine to better teach his courses.

The "Games" section illustrates what the phrase "creative extension of the human intellect" is all about. Here one can see clever students turned loose with their new found skill making the machine jump through their hoops, be it a basketball game, a battleship game, or a hand of black jack.

The "Miscellaneous" section might well be titled "A gay miscellany of improbable programs." Here, one sees how students, because they did not know "it can't be done on a computer", quietly went off and succeeded in doing it. Indeed, nothing in this report gives a better expression to what really went on among the students in the schools than this single group of student programs.

In May of this past year, students at Hanover High sponsored a Student Computer Conference. The conference was held at Dartmouth and featured speeches by Professors Thomas Kurtz and John Kemeny. The bulk of the day, however, was

devoted to student speakers, each describing work he did in conjunction with the computer. The day's schedule of events is Appendix F.

It must be mentioned in writing of students that the bulk of the work in evidence this year has come from students of average or better than average ability. However, several small experiences in the schools this past year lead one to predict that with good instruction, students of all levels should be able to learn how to program a computer in senior high school. The only difference that ability makes is that more time must be allowed to teach the same material to slower students.

* * * * *

Item -- Mr. Charles Tousley, teacher at Keene High School comments:

> The difference in the life of the students has been remarkable. It is a center of activity all the time for a certain group (maybe 50 students); the others occasionally, and some have no interest in it whatsoever . . . one student who failed freshman algebra last year because of lack of interest, on his first try wrote a program using the cosine function to figure out some angles for timing the valve openings in an engine he was building.

* * * * *

Student Comments

"The computer has helped me a lot in solving hard math problems. It is well liked, and there is usually a rush to see who get signed up first to use it first. I like it very much.

"I would like to have it in my house; that's not possible though. I think that students next year should have a chance to use this almost unlimited machine.

"I have used it for doing much of my algebra; once in awhile I play a game or two. Mostly I like to introduce more students to it and show them how it functions.

"Most would use it to design or complete their programs, while others enjoy the games available on it. Some even write games themselves. Everyday the machine is used except when several people that control the authority are sick -- like Mr. Smith for one. I think if all the time in the world was given, one student could use it up, somehow."

* * * * *

"It has helped me in geometric proofs, because I learned to take problems step by step and follow them through."

* * * * *

"I, personally, have enjoyed using the computer. It would be better if we could use it for a longer period of time. I think it would be nice if we could have it next year.

"I think that if we could have no limit in time, people would use the computer for about an hour. But, unfortunately, there are too many students in this school for this type of program."

* * * * *

"I have enjoyed and used the computer to a great extent. I would be rather angry if the terminal were dropped next year, because I couldn't stand doing much of the repetitive homework assigned knowing that I could write a ten-line program and get the whole assignment done in a minute or two.

"I have tried to write programs for every course I have and some just to amuse myself. Right now I'm debugging a program which should conjugate French verbs.

"Unfortunately Keene has no 'average' students; the 300 or so who are interested in programming would use it just about every chance they had while the other students would probably use it two or three times a year."

* * * * *

"I have enjoyed very much the teletypes of the computer. It would be very beneficial and I would enjoy having it here next year. It is a great aid -- both mathematical and enjoyable.

"I have used the machine for both school work and enjoyment. The average student would use the machine about half an hour a day -- a guess from previous experience and noting other students."

* * * * *

"The use of the GE-625 computer has made a noticable difference to me this year. Previous to the computer, I had little confidence in tackling any complex mathematical operation. Since BASIC requires that a mathematical operation be broken down into its simplest parts, even a very complex mathematical operation could be expressed in BASIC. This makes the computer quite a confidence builder."

* * * * *

"I have enjoyed having the computer at St. Johnsbury very much. I believe it has served as a valuable tool for the education of myself and other students at the school. Yes, I would like to have the terminal here next year. Although, I, myself, will not be here for its use, I believe this connection will serve the needs

of the other students at the school to find a further education centered around such automated devices such as this computer.

"Personally, I have used the computer as an educator, in that I have learned a great deal about the use of such machines in science and that it has spurred me on to learn the basics of a computer; and I have used it as a very beneficial time-saving calculator on science questions, the answers to which have not previously been available to this school.

"I believe that the average senior science student could well use the computer one hour each day. Although, the overall average student would only use it from one quarter to one third that time."

*   *   *   *   *

"I have found the computer not only useful in doing long trig problems, but also fun, with the games programs that can be put in. Not having a computer terminal next year would eliminate one of the most profitable extra-curricular activities that this school has to offer! The computer can cut homework time by speeding calculation and can further the development of logical thinking. I have used the computer in many ways: games, finding functions, and solving different types of problems -- all of which I try to program myself."

*   *   *   *   *

"I think that I might have entirely ignored the computer were it not for the incentive from the required math programs. . . . The computer can provide an education in itself if the user is conscientious. I feel that my use of the computer provided an excellent supplement to the regular Math IV course. Although the required programs were really 'short cuts' for homework problems, the understanding needed to write the program was important, and far more valuable than tedious calculations."

*   *   *   *   *

"The computer has been used for a teaching aid as well as an enjoyable companion. Programs have been molded from serious math and science programs to chess, games, pictures, and Christmas wishes.

"I sincerely feel the computer is a valuable addition to the school academic life. Even when students just think of it as an intelligent toy, they are learning through their own curiosity and experimentation."

*   *   *   *   *

<u>Case Studies</u>

Following is a collection of materials illustrating what teachers and students together can do with a time-shared teletype.

Case Study #1

* Duncan McEwen, a freshman at Mt. Hermon School submitted a program called TEST. He describes it:

> TEST is a program which, when given a set of data, via the list, will find the largest, smallest, median, and mean values. I just originated this program when I was confronted with ordering data; from there it was easy.

* His teacher, Mr. Peyton Pitney, relates how Duncan became involved in elementary statistics:

> At the end of last term, Duncan was trying to order numbers from largest to smallest. He wrote a program to do the job, but it was rather lengthy. We tipped him off and consequently lines 110 to 190 now appear. Then he said, 'So what! What can I do with it?' I talked a little with him about fundamental ideas of analyzing data and made up an experiment for him to do, a copy of which is attached. Note that his median test will be successful if T is odd or even. TEST is his answer to Part I. As he works on Part II, I will point out that he ought to round off to the nearest 1/100th of a dollar.

See page 25

```
LIST

TEST          15:16      10/17/68

1 DIM X(100)
3 READ T
5 DATA 80
10 FOR I=1 TO T
20 READ X(I)
26 LET S=S+X(I)
50 NEXT I
55 PRINT "THE MEAN OF ITEMS" S/T
110 FOR I= 1TO T
120 FOR J=1 TO T-I
130 LET X=X(J)
140 LET Y=X(J+1)
150 IF X<=Y THEN 180
160 LET X(J) = Y
170 LET X(J+1)=X
180 NEXT J
190 NEXT I
200 PRINT "LARGEST ITEM" X(T)
203 PRINT "SMALLEST ITEM" X(1)
210 IF INT(.5*T)=.5*T THEN 240
220 PRINT "MEDIAN OF ITEMS" X(INT(.5*T)+1)
230 GO TO 350
240 PRINT"MEDIAN OF ITEMS"(X(INT(.5*T))+X(INT(.5*T)+1))/2
250 DATA 30.25,24.10,22.50,32.40,20.15,28.50,38.85,43.80
260 DATA 42.60,23.50,12.25,21.80,33.50,22.15,31.25,13.50
270 DATA 31.70,36.65,37.40,19.20,29.75,27.10,33.60,33.00
280 DATA 39.25,26.10,33.80,30.50,32.70,29.35,35.45,22.75
290 DATA 25.15,31.95,28.60,32.50,42.80,17.90,34.25,38.25
300 DATA 35.20,38.15,25.75,44.60,34.45,33.40,36.90,40.10
310 DATA 25.00,27.50,36.80,32.75,27.00,43.80,35.00,23.80
320 DATA 35.75,27.35,29.75,32.45,25.40,33.05,37.55,37.15
330 DATA 30.25,31.25,24.80,26.70,35.50,34.95,29.30,41.75
340 DATA 26.23,46.20,24.40,33.40,12.75,33.95,26.20,31.50
350 END


READY

RUN

TEST          15:18      10/17/68


THE MEAN OF ITEMS 30.9822
LARGEST ITEM 31.5
SMALLEST ITEM 30.25
MEDIAN OF ITEMS 36.725


TIME:    .62 SECS.
```

Case Study #2

* Mr. William Stowe, teaching eleventh grade physics at St. Johnsbury, used the computer in his laboratory. He sketches what was done:

> The method was to present the 136 section with a problem; and, with myself acting largely as chairman, develop the physical relationships and the computer program to solve the problem. Attached is one of the student's write ups of the thought experiment, which describes it probably better than I would.
>
> The conclusion on one of the reports from one of the less talented students was 'I conclude that the experiment was quite accurate and also quite cool.'

* David Jordan, his student, describes the experiment:

> The basic idea of this program is that acceleration of gravity is not constant, but rather it depends on distance between the centers of the two objects. In this program, we let the distance between the center of the earth and the object be equal to 5,000 miles or 1,000 miles above the earth. The assumption we make in this experiment is that the acc. of g for distance of 1 mile is constant. Therefore we divide the total displacement of the ball (1,000 miles) into 1,000 intervals. For each interval we compute, the acceleration by the basic formula $g' = gs^2/s'^2$, where g' is the acceleration of gravity at distance s' from the center of the earth. The final velocity of each interval becomes the initial velocity of the next one. So, for each interval we have g', s, and V_1 or if we were to use the symbols in the program Gl, D/N, and Vl. We can compute the V_f for each interval with $V_f = \sqrt{Vi^2+2g's}$ or $V_f = \sqrt{Vl^2+2Gl \cdot D/N}$. The velocity at which the dropped object hits the earth is the final velocity of the last interval.

Case Study #3

* One student who learned several interesting things on his own was a ninth grader, Christopher Lane. The first program here was written after a suggestion from his teacher, Mr. Peyton Pitney. Chris outlines his program done during his first two weeks on the computer:

> The problem said to make a program that lets a user pick a number at his will and find the square root of it, using Newton's Method. At the start I need the number and a guess for its square root. I let the user supply the number and I set conditions for a first guess. Once I had a number (call it A)

and a first guess (call it B), I divide them. Then I used an exit which would save the computer the trouble of getting them equal to the hundred-thousandth place and made it get B and C, where C denotes the quotient, equal to the thousandth place. If the test was not satisfied, I used a new value for B which was the average of C and the previous value of B. Then I sent the computer back to repeat the division. Such is the skeleton of the program.

Secondly, I decided to dress the program up by adding wording. If the user does not follow instructions, there is a remark to set him straight. I also added the option of going on with the program or not. At the end the computer types a kind of signature, 'Whiz Kid', to end it all nicely.

* After doing this, he began to explore the second program and went further.

INFO* is a take-off of my early program NEWTON*, At first, I started off with just square root, square, and cube; but as I was polishing those up, I figured out how to get the cube root. It's the same as Newton's Theory, but you divide once more and then find the average. Later I added all four, (cube, cube root, square, and square root of given number), and if the user doesn't answer right, I have a correction line. By this time, it was a mess of numbers and miss spellings [sic]; and, as I cleared them up, I found out how to use word answers (string variables). So finally, I got my complete program.

A ninth grader "figures out how to get the cube root." He verified the idea by writing a computer program. And in figuring out how to do the cube root, he knows how to approximate the n-th root of any positive real number. A fourteen-year-old boy, an accessible computer, a creative extension of the human intellect.

Other examples of student-teacher usage of the machine appear throughout the report. Many other fully-documented examples may be found in the Topic Outlines available on request from Kiewit Computation Center.

Statistics

A single teletype in a public school was available from eight in the morning to four in the afternoon. In a private school, it was available eight to eight (the full

time-sharing schedule).

If one assumes each hour to be broken into three twenty-minute blocks, high schools had 24 blocks per day for 22 days a month, making 528 blocks per month. Private schools had 36 blocks per day for 26 days per month (Saturday included) making 936 blocks per month.

The teachers at these schools estimated the optimum number of active users to be 75. If one computes the average monthly blocks to be 662, then each active user would be getting almost nine twenty-minute blocks per month, i.e., each active user in an ideal situation would be getting almost three hours of terminal time per month.

It is interesting to compare this with the information on usage below in Figure 3.

	Public	Private	Combined Average
I. Cost (nine-month year)			
Overall Cost	$6,226.69	$8,912.63	$7,074.88
Communication	2,536.34	3,119.21	2,720.40
Computer	3,690.35	5,793.42	4,354.48
II. Cost (monthly)			
Overall cost	$ 691.85	$ 990.29	$ 786.10
Communication	281.82	346.58	302.27
Computer	410.04	643.71	483.83
Cost/User	10.03	7.80	9.29
Cost/Hour	4.94	5.34	5.07
III. Usage			
Number of users per month	68.90	127.00	88.30
Terminal hours per month	139.92	185.36	155.07
Terminal time/user/month	2.03	1.46	1.75

Figure 3. -- Statistics on the First Year

The figures above have been computed on a monthly basis for two reasons:

* Telephone and computer charges are made on a monthly basis.

* Teletypes are rented at a fixed monthly rate.

Because of these considerations, schools wishing to install teletype terminals are forced to think in terms of months of use.

One possible way to phase in a computer system into a secondary school with a limited budget might be to use a time-sharing service for only a few of the nine months the first year and increase the number of months in succeeding years as the budget grows larger.

Notice in Figure 3 that a large (over 30 percent) share of the operating cost was teletype rental and telephone-line charges. The average distance of the schools from the Computation Center is about sixty miles. Two items could lower the cost:

* Cheaper teletypes (Model 33's are less expensive than 35's).

* Time-shared telephone lines (being experimented with this year).

In addition, as usage builds, it is anticipated that computer rates will decline.

Conclusion

The first year's experiment with a computer terminal in the school has shown several interesting things:

* The computer is best used if it is used to explore problems of personal interest to the user, i.e., as a creative outlet for his curiosity.

* Programming courses are obsolete. Developing the ability to program is a matter of a few hours.

* Teletype time is too precious to be wasted by using the computer as a teaching machine.

* The average student can learn to program in seventh grade.

* The major influence a student's ability has on using the computer is the length of time required to do a task. Even very slow students can productively use a computer.

The lone user at the teletype has been our most important teacher this year. He has taught us a great deal. In the year to come, there will more frequently be a teacher waiting next in line to use the teletype. How his increased use of the computer in his classes will affect our lone student user remains to be seen.

APPENDIX A

Individual Student's Programs
(As submitted in Kiewit Cup Contest)

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All of the following programs were written by secondary school students. Most were written by public high school students. Almost all were written voluntarily, outside of class. The grade number is that of the student who happened to submit the program and should not be construed as the only grade or the best grade in which to do the program.

NUMBER THEORY	Grade
Pythagorean triplets	8, 11
Ordering a set of numbers	8
Relative primes	9
Greatest common factor	10
Prime number sieves	7, 9, 12
Fibbonacci sequence	8, 9
Decimal equivalent of n/11	9
Newton's method of finding a square root	9
Printout of Pascal's triangle, mod n	8
Cube roots	9
Conversion of number from any base to any other base	9
Nth term and partial sum of any arithmetic or geometric sequence	10
All 3 x 3 magic squares that add to a given sum	10

Investigate prime numbers and factors of composite numbers	10
Prime number cycles	12
Add, subtract, multiply, or divide two numbers of any base	8
Log and anti-log of any number in any base	9
Fraction to decimal conversion	8, 9
Finding largest factor of given number	10
Multiplication table	8
Order two numbers	7, 8
Greatest common factor and least common multiple	8
Prime factors of number	8, 9, 10, 12
Ratio of terms in Fibbonacci sequence	8
Sum of sequence $1/n$, $n = 1,2,\ldots$ And also $1/n^2$	8
Printout Pascal's triangle	11
Base conversion, decimal to any other conversion from any base to any other base	8
Add, subtract, multiply or divide two numbers	8, 9
Successive powers of a number	8,9
Test for perfect numbers	9
Find chains of "Sociable" numbers	9
Find "Automorphic" numbers	10
Order three numbers	8
Solution of integer word problems from Dolciani's Algebra One text	8
Eight digit, full accuracy printout	10

Prime numbers between 1 and 1000	9
Binary to decimal base conversion	11

ALGEBRA

Nth term of binomial expansion (general form or actual value)	12
Roots of Quadratic equations	10
Graph - plotting any f (x)	9
All forms of the equation of a line from coordinates of two points	12
Find truth set of diophantine equations	7
Determine domain for which inequality holds	9
Linear interpolation of log tables	8
Find the greatest common factor of polynomial with integer coefficients	12
Composite program using continued fractions to do several operations including solutions of linear diophantine equations	12
Solution set of three inequalities	11
Information for graphing any conic of form $ax^2 + by^2 + cx + dy + e = 0$	8
Finding the square root of a number	8
Prints graph of function over specified domain	10
Slope and Y intercept of a line from endpoints	10, 12
Fifth root of given number	9
Sum of N terms in geometric sequence	10
Binomial expansion to nth power	12
Graph of a parabola	11

Determining pairs of values x, f(x)	9
Solve logarithmic or exponential equations	9
Sine values from Taylor series	12
Length of line and midpoint from endpoints	10
Solve triangles using law of sines	12
Evaluation of 2 x 2 and 3 x 3 determinants	11
Solving two equations in two unknowns	11
Solving three equations in three unknowns	11
N equations in N unknowns	10
Solve roots of a polynomial Newton's Method	11, 12
Roots of any 5th degree equation on a given interval	10
Factoring trinomial with rational roots	8, 10, 11
Zeroes of polynomial by rational zero theorem	11
Real and imaginary roots polynomial of nth degree with complex coefficients	12
Factoring a polynomial with rational roots	8
Step by step demonstration of quadratic solution	10, 11
Roots (real or imaginary) of quadratic	10, 11
Roots of any function by searching the X axis	11, 12
Integral roots of any polynomial up to degree ten	9

ANALYTIC GEOMETRY AND CALCULUS

Area under curve using rectangles	12
Points of intersection of parabola and a line	10
Equation of perpendicular and lines parallel for given line and point	10
Trapezoidal area under curves	9, 10, 12
Approximating π by Monte Carlo Methods	11
Limits of f(x) as $\Delta x \rightarrow 0$	12
Simpson's rule for approximating the definite integral	12
Area under curve by Rieman sums (Random partition)	11
Definite integral of function that is a linear combination of powers of X (Polynomial)	12

GEOMETRY

Composite program giving all information for graphing a circle, parabola, hyperbola or ellipse	10
Angles-sides information in triangles	10
Determine the angle between two intersecting lines	11
Triangle solutions from some angles and sides	10, 12
Areas of parallelogram, trapezoid, triangle, square, rectangle, ellipse, n-sides polygon	10
The projection of a line segment on to both the X and Y axis	10
Area of any convex polygon	10, 12
Third side of right triangle with Pythagorean theorem	10

Volume of sphere, cone, cylinder	10
Polygon teaching machine	10
Determines if three sides form a right triangle	8
Area and perimeter of rectangle	9
Area of spheres with R = 1,2,3,...,10	12
Spheres: diameter, circumference of great circle, volume and surface area	10
Area and volume of cylinders	12
Length of an arc of a circle from chord length and radius	12
Distance between two points	10
Compute sum of the perimeters of triangles successively inscribed in one triangle	12
Polar-rectangular coordinate conversion	10, 12
Translated graph	12
Area, center, radius and circumference of a circle from three non-colinear points	10

PROBABILITY AND STATISTICS

Simulation of Fuffon's needle problem	12
Composite program of probability of drawing objects with or without replacement	10
Area under normal curve	12
Composite statistics program computing mean, mode, geometric mean, harmonic mean, root mean square, and standard deviation	12
Simulation of single coin toss	8
Simulation of two coin toss	8

Simulation of tossing X coins B times	8
Permutations of n objects	12
Standard deviation of a set of numbers	11
Statistics on a single set of data; largest element, smallest element, mean and median	9
Compute permutations on combinations	12
(See also Games)	

PHYSICS

Particles in collision	12
PV = NRT (any part of the gas law)	10,12
Fahrenheit - Centigrade (Conversion either way)	9
Conversion among three systems (MKS, CGS, FPS)	11
Inertia of a rotating disk	12
Combination of force vectors	12
Wave length and speed of light from frequency in experiment	11
Orbit of "Syncom" satellite	11
Acceleration of an object falling from 5,000 miles above the earth	11
Muzzle velocity of bullet from impact into a wooden pendulum	12
Velocity of object thrown from a cliff	12
Solution of PI or DELTA electrical networks	12
Resistance and tolerance of a resistor	12
Total induction in either series of parallel circuit	12

Amperage, voltage drop and power converted in series or parallel circuit from resistances and voltage	12
From focal length of objective and eye piece, the magnification of the microscope	12
Focal length of mirror	12
Conversion metric - English system	9, 11, 12
Efficiency of simple machines; lever screw, wheel and axle, inclined plane, and pulley	9
Ohms Law for information on circuit	9
Expansion of metal with temperature change	10
Distance, rate, or time of moving object	11
Boyles gas law; Kelvin fahrenheit centigrade conversion	9, 10
Clausius - Clapeyrean equation	12
Composite program of circuit formulas	11
Simulation of gas melecules moving into a vacuum	12
Distance light travels in X years	9
Trajectory of objects shot through the air	10, 12
Composite mechanics program in physics	11

CHEMISTRY

Data retrieval on elements	12
Computes (sodium chlorate/sodium chloride) ratios from experimental data	9
Solves equations for ideal liquids in terms of the additivity of vapor pressures	10
Given concentrations of two electrolyte compounds, determines whether a precipitate will form	11

Solubility of ionic compounds	10
Heat calculations: reaction, fusion, solution, specific heat, or temperature	9
Placement of electrons in shells, subshells, and orbits given atomic number	12
Calculate E.M.F. of reaction	12
Teach valences of chemical radicals	12
Name organic compounds from formulas	10
Grams/mole, atoms/mole from atomic weights and molecular formulas	11

GAMES

Triangle game	12
Horse race game with up to eight players (a simulation)	11
Roulette game	9, 11
Russian roulette game (with a six-cylinder pistol)	11
Maze game	10
Battleship game on 66 x 66 square board	10, 11
Number matching game	7
Tic tac toe game using a magic square	10
Poker game	11
Basketball game	12
Bowling game	11
Three small number games	12
Black Jack game	10
Number guessing game	7

Hockey Game	8
Car race	9, 10
Russian dialet game	11
Soccer game	11
Presidential election game	10
Game of Keno	12
Baseball game	12
Kanabola game	11
Game of Jotto (word game)	12

MISCELLANEOUS

Annuity calculations	11
Compute layout of school newspaper	12
Truth table of any Boolean expression of up to six variables	10
Information on battleships at Pearl Harbor on December 7, 1941	11
Stems for irregular French verbs in any of six tenses	11
Learning program that plays NIM	10
Predict basketball game scores	10
From transmission ratios and Newton's law of engine-the top speed and acceleration of an automobile	11
Write random Haiku (short poems)	10, 8
Store baseball player records	10
Teach program to practice German adjectives	11
Compile results of political opinion survey	11
Given note what strings should be played on a 6-string guitar	10

Probable mineral from four pieces of experimental data	11
Seating plan for dining hall	12
How a library fine doubles each day	10
Computes and prints payroll for small company	12
Change numbers <4000 to Roman numerals	9
Randomly assigns jobs to workers	9
Code and decode program using random number table	12
Score sailboat races	10
Compose random music	12
Teach Morse Code	12
Statistics on imports-exports of China 1952-63	10
Change musical keys	12
Comparison of various shipping routes and their costs	11
Golfer's handicap on various courses	12
Tells your fortune from height and weight	8
Compose grocery list and total costs	9
Teaching German nouns	9
Translates numbers from numerals to words	11
Analysis of your golf game	12
Pay weekly and yearly to or from hourly wages	10
Generation of random sentences	10
Teaching machine for word prefixes and suffixes	12
Computation of compound interest	10

Baseball score prediction	10
Skeleton teach program	11
Physics teaching program (for chapters 2, 3 of Heaths' text)	11
Grading program	7
Tally election results	10
Commission on sales	11
Sports quiz	10
Data retrieval from table	12
Compose random music given time signature	10, 11
Finds different forms of the French verb "avoir'	7
Basketball practice arrangement of teams	12
Print room passes	11
Lining up decimal points in printout	11
Computer letter writing	8
Tally federal tax, F.I.C.A. and state tax from W-2 forms	12
Student schedule card	9
Test to see if words form a sentence	10
Write random French sentences	10
Letter writing program	12
Analysis of the effect of per capita income on the voter in the 1948 Presidential election	11
Abbreviated BASIC system	9
A TRACE System for locating programming errors	11

APPENDIX B

INDEX OF TOPIC OUTLINES ACCORDING TO GRADES

Grade	Title
4	Four Classes with Fourth Graders -- Introduction to BASIC William A. Smith, Lebanon High School
7 - 12	A BASIC Manual for High School Students (with exercises) Floyd McPhetres, Hartford High School
7 - 9	Junior High School Uses of a Time-shared Computer G. Ralph Bolduc, Cape Elizabeth High School
7 - 12	Some Computer Applications in Secondary School Science Spencer Laramie, Mascoma Valley Regional High School
9	Two Examples of Linear Programming in an Algebra I Class William Smith and David Penner, Lebanon High School and Phillips Andover Academy
9	Solution of Simultaneous Linear Equations John Connover, St. Johnsbury Academy
9	BASIC in 10 Minutes a Day Louis Hoitsma, Phillips Andover Academy
9	Introduction of the BASIC Language, Teletype Usage and Elementary Programming Peyton Pitney, Mount Hermon School
9	Ninth Grade Word Problems Warren Hulzer, St. Paul's School
9 - 10	Random Sample Studies Charles A. Tousley, Keene High School
10	The Binomial Theorem Gary Toothaker, Vermont Academy
10	Genetics of the Fruitfly -- Phenotype Ratios Charles A. Tousley, Keene High School
10	The General Solutions of the Quadratic Equations G. Ralph Bolduc, Cape Elizabeth High School
10 - 11	Value of "Cos t1" (an iterative technique) John C. Warren, Phillips Exeter Academy

Grade	Title
10 - 11	The Circular Function John C. Warren, Phillips Exeter Academy
10 , 12	The Use of the Computer in Air Pollution Study John Connover, St. Johnsbury Academy
10 - 11	Summer School Computer Course John Hauber, Loomis School
10 - 11	Slope of a Line and Common Solutions for Systems of Linear Equations G. Ralph Bolduc, Cape Elizabeth High School
11	Areas and Perimeters of Circles and Ellipses Paul Kenison, Manchester Central High School
11	Slopes of Exponential Functions George H. Lewis, Concord High School
11	Five Ionization Reaction Problems Spencer Laramie, Mascoma Valley Regional High School
11	Area Under Trapezoid Charles A. Tousley, Keene High School
11	Introduction to Logarithms Charles A. Tousley, Keene High School
11	Finding Nth Degree Equations from a Set of Tabular Values Paul E. Kenison, Manchester Central High School
11 - 12	Finding Approximations for Irrational Zeros of Polynomial Functions Peyton Pitney, Mount Hermon School
11 - 12	Three Simple Examples of Computer Use in a Physics Laboratory John Martin, Rutland High School
12	Using a Time-shared Computer in Developing the Law of Sines, the Law of Cosines, and the "Solution of Triangles" Floyd McPhetres, Hartford High School
12	Free Falling Bodies and Projectile Motion Spencer Laramie, Mascoma Valley Regional High School
12	Computer Course for Business Students Ann Waterhouse, South Portland High School

Grade	Title
---	An Adult Education Course in BASIC Programming John Martin, Rutland High School
8 - 12	Collected Uses of a Computer in Probability and Statistics Mary Hutchins, Hanover High School
12	Two Programs on Riemann Sums George R. Smith, St. Paul's School
12	Numerical Integration G. Albert Higgins, Jr., Mount Hermon School
11 - 12	A Unit in Matrix Algebra Ann Waterhouse, South Portland High School

APPENDIX C

SUMMARY OF NSF PROPOSAL OBJECTIVES

I. Meeting Objectives

Following is a summary of the project findings to date, as they relate to its objectives as set forth in Part II of the initial project proposal.

A. To demonstrate that computing can be useful in the teaching of subjects other than mathematics.

The computer has been of use in many subjects other than mathematics. Programs submitted by students from the sciences include: several programs to do physics lab calculations, programs to do chemistry lab calculations, programs for class demonstrations in chemistry and physics, a teaching program (again, written by a student) to teach other students the valences of chemical radicals.

In other classes . . . one student wrote a program that uses the machine to retreive data on the various ships in Pearl Harbor in December, 1941 . . . another wrote a program that will produce the irregular French verb endings given a verb and the tense desired . . . other projects completed include historical games, computer dances, business programs, and scoring of sport events.

One significant obstruction to demonstrating the computer's usefulness in teaching in the social sciences is the average social science teacher's inexperience with statistics. Indeed, some high school students have a much better grasp of applied statistics and

their use on the computer, than many college professors of the Social Sciences.

B. To demonstrate that computing can encourage the student to think creatively.

Literally hundreds of programs received from students in the last nine months testify to the student's creative ability. (See Appendix A). The very nature of going from a rough idea to an articulate set of specific directions in a working program is in itself a highly creative act.

Several of the more complicated games written by some advanced students as well as some of the less involved programs written by slow students may stand, each in its own way, as the most outstanding intellectual creation that student will make in his four years in school. This claim is backed by the fierce pride students have in their programs. They are their very own. They made them and they work.

C. To demonstrate that computing can be effectively introduced into secondary schools without extensive curriculum changes or teacher retraining.

The four-week training session for teachers last summer was shortened to two weeks this summer. This speaks for itself. Commentary on teacher and student training at teachers conferences also confirmed the ease and speed with which computing can be introduced into schools.

D. To experiment with techniques for introducing computing to the student, and for helping the teacher integrate computing in his courses.

Techniques for introducing the computer abound in the Topic Outlines and are discussed in the body of the First-Year Report. Over thirty Topic Outlines written by the teachers themselves are now available.

E. To develop materials that will aid other schools to take full advantage of the opportunities computing provides.

"The Report on a Four-Week Training Session for Teachers", this "First Year Report", and the collection of Topic Outlines should allow other schools to take full advantage of our experience.

II. Materials to be Developed

A. Materials for use in mathematics courses in secondary schools.

The reader is referred to the Topic Outlines.

B. Materials for use in non-mathematical courses in secondary schools.

The reader is referred to the Topic Outlines for the few existing examples currently available. Many of the teachers trained this summer are not math teachers, and it is anticipated that they will contribute a large collection of examples for inclusion in the Final Report to be written next summer.

C. Materials not directly related to specific courses.

Ideas may be found among the student programs in Appendix A. Also the project coordinator has written three small sequences on the machine to teach:

1. Simple BASIC -- BASICT***.
2. How to handle rectangular arrays of numbers -- MATTEACH.
3. Statistics on a single set of data -- STATEACH.

D. <u>Suggestions for computer clubs</u>.

The first suggestion is to forget them. The sole interest that all members seem to have in common is the teletype terminal and how to keep it running. The disparities in age and ability of student programmers quickly fragment any clubs into small cliques of students leaving as the only common practice the instruction of moves by the "old hands".

E. <u>Suggestions for Student Projects</u>.

The reader is referred to the list of student programs in Appendix A. What is a trivial exercise for one student can be a three-week project to another. Programs similar to the working programs in Appendix A were attempted but not successfully completed at some schools. Student projects depend on student ability.

F. <u>Outlines for Use in Courses</u>.

The reader is referred to the Topic Outlines listed in Appendix B.

G. <u>Guides for effective teletype utilization</u>

The subject is covered in the main body of this report.

APPENDIX D

HIGH SCHOOL COMPUTER CONFERENCE -- SCHEDULE OF EVENTS

WELCOME by Charles Gray, Conference Chairman

10:00 a.m. -- 10:30 a.m.	Lecture on Machine Language (105 Bradley) Dartmouth Student Programming Assistant
	Lecture on LISP (102 Kiewit) Bennet Vance, Hanover High School
10:30 a.m. -- 11:00 a.m.	Tours of Kiewit Computation Center
11:00 a.m. -- 11:30 a.m.	Lecture on Machine Language (105 Bradley) Dartmouth Student Programming Assistant
	Lecture on LISP (102 Kiewit) Bennet Vance, Hanover High School
11:30 a.m. -- 12:30 p.m.	LUNCH at Thayer Dining Hall

(Afternoon Session to be held in Filene Auditorium, Bradley Building)

12:45 p.m. -- 1:45 p.m.	Professor John Kemeny Mathematics Department, Dartmouth College
1:45 p.m. -- 2:05 p.m.	William Farrell, Hanover High School An Economics Game Program
2:05 p.m. -- 2:25 p.m.	David Jones, Rutland High School A Battleship Game Program
2:25 p.m. -- 2:55 p.m.	David Nye, Hanover High School Working with XBASIC
2:55 p.m. -- 3:05 p.m.	BREAK
3:05 p.m. -- 3:20 p.m.	Gerry Durant, Mascoma Valley High School Election Prediction Program
3:20 p.m. -- 3:35 p.m.	Fred White, Hanover High School Program in Logic
3:35 p.m. -- 4:00 p.m.	Professor Thomas Kurtz, Director of Kiewit Some New Features in Phase II

APPENDIX E

COMPUTER USE BY TEACHERS, GUIDANCE PERSONNEL, AND ADMINISTRATORS

Note -- The following is a list of extra jobs that can be done by a time-shared computer to help school personnel. It goes without saying that they received lowest priority, behind student usage and classroom teaching usage.

1. Class ranking
2. Grading (test, term, year averages)
3. Planning dining hall seating
4. Limited scheduling of courses
5. Scoring ski meets
6. Comparing various tax schedules in anticipation of school building projects
7. Projecting various teacher retirement plans.
8. Investigating for the school board the total cost of various salary plans.
9. Computing correlation coefficients between tests requested by guidance counselors
10. Refining a weight-lifting schedule (done by a physical education teacher)
11. Preparing data on Blue Cross and retirement plan options for school board and teachers' groups

APPENDIX F

EXAMPLE OF A TOPIC OUTLINE

NSF-DARTMOUTH

SECONDARY SCHOOL PROJECT

(NSF Grant No. GW-2246)

TOPIC OUTLINE

TOPIC: Junior High School Uses of a Time-Shared Computer

TEACHER: G. Ralph Bolduc

SCHOOL Cape Elizabeth High School

GRADE: Seven, Eight, Nine

COURSE: Math, Science

CONTENTS:

1) Four approaches to introducing the computer to seventh graders.

2) Five Appendices with illustrative examples.

THIS IS A PRELIMINARY VERSION. COMPUTER PROGRAMS MAY CONTAIN ERRORS.

Kiewit Computation Center
Dartmouth College
Hanover, New Hampshire 03755
August 2, 1968

The following is a report of use in Junior High School as attempted by four teachers. It is a summary of how the use of the computer was introduced and what the students did. Also included are a list of suggested computer problems.

I.

William R. Faulkner, Jr. of St. Paul's School Concord, New Hampshire, has a program in which the computer is integrated into the regular curriculum of the seventh grade.

The students are taught the fundamentals of BASIC and computer usage in the early Fall. Through the Fall and Winter terms, six required programs are completed by the students. In the Spring, only one program is required, but suggested programs, five in all, may be done by interested students as special projects.

For a more detailed report on this project, see the appended material "Integration of the Computer in a Preparatory School Curriculum". (Appendix A)

II.

Mary Hutchins of Hanover, New Hampshire introduced her seventh grade students to the computer by showing them how to get access to the computer through the teletype. She then showed them a program, "PMETER" (See Appendix B) which found the perimeter of a rectangle. They were to call up the program, insert their own data and run the program.

The students then discussed the program to observe what each line of the program did. In this way they learned six of the commands and their functions.

After students had had more "hands on time", they were handed out a sheet with five programs. These programs incorporated four new commands which were explained to the students.

From this point on, due to the difficulty of scheduling terminal time, the students were on their own. They were free to write any type of program which interested them. Help was available from the teacher whenever a student ran into difficulty.

III.

Spencer Laramie, of Mascoma Valley Regional School, introduced his students to the computer by use of a program which contained eight of the commands. There were shown a RUN and LIST of the program and each line was explained.

Students who were interested were allowed to sign up for more instruction, which was given during the Activities Period or after school.

One of the features of the added instructions was that the students were taught how to flow chart. This proved to be very helpful later as they began to write more complicated programs.

Because of the difficulty of arranging teletype time no formal assignments were made. However, students were given a sheet containing a list of suggested programs which would require more knowledge of the language. Some of the problems would require research on the part of the student as they were a little beyond his formal background.

IV.

Ralph Bolduc of Cape Elizabeth, Maine, introduced the computer to several classes in the Junior High School

Three class sessions were used to teach the students the seven initial commands in BASIC, how to connect to the computer through the teletype, and how to write a simple program.

The programs shown students in these classes were connected with the work which they were doing at that time in class. In two cases it involved area and perimeter problems and in one writing decimal representations for fractions.

Again due to the limited availability of the teletype, no formal assignment was given. However, interested students were given additional instruction after school and were issued user numbers and allowed to work on the teletype. Teachers of these students were alerted to the fact that they were users and they were sometimes called upon to give a demonstration of the computer as it might apply to a topic under discussion.

SUMMARY

Although the methods used varied, the end results all seem to be about the same. The Junior High School student proved himself to be a good programmer. They turned out a great deal of work, much of it more complicated than would be expected from students at this level.

Many wrote game programs which they used to impress and intrigue their friends. Some wrote programs which required a good deal of research on the part of the student into, not only mathematics and science but, computer language.

Jerry Durant, a student from Mascoma Valley Regional School, wrote a program analyzing the results of a vote taken in a student Presidential Primary at his school. The program won an Honorable Mention in the nation-wide AEDS computer programming contest.

A list, and brief description of some of the other special projects done by Junior High students will be found at the end of this report.(Appendix E)

It is safe to say that Junior High School is a good place to introduce the use of the computer. The ability to program can be gained there and eventually the full potential of the computer will be realized when the student progresses further in his mathematics education. There are certainly many areas in which the use of the computer can be tied into class work without having to force this upon students. A list of some of these areas will be found at the end of this report.

The use of computers in Junior High School will be limited only by availability of a computer, and the interest of the teacher. Given these, the average seventh grader stands ready, willing and able to use a computer.

APPENDICES

A. Report by William R. Faulkner, Jr.
St. Paul's School, Concord, New Hampshire

B. Programs used by Mary Hutchins and Spencer Laramie

C. Areas where computers might be used in Junior High School Curriculum.

D. Suggested Problems for Use in the Junior High School.

E. Some Special Projects written by Junior High School Students.

APPENDIX A

Report by William R. Faulkner, Jr.
St. Paul's School, Concord, N. H.

INTEGRATION OF THE COMPUTER IN A PREPARATORY SCHOOL CURRICULUM
St. Paul's School, Concord, N H.
Form I (Grade 7)

During the early weeks of the Fall Term, I introduce the boys to the computer and necessary methods and language they will need immediately to operate it. This introduction takes the form of 15-minute segments of class periods, one at the computer to demonstrate the telephone technique and the idiosyncrasies of the keyboard and another in the classroom about the HELLO sequence for re-emphasis. After the suggestion that we treat the computer as a younger brother or sister who can add, subtract, multiply, and divide, I ask the class for directions which will cause the computer to compute the area and perimeter of a rectangle and then give out its result. Discussion eventually produces a program which meets my criteria of format and their criteria of understandability. [This program will have incorporated READ - DATA, LET, PRINT, and END.] At this point, I erase the program from the board, and turn to another topic without relation to the computer. At the conclusion of the class, I 'remember' that their <u>first assignment</u> on the computer is a program to find <u>the area and perimeter of a rectangle</u>, and they are sent off with one week to complete this task and successfully place it upon the teletype.

APPENDIX A page 2

The second required program must produce the factors of any given number N. They are allowed three weeks for this program, and I announce my availability and eagerness to help them with it if they will simply demonstrate some forethought [This program will incorporate FOR - NEXT, IF - THEN, INT(N), and <>, in response to such demands as 'divide N by everything, I mean all numbers from 1 to N', 'well, if you get a whole number then it's not prime', 'it's not prime if it goes in'.] After the completion date, I correct and grade their efforts. Without knowing what their actual grade is, each student who does not have a correct program has one week to correct his error(s) and, by so doing, receive back one-half of the credit he has lost. Following this week, a selection of correct programs is distributed to the class to the glory of the chosen few and the enlightenment of the others.

The third required program must produce the common factors of two given numbers M and N. They are allowed three weeks for this and following programs, with the one week revision period handled as described above. I require this program as a spiral method, to re-inforce those who have experienced success earlier but, more importantly, to allow those who did not have success, but have now received a set of complete solutions, to apply this information in a slightly modified program.

Appendix A page 3

In the Winter Term, the first assignment is a program to list the prime numbers up to a given number N. This is spiraled by the second required program, the prime numbers between a given M and a given N. The third program asks for the prime factors of a given number N.

In the Spring Term, I spiral by asking for a program which will express a given number N as a product of its prime factors. Each of these programs listed above fits naturally into the material covered in Arithmetic, and I am certain that I could continue the assignments with similar programs. However, I have chosen to conclude the required work at this point and leave the remainder of the Spring Term open for those who wish to undertake additional programs on individual incentive. In large part, I feel that the effectiveness of my incorporation of the computer into the curriculum and the extent to which I have inspired my students to be mathematically interested and inquisitive as well as able can be measured by the amount of work undertaken and completed in these last weeks.

During the Spring Term of the academic year 1966-1967, one student completed five additional programs, a second student completed two, and many others completed or attempted one. My suggested programs were, not in order of difficulty or completion, (1) list n , n!, and ℓn in three columns. (2) order three numbers, (3) list all primes which are the sum of squares, (4) list pythagorean triples, and (5) establish a general conversion between arbitrary bases. Each of these programs gave me the opportunity to explore an old topic in depth or a new topic with the student.

Appendix A page 4

In conclusion, I must mention that work with the computer appeals to those who have a strong leaning toward 'method' rather than 'computation'. In this way, it balances the stress upon arithmetical precision. Further, the challenge of mastering the machine has an appeal with is not directly related to the student's academic average.

On the following pages, you will discover a sampling of the programs completed by my class of 1966-1967.

William R. Faulkner, Jr.

Suggested Program # 1

SUMFAC by Robert P. Cummings

```
10 LET A = 1
20 LET B = 1
30 LET C = 1
40 PRINT A,B,C
50 LET A = A + 1
60 LET B = A + B
70 LET C = C * A
80 GO TO 40
90 END
```

JAGGED by Jonathan F. Tait

```
5   INPUT M
10  FOR A = 1 TO M
40  IF A <> 1 THEN 70
50  PRINT A, A, A
55  LET P = A
57  LET X = A
60  NEXT A
70  LET S = A + P
80  LET S1 = A * X
90  PRINT A, S1, S
100 LET P = A + P
105 LET X = X * A
110 GO TO 60
120 END
```

SUGGESTED PROGRAM # 2

4310 by Robert P. Cummings

```
1   REM * THIS PROGRAM PUTS ANY THREE NUMBERS IN ASCENDING ORDER *
2   PRINT 'INPUT THREE NUMBERS IN ANY ORDER';
5   INPUT A, B, C
10  IF A > B THEN 33
20  IF B > C THEN 40
30  PRINT A, B, C
31  GO TO 68
33  IF C > B THEN 55
35  PRINT C, B, A
37  GO TO 63
40  IF A > C THEN 50
45  PRINT A, C, B
47  GO TO 68
50  PRINT C, A, B
53  GO TO 68
55  IF C > A then 65
60  PRINT B, C, A
63  GO TO 68
65  PRINT B, A, C
68  PRINT 'THESE ARE NOW IN
           ASCENDING ORDER.
           RIGHT';
69  GO TO 5
70  END
```

Suggested Program # 3

```
729  by Robert P. Cummings
10   FOR B = 1 to 200
20   FOR A = 1 TO B
30   LET C = A^2 + B^2
40   FOR Z = 2 TO C-1
50   LET X = C/Z
60   IF X = INT(X), THEN 80
65   NEXT Z
70   PRINT C;
80   NEXT A
90   NEXT B
100  END
```

```
GRIND2 by Jonathan F. Tait
1   PRINT 'THIS PROGRAM PRINTS ALL
          THE NUMBERS FROM 1 TO
          200 THAT ARE'
2   PRINT'THE SUM OF TWO SQUARES'
10 FOR A = 2 TO 200
20 FOR B = 2 TO SQR(A)
23 LET C = A/B
30 IF C = INT(C) THEN 125
40 NEXT B
50 FOR D = 1 TO SQR(A)
60 LET E = A - D^2
70 IF SQR(E) = INT(SQR(E)) THEN 100
80 NEXT D
90 GO TO 125
100 PRINT A;
125 NEXT A
130 END
```

Suggested Program # 5

BASE N by Robert P. Cummings

```
10  INPUT A, B
12  PRINT A '(10)' '=' ;
15  DIM D(25)
18  FOR N = 1 TO 25
20  LET C = A/B
40  LET D(N) = (C - INT(C) )* B
50  IF INT(C) = 0  THEN 70
55  LET A = INT (C)
60  NEXT N
70  FOR E = N TO 1 STEP -1
80  PRINT D(E);
90  NEXT E
98  PRINT 'IN BASE' B
99  GO TO 10
100 END
```

N.B. This program does not satisfy the general suggested program, but it is praise-worthy.

INTEGRATION OF THE COMPUTER IN A PREPARATORY SCHOOL CURRICULUM
St. Paul's School, Concord, N. H.
Form I (Grade 7)

On this and the following pages, you will discover a sampling of the required programs completed by my class of 1967-68.

William R. Faulkner, Jr.

#2 COMPU 2 by R. Clive Altshuler

```
4   REM THE PURPOSE OF THIS PROGRAM IS TO FIND THE FACTORS
5   REM OF A GIVEN NUMBER
10  PRINT 'WHAT IS THE VALUE OF X';
20  INPUT X
30  FOR Y = 1 TO X
40  LET N = X/Y
50  IF N <> INT(N) THEN 70
60  PRINT N;
70  NEXT Y
90  GO TO 10
100 END
```

2 BITE by Frederic Rockefeller

```
10  LET P = 76590
20  LET L = 1
30  IF INT(P/L) = P/L THEN 50
40  GO TO 60
50  PRINT P/L
60 LET L = L + 1
65 IF L > P THEN 100
70 GO TO 30
100 END
```

Appendix A page 9

\# 3 IT by Bruce T. Ma

```
1  REM THIS PROGRAM IS TO FIND THE COMMON FACTORS OF TWO
3  REM POSITIVE INTEGERS
5  PRINT 'WHAT INTEGERS DO YOU WANT THE COMMON FACTORS OF?'
10 INPUT X, Y
15 LET M = 1
20 IF X/M = INT(X/M) THEN 30
25 GO TO 45
30 IF Y/M = INT(Y/M) THEN 40
35 GO TO 45
40 PRINT M;
45 IF M > X THEN 60
50 LET M = M + 1
55 GO TO 20
60 END
```

\#3 UNNAMED by Paul C. Tung

```
10  INPUT A
20  INPUT B
30  FOR C = 1 TO A
40  FOR D = 1 TO B
50  LET E = A/C
60  LET F = B/D
70  IF E = F THEN 110
80  IF E <> INT(E) THEN 130
90  IF F <> INT(F) THEN 120
100 IF E <> F THEN 120
110 PRINT E
120 NEXT D
130 NEXT C
140 IF E = 1 THEN 160
150 IF F = 1 THEN 160
160 GO TO 10
170 END
```

#3 BRAIN by Bruce T. Ma

```
10  PRINT 'WHAT IS THE VALUE OF X'
15  INPUT X
18  FOR M = 2 TO X
20  FOR N = 2 TO M
25  IF INT(M/N) = M/N THEN 35
30  NEXT N
35  IF N = M THEN 45
40  NEXT M
45  PRINT M 'IS A PRIME'
50  GO TO 40
65  END
```

#3 PRIME NUMBERS by Paul C. Tung

```
10  INPUT N
20  FOR X = N TO 2 STEP -1
30  FOR Y = 2 TO X
40  LET Z = X/Y
50  IF Z<>INT(Z) THEN 100
60  IF Z = 1 THEN 90
70  IF Z = INT(Z) THEN 110
90  PRINT X
100 NEXT Y
110 NEXT X
120 GO TO 10
130 END
```

Appendix A page 11

#5 COMPU 5 by R. Clive Altshuler

```
10  REM THE PURPOSE OF THIS PROGRAM IS TO FIND THE PRIME
20  REM NUMBERS BETWEEN A GIVEN NUMBER AND ANOTHER GIVEN NUMBER.
30  PRINT 'WHAT NUMBER DO YOU WANT TO FIND THE PRIMES UP TO';
40  INPUT L
43  PRINT 'WHAT NUMBER DO YOU WANT TO FIND THE PRIMES FROM'
45  INPUT X
50  FOR F = X TO L
60  FOR Z = 2 TO (F-1)
70  LET D = F/Z
80  IF D = INT(D) THEN 110
90  NEXT Z
100 PRINT F;
110 NEXT F
120 PRINT'THESE ARE THE PRIME NUMBERS BETWEEN'X 'AND'L'.'
130 END
```

#5 PECK by Frederic Rockefeller

```
5   PRINT 'PRINT NUMBERS YOU WANT TO FIND THE PRIMES BETWEEN'
10  INPUT X, Y
20  IF Y > X THEN 40
30  GO TO 60
40  FOR O = X TO Y
50  GO TO 70
60  FOR O = Y TO X
70  FOR A = 2 TO (O-1)
80  LET B = O/A
90  IF INT(B) = B THEN 110
100 GO TO 120
110 GO TO 140
120 NEXT A
130 PRINT O
140 NEXT O
145 NEXT O
150 END
```

N.S. This program has programming errors in lines 20 - 60 and, 140, and 145.

#6 T by Allen E. Griffin

```
10  INPUT A
20  FOR B = 1 TO A-1
30  LET C = A/B
40  IF C = INT(C) THEN 50
45  NEXT B
47  GO TO 200
50  FOR D = 2 TO C/2
60  LET E = C/D
70  IF E = INT(E) THEN 45
80  NEXT D
90  PRINT C ''IS A PRIME FACTOR OF'' A
100 GO TO 45
200 END
```

#6 PRAST by W. R. Spencer Morris

```
10  PRINT ''PUT A # AFTER THE ?''
20  INPUT X
40  FOR O = 1 TO X
50  LET Z = X/O
60  IF Z = 1 THEN 80
70  IF Z = INT(Z) THEN 90
80  NEXT O
90  FOR N = 2 TO Z
100 LET U = Z/N
110 IF U = 1 THEN 130
120 IF U = INT(U) THEN 80
130 NEXT N
135 IF Z = L THEN 160
140 PRINT Z ''IS A PRIME FACTOR OF'' X
150 GO TO 80
160 END
```

#5 G by Allen E. Griffin

```
1  REM THE OBJECT OF THIS PROGRAM IS TO FIND THE PRIME #S
2  REM BETWEEN ANY TWO GIVEN NUMBERS.
3  REM WHEN ? APPEARS, TYPE A #, A COMMA, AND ANOTHER #.
4  INPUT Q,C
5  FOR B = Q TO C
10 FOR A = 2 TO INT(B/2)
20 LET M = B/A
30 IF M = INT(M) THEN 56
50 NEXT A
51 PRINT B 'IS PRIME'
56 NEXT B
90 END
```

APPENDIX B

PROGRAMS USED BY MARY HUTCHINS AND SPENCER LARAMIE

```
HELLO
GE 600 LINE T/S FROM DARTMOUTH
TERMINAL 136 ON AT 12:00  12/05/67
USER NUMBER--H15001,67-68
NEW OR OLD--NEW
NEW FILE NAME-- PMETER
READY
10 READ L,W
20 LET X =2*L
30 LET Y = 2*W
40 LET P = X+Y
50 PRINT "PERIMETER -",P
60 PRINT
70 GO TO 10
80 DATA 15,6,20,7
99 END

READY

RUN

PMETER     12:03      12/05/67

PERIMETER -       42

PERIMETER -       54

OUT OF DATA IN 10


TIME:  .04 SECS.

SAVE
READY
```

Appendix B page 2

I MIDDLE

```
5  READ N
10 READ A,B,C
15 LET D = A+B+C
20 PRINT D/N
25 DATA 3
30 DATA 10,15,8
99 END
```

II RAIZUP

```
10  READ X
20  FOR I = 1 TO 4
30  LET Y = X↑I
40  PRINT Y
50  NEXT I
60  DATA 2
99  END
```

III AREA

```
10 READ B,H
20 LET A = .5*B*H
30 PRINT A
40 GO TO 10
50 DATA 8,6,10,5,42,12
99 END
```

IV NUMLIST

```
10 READ N
20 FOR I = 1 TO N-1
30 PRINT N-I;
40 NEXT I
50 DATA 8
99 END
```

V MAXGAME

```
10 FOR I = 1 TO 10
20 LET X = RND
30 LET Y = INT(10*(X+.5))
40 LET W = RND
50 LET Z = INT(10*(W+.5))
60 IF Y + Z > 10 THEN 90
70 LET S = S+Y+Z
80 PRINT S
90 NEXT I
99 END
```

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SPENCER LARAMIE

RUN

EXAMPLE 14 12 06/19/68

```
 8
SNOOPY AND THE RED BARON FLY KITES
 27
```

TIME: .05 SECS.

LIST

EXAMPLE 14:12 06/19/68

```
100  FOR I = 1 TO 6 STEP 2
200  READ X,Y, Z
300  LET W = (X*Y) + Z
400  IF W <= 0 THEN 700
500  PRINT W
600  GO TO 800
700  PRINT "SNOOPY AND THE RED BARON FLY KITES"
800  NEXT I
900  DATA 1,5,3
910  DATA 3,2,-6
920  DATA 3,6,9
999  END
```

APPENDIX C

Areas where computer might be used in Junior High School Curriculum

1. Areas, Perimeter and Volume Formulas
2. Rounding Off Numbers
3. Changing Fractions to Decimals
4. Per Cent Problems (Per Cent, Percentage, Rate, Base)
5. Factors of a Number
6. Prime Number
7. Prime Factors of a Number
8. Finding Square Roots, Cube Roots, etc.
9. Change of Base
10. Slope of a Line
11. Cramer's Rule (Solution of Simultaneous Equations)
12. Ratio and Proportion

Since this list was compiled by Math Teachers, there is a wide area that is left uncovered. Schools using the Introductory Physical Science course should be able to make use of the computer there. (See also Mr. Spencer Laramie's Topic Outline of the use of the computer in High School Science.)

APPENDIX D

SUGGESTED PROBLEMS FOR JUNIOR HIGH USE

1. Write a program that will print out your name
2. Write a program to find the product of two numbers.
3. Write a program that will read successive pairs of numbers and, on each pass, will print the numbers and their sum.
4. Write a program to read and compute the sum of the first 12 even integers.
5. Write a program to compare two numbers. If the first is larger than the second print "NOT LESS THAN OR EQUAL". Otherwise print "LESS THAN OR EQUAL TO".
6. Write a program to generate and compute the first ten integers and their cubes.
7. Write a program to find the sum of pairs of numbers. Print out each number and the sum in appropriate headed columns.
8. Rewrite number 7 so that the product is also found.
9. Rewrite numbers 7 and 8 so that when it prints out the results, it prints out the smaller of the two given numbers first.
10. Rewrite numbers 7, 8 and 9 so that the results of the sixth pair are printed last.
11. Write a program to compute the net wages of employees of a private company. You are given the gross wages, income tax of 20% if income is $80 or less, 22% if income is more than $80, union dues of 1% of total wages, FICA tax 4 1/2% of income equal or less than $90 per week. Do not be concerned with dependents. The company has 8 employees.
12. Write a program that will generate the first ten integers, calculate their squares and print out in columns headed "Number ", "Square", "Sum of Squares".
13. Write a program to generate the first ten integers, compute their square roots, print out the number and its square root in appropriately labeled columns.

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14. Write a program to find and print the prime numbers less than 500.
15. Write a program to find the square root of a number without using the square root function in the library.

16. Write a program which will compute the slope of a line given the coordinates of two points.

This is only a partial list of possible programs. The students themselves by their questions will suggest many more.

APPENDIX E

Some Special Projects Written by Junior High School Students

1. CHAMA$0 - Dan Leary, Grade 9, Loomis School, Connecticut
   Plays slightly modified roulette game.

2. TRIN - George Williams, Grade 8, St. Paul's, Concord, N. H.
   Factors a trinomial of second degree.

3. BLACKJAC - Torgeir Owren, Grade 9, Hanover, N.H.
   Plays a game of blackjack.

4. SENT - Adam Burrows, Grade 9, Loomis School, Connecticut
   Generates sentences from inputed words.

5. LØGLIN - Timothy Grant, Grade 8, St. Paul's, Concord, N.H.
   Does linear interpolation of logarithms.

6. MULTIPLY - Jim Browning, Grade 7, Hanover, N.H.
   Prints out a table of products for ten consecutive integers times any ten given integers.

7. RØCK - John Wright, Grade 8, St. Paul's, Concord, N.H.
   Prints out terms of the Fibonacci Sequence.

8. MULTYTØS - George Williams, Grade 8, St. Paul's, Concord, N.H.
   Simulates the tossing of X number of coins B times.

9. LØG ANTEI - Thomas Bennett, Grade 9, St. Paul's, Concord, N. H.
   Finds the log or antilog without using "LOG" function.

10. D1Ø2 - Duncan McEwen, Grade 7, Mount Hermon School, Massachusetts
    Finds truth set of Diophantive Equations whose replacement set is the set of positive integers.

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11. PØLYZERØ - Thomas Bennett, Grade 9, St. Paul's, Concord, N.H.
    Finds rational roots of polynomial equation, in simple form, which is equal to zero.

12. M. BLACK - Ray Wagoner, Grade 9, Mount Hermon School, Mass.
    Used to randomly assign jobs under the Mount Hermon work program.

13. RØMAN - George Forish, Grade 9, Mount Hermon School, Mass.
    Changes integers less than 400 to Roman numerals.

14. SIERRA - Jon Goodwin, Grade 7, Hanover, N.H.
    A game program dealing with the economy of a province in Sierra Leone.

15. HIS - John Wright, Grade 8, St. Paul's, Concord, N.H.
    Finds Pythagorean Triples.

16. RØØT - Bruce Battis, Grade 9, Mascoma Valley Regional, N.H.
    Finds the fifth root of a number.

17. BATHTUB - John Wright, Grade 8, St. Paul's, Concord, N.H.
    Takes any two integers and gives their greatest common divisior and their lowest common multiple.

18. CAR RACE - Ray Wagoner, Grade 9, Mount Hermon School, Mass.
    Simulates car race. User chooses the car he will drive.

19. NEWTØN* - Christopher Lane, Grade 9, Mount Hermon School, Mass.
    Finds square roots by Newton's method.

20. VØTERS - Jerry Durant, Grade 9, Mascoma Valley Regional, N.H.
    Tabulates votes of Presidential Primary run at school. Gives total vote and percentage by classes and for entire school.

The above list is a very small sampling of the work turned out by Junior High Students.