Secondary school use of the time-shared computer at Dartmouth College

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INTRODUCTION

Soon after the first Dartmouth Time-Sharing System began operation in May of 1964, the local high school installed a teletype. Within two and one-half years, eight high schools had tied into the Dartmouth System. The effects were startling. Hundreds of students were taught the BASIC language. Some of them produced highly sophisticated programs. Teachers were using computer applications in mathematics and science courses. These effects convinced Dartmouth of the high value of computing in secondary education. However, the results were not sufficiently examined. There was no documentation on recommended procedures nor written units of classroom applications. Therefore, in the spring of 1967, Dartmouth College proposed that the National Science Foundation support work in developing, expanding, sharing, documenting, and publishing the results of computing experience in secondary schools.

This proposal was accepted and funded in part by the National Science Foundation.* Eighteen secondary schools are now involved with the College in this two and one-quarter year project begun in June, 1967. The main purpose of the project was stated in the project proposal:

"...to demonstrate the large-scale use of the computer as a broad aid to secondary education without requiring major curriculum changes or extensive teacher retraining. Through materials to be developed cooperatively with the participating schools, we expect to show the value of computing as an aid to course teaching in many subjects, and as a significant mechanism for extracurricular education of students. . . .

These materials . . . will provide important guidelines for the development of the potential of computers in secondary education on a broad front."

The project was designed to meet the following objectives:

• To demonstrate that computing can be useful in teaching other high school subjects as well as mathematics.
• To demonstrate that computing can encourage students to think creatively.
• To experiment with classroom techniques and to suggest practical methods for integrating computing into course work.
• To publish materials which will serve as guidelines for other undertaking projects to develop the potential of computers in education.

These objectives are reviewed in Appendix B.

In accomplishing the goals of the project, Dartmouth became a regional computer center for a group of secondary schools. How Dartmouth did this, the costs involved, and the effects in the secondary schools themselves are the main topics of this report. First to be considered is the regional system.

The system

The schools

The project schools are listed in Table I along with their location, ninth through twelfth grade school population, size of their 1968 graduating class, and the percentage of the graduates who went to a four-year college.

There are 12 public schools and six private schools spread over a six-state region. This group of schools represents a varied sample of American high schools. They range from small rural schools to large city
Table I—High schools participating in Dartmouth's NSF secondary school project

<table>
<thead>
<tr>
<th>School</th>
<th>Location</th>
<th>Population</th>
<th>Grade Graduating</th>
<th>Percent to College</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Benjamin Franklin High School</td>
<td>New York, New York</td>
<td>3,200</td>
<td>190</td>
<td>47.4</td>
</tr>
<tr>
<td>* Cape Elizabeth High School</td>
<td>Cape Elizabeth, Maine</td>
<td>573</td>
<td>116</td>
<td>48.3</td>
</tr>
<tr>
<td>* Concord High School</td>
<td>Concord, Massachusetts</td>
<td>1,478</td>
<td>333</td>
<td>37.5</td>
</tr>
<tr>
<td>* Hartford High School</td>
<td>White River Junction, Vermont</td>
<td>516</td>
<td>135</td>
<td>24.4</td>
</tr>
<tr>
<td>* Hanover High School</td>
<td>Hanover, New Hampshire</td>
<td>679</td>
<td>110</td>
<td>61.8</td>
</tr>
<tr>
<td>* Keene High School</td>
<td>Keene, New Hampshire</td>
<td>1,415</td>
<td>284</td>
<td>33.1</td>
</tr>
<tr>
<td>* Lebanon High School</td>
<td>Lebanon, New Hampshire</td>
<td>536</td>
<td>152</td>
<td>34.8</td>
</tr>
<tr>
<td>+ Loomis School</td>
<td>Windsor, Connecticut</td>
<td>444</td>
<td>100</td>
<td>100.0</td>
</tr>
<tr>
<td>* Manchester Central High School</td>
<td>Manchester, New Hampshire</td>
<td>1,616</td>
<td>356</td>
<td>41.6</td>
</tr>
<tr>
<td>* Mascoma Valley Regional High School</td>
<td>West Canaan, New Hampshire</td>
<td>456</td>
<td>61</td>
<td>29.5</td>
</tr>
<tr>
<td>+ Mount Hermon School</td>
<td>Mount Hermon, Massachusetts</td>
<td>620</td>
<td>177</td>
<td>99.4</td>
</tr>
<tr>
<td>+ Phillips Academy</td>
<td>Andover, Massachusetts</td>
<td>860</td>
<td>242</td>
<td>94.6</td>
</tr>
<tr>
<td>+ Phillips Exeter Academy</td>
<td>Exeter, New Hampshire</td>
<td>789</td>
<td>252</td>
<td>97.6</td>
</tr>
<tr>
<td>* Rutland High School</td>
<td>Rutland, Vermont</td>
<td>1,063</td>
<td>196</td>
<td>32.6</td>
</tr>
<tr>
<td># St. Johnsbury High School</td>
<td>St. Johnsbury, Vermont</td>
<td>701</td>
<td>149</td>
<td>32.2</td>
</tr>
<tr>
<td>+ St. Paul's School</td>
<td>Concord, New Hampshire</td>
<td>458</td>
<td>95</td>
<td>100.0</td>
</tr>
<tr>
<td>* South Portland High School</td>
<td>South Portland, Maine</td>
<td>1,700</td>
<td>335</td>
<td>50.1</td>
</tr>
<tr>
<td>+ Vermont Academy</td>
<td>Saxtons River, Vermont</td>
<td>217</td>
<td>65</td>
<td>95.4</td>
</tr>
</tbody>
</table>

* Public
+ Private
# St. Johnsbury is considered a public school for the purposes of the project. It is the sole high school for the town of St. Johnsbury, Vermont. It operates its teletype from 8 a.m. to 4 p.m., Monday through Friday, as do all the public schools. Private school hours are 8 a.m. to 8 p.m., Monday through Saturday.

schools to highly specialized private schools. Six of the public schools are large city schools with populations of over 1,000 students. The rest are smaller rural and suburban community schools, one of which is in a college community (Hanover High School). The public schools are less oriented towards higher education than the average American school. On the average, just under 40 percent of the public-school students go on to four-year colleges compared to the 1965 national average of 53 percent. Ninety-eight percent of the private-school graduates attend four-year colleges.

Hardware

The schools are connected to the Dartmouth/GE-635 Time-Sharing System via long-distance phone lines. The majority are utilizing the Model 35 KSR teletype of the Bell Telephone System. The schools all had one teletype installed for the year 1967-68 with two exceptions: Mt. Hermon School and South Portland High School had an additional teletype installed which they completely supported with their own funds. The 1968-69 school year should see additional teletypes placed in three more schools.

There were no unusual hardware difficulties experienced by any of the schools. Most operational problems were related to the central system at Dartmouth. Consequently, they affected all users.

Teacher training

The quality and the quantity of the machine usage contributes a large amount to the success of any computer project. It was felt necessary to have at least one teacher in each school who was proficient enough with the BASIC language and the hardware to feel at ease teaching it to students and fellow teachers. With this in mind, during June of 1967, each school sent one teacher to a four-week summer training program at Kiewit Computation Center. These initial sessions were taught by Mr. John Warren of Phillips Exeter Academy. He was an experienced two-year user of the Dartmouth computer in a secondary school environment. The teachers were instructed in the BASIC
language and possible classroom applications. They also received suggestions on handling teletype breakdowns and telephone problems, and on method of administering student use of the teletypes.

Our first year documentation shows that these sessions were very successful. However, it was found that during the school year, few additional teachers learned to program the computer. The main reason for this was that almost all available “hands-on” time was taken by students. Teachers need much more time at the teletype than students to learn the BASIC language. Consequently, Dartmouth decided to hold two two-week teacher training programs during the summer of 1968. The purpose of these training sessions was to raise the number of teacher users to at least four in each school. Four enthusiastic teachers can be much more influential with teachers and administrators than one. More teacher users should greatly increase the classroom use of the computer as well as the number of students trained in the language. (Early reports from teachers indicate that this is exactly what is happening.) A core of teachers should be a big factor in perpetuating good computer use in the schools. No matter how successful the present students are, they are only transients and can have little effect in the continuation of their efforts. Teachers, a more permanent part of the institution, can.

Our experiences training teachers have taught us several things:

- Mathematics teachers learn to program a computer easier than teachers from any other high school subject area.
- Science teachers, especially those who teach chemistry and physics, learn fairly easily, also.
- Social studies teachers have the most trouble learning.
- Younger teachers learn easier than older teachers.
- Experienced teachers are more successful back in school than beginning teachers.
- There are exceptions to all of the above.

These observations are what one would normally expect. Mathematics and science teachers are familiar with the kinds of thinking necessary to successfully program a computer. Social studies, as it is taught in high schools, does not demand this kind of thinking. Those who normally teach computer training are mathematically-oriented themselves and, hence, are not sensitive to the problems encountered by a humanities teacher. Younger people are often more adaptable than older ones. They are less experienced and hence more willing to try new things. We recommend to any school who is thinking of obtaining access to a computer that they will improve their chances of success by training a young, successful mathematics teacher, who does not already have extra duties such as department head. Then, give him a reduced teaching load so he may adequately perform the extra duties involved.

**Special services**

As a regional computer center for secondary schools, the Kiewit Center provides a number of special services for the teachers and students. Some of these activities are designed to help give better computer service. Others were initiated to promote project ideas and still others are provided just for fun. Special services can be grouped in the two categories of problem solving and communications:

1. **Problem Solving**—The Kiewit staff stands ready to assist the schools in any way possible. All telephone and teletype malfunctions are reported to the Computation Center. Not only can we better diagnose problems (which often turn out to be at the Center), but we receive faster service from the phone company besides. Center personnel are also on hand to solve any questions concerning programming or to provide the use of peripheral equipment such as the high-speed printer, card reader, or card punch. The project Coordinator handles any problems associated with the project itself.

2. **Communications**—Providing communication between the Center and the project members and among the members themselves proved to be important not only to the success of the project but to the success of secondary use as a whole. The spreading of ideas serves to test their value through repeated trials and to provide motivation for creating new ones. Teachers’ time is very valuable. They do not have secretaries nor mailing budgets. They cannot be expected to keep up contacts on their own. Several methods were used by Kiewit for providing communication among the Center, the schools, the teachers and the students with varying degrees of success.

These were:

- Teachers’ gossip file—This was a file in the system which the teachers could call up to list or to add a message. It was not a very successful communicating device among the teachers. They had difficulty competing with the students for terminal time. When they did find themselves at a terminal,
they did not want to spend the time required to list the file.

- Student gossip file—This is a similar file for students, but much more successful. They exchanged school news and swapped ideas on programming problems.
- Biweekly Bulletin—This is a bulletin published every two weeks and sent out to all the schools. It includes original students' program descriptions, descriptions of teachers' class usage, and other items of interest to secondary school users. Most student work published in the Biweekly is submitted as entries for the Kiewit Cup Contest. This is a contest sponsored by the Center which presents citations to individual students who submit outstanding programs and awards a cup to the school which "demonstrates the most outstanding use of the computer." This contest in 1967-68 served a purpose for the project by providing a sample of the work the students were doing on their own. We have maintained it through the second year because of widespread student interest.
- Teachers' conferences—Twice each year the Center holds a Saturday conference for participating teachers. These enable all the teachers to get together and discuss problems of common interest and hear first-hand about new developments at the Center. Common procedures include open discussions, presentation of classroom work, and guest lectures. The conferences are very popular with the teachers.
- Student conference—This was a one-day conference organized by a group of students and the project Coordinator. The students came from all the project schools with a teacher. Most of the speakers were fellow high school students.
- Teacher newsletters—Letters were sent containing information on conferences, school visits, and other subjects of interest only to project teachers.
- Visits to the schools by the Coordinator—These proved to be necessary during the first year to ensure that all was progressing smoothly. Some teachers chose not to communicate frequently with the Center. They would make suggestions and ask questions in person, while reluctant to phone or write. The visits also gave the Coordinator a chance to see personally what was going on in every school and to meet and talk with students.

Costs

Table II gives a cost analysis for the schools. It shows that the overall cost of a one-teletype operation in the 1967-68 school year ranged from approximately $4,550 to $12,260 a year.* It should be noted that actual computer time is about 60 to 65 percent of the total cost. The remaining costs are telephone charges.

There is a definite difference in costs to the private and public schools, the private costs being higher. The main reason for this is that private schools' teletypes are available for student use about 32 hours more per week than in the public schools.

In C, all the examples are of public schools except for the typical private school and the highest cost school. It should be noted that among the private schools, the range in computer costs is only $573.36 while the range in overall costs is $2,230.87. All these schools are using their terminals at close to the same number of hours and effectiveness. The cost difference comes with communications, which is a function of the distance from the Kiewit Center. At the present time, differences in school population are not reflected in cost or usage. With just one teletype, it does not take very many high school kids to keep it going all of the available time.

It should be noted that the trend at Dartmouth, as in other time-sharing installations, is towards lower computer rates. In the fall of 1968, Dartmouth's rates for computer time were reduced approximately 40 percent for the secondary schools. This should reduce the overall charges by a factor of 25 percent for the 1968-69 school year. Also, under development are various methods for combining several teletypes on one telephone line. This seems to indicate that communications costs will also lower.

The project's overall computer costs are somewhat misleading. Some of the schools are a long distance away. Under normal circumstances they would be tied into a closer installation. Also, the current rates reflect the costs of some of the special services Dartmouth provides and the small number of commercial users on the system.

According to 1965 salary figures for the states involved, a Dartmouth teletype connection last year cost $200 to $1,500 a year more than the average teacher. Is it worth it? To answer that question, we should look at what is happening in the schools themselves.

The schools

To answer the question "Is it worth it?" we have to look at the average high school student sitting at a teletype.

* It should be noted that the actual cost to the schools ranged from $0 to $5700. Sixty-five percent of the total computer and communications costs were financed by the NSF and Dartmouth College.
Table II—Cost figures for the secondary schools

<table>
<thead>
<tr>
<th></th>
<th>Public</th>
<th>Private</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Average Cost (9-month year)</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall cost</td>
<td>$6,226.69</td>
<td>$8,912.63</td>
<td>$7,074.88</td>
</tr>
<tr>
<td>Communication (tty)</td>
<td>$2,536.34</td>
<td>$3,119.21</td>
<td>$2,720.40</td>
</tr>
<tr>
<td>Computer</td>
<td>$3,690.35</td>
<td>$5,793.42</td>
<td>$4,354.48</td>
</tr>
<tr>
<td>Overall cost/hour</td>
<td>$4.94</td>
<td>$5.34</td>
<td>$5.07</td>
</tr>
<tr>
<td>Actual cost/school/terminal</td>
<td>$1,563.39</td>
<td>$4,280.09</td>
<td>$2,469.47</td>
</tr>
<tr>
<td>Actual cost/hour/terminal</td>
<td>$1.24</td>
<td>$2.57</td>
<td>$1.77</td>
</tr>
<tr>
<td><strong>B. Average Usage</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of users/month</td>
<td>68.90</td>
<td>127.00</td>
<td>88.30</td>
</tr>
<tr>
<td>Terminal hours/month</td>
<td>139.92</td>
<td>185.36</td>
<td>155.07</td>
</tr>
<tr>
<td>Terminal hours/user/month</td>
<td>2.03</td>
<td>1.46</td>
<td>1.75</td>
</tr>
<tr>
<td><strong>C. Examples of Overall Yearly Cost Per Terminal</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School</th>
<th>Communications</th>
<th>Computer</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest</td>
<td>$1,366.00</td>
<td>$3,275.40</td>
<td>$4,541.40</td>
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<tr>
<td>Highest</td>
<td>$3,335.32</td>
<td>$8,921.18</td>
<td>$12,256.50</td>
</tr>
<tr>
<td>Typical Private</td>
<td>$3,901.65</td>
<td>$6,169.23</td>
<td>$10,070.90</td>
</tr>
<tr>
<td>Small Rural Local</td>
<td>$1,417.86</td>
<td>$3,402.22</td>
<td>$4,820.08</td>
</tr>
<tr>
<td>City</td>
<td>$2,923.51</td>
<td>$3,848.76</td>
<td>$6,772.27</td>
</tr>
<tr>
<td>Suburban</td>
<td>$2,500.38</td>
<td>$3,603.57</td>
<td>$6,112.95</td>
</tr>
</tbody>
</table>

* 1967–68 figures. 1968–69 figures will be about 30 percent lower.

While teaching students to use the computer, some interesting observations were made:

1. Students need only about 20 minutes per lecture or about two hours total terminal time to learn to use the machine (compared to 20 hours for teachers).

2. Whole courses devoted to programming are obsolete. Students are more successful working with their own problems. They learn BASIC so quickly that any necessary instruction time is easily included as a topic in a standard high school course. There are courses taught in some of the project schools which are computer oriented. However, these courses do not stress computer techniques. Rather, they present math best taught with the aid of a computer.

3. Time spent teaching BASIC in many regular courses was not time lost. Teachers found that they actually covered more material by the end of a term. Less time was spent on tedious calculations. Less time was needed for drill work because programming a concept demands complete understanding. Complex problems pre-

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* See Appendix A.
4. There was no grade level found best suited for teaching students how to use the computer. One of our teachers taught elementary BASIC programming to a group of talented fourth graders. Several schools taught BASIC to seventh graders and found that the average seventh grade student can learn to program.

5. No ability level has been found below which students could not learn to program. This is not to say all students learn with equal ease or are equally interested. However, computer work has shown itself not to be one of those activities which only the brightest of the college bound can handle.

Student use

Students used the computer both inside and outside of their classrooms. They used it for assigned computer work, for doing homework, for projects, and for fun. Most of the student programs entered in the Kiewit Cup Contest were written just for fun. These programs, representing a small fraction of the students' actual work, are quite commendable. A short summary of the list of Kiewit entries could hardly do justice to the imagination and ability of these students who had limited access to a computer over a short nine-month period. These entries are substantial evidence that, given an opportunity to follow his own interests and inclinations, a student will use the computer as a creative extension of his intellect.

The list of Kiewit Cup programs includes programs in the mathematical areas of number theory, algebra, plane and analytic geometry, calculus and probability and statistics, and in the science areas of chemistry and physics. Also, a small scattering of programs in almost all other academic subjects touched upon in high school is included. In addition, there is a large group of game playing and other miscellaneous programs.

The number theory and algebra programs were the most numerous. These included all the usual topics such as factoring, prime numbers, graphing, equation solving, and the like—many of which were very sophisticated. One ninth grader used Newton's method to find the square root of a number and developed a similar method of his own to find cube roots. Calculus programs included calculating limits, areas under a curve, and differentiation. One of the area programs utilized Simpson's Rule and another used random proportioning and Riemann Sums. One student submitted a clever approximation of π by Monte Carlo methods. The geometry, and probability and statistics submittals covered the standard calculations found in those fields. There were several very nice probability simulations. Nice simulation programs were also found among the physics and chemistry group. One student wrote a program to predict the orbit of the "Syncom" satellite. Another program teaches the valences of chemical radicals. A couple of the 27 different game submittals were considered so much fun that they were put in the Kiewit game library.

More than any other group, perhaps, the miscellaneous programs are the best indication of what high school students can do. Some of these programs write poetry, compose music, teach other students topics in foreign languages, or science or grammar. They score games, analyze elections and surveys, layout the school newspaper, and compute payrolls. The topics are just too numerous to list. Some high school students became very interested in systems problems. One wrote his own abbreviated BASIC system and another developed a TRACE system for locating his programming errors. An eighth grade student wrote an excellent interpreter of LISP in the BASIC language. Anyone using LISP in the Dartmouth System uses his interpreter.

The winners in the Kiewit Cup Contest included students from seventh through twelfth grades and from all supposed ability levels. Some of them have gone on to college, while others were sent to reform school. Some were repeating a course when a use of the machine caught their interest. Some have never shown much interest in anything associated with school before.

Students seldom allow the teletypes to sit idle at their high schools. The statistics on usage (Table II.B.) hardly leave enough idle time for standard hardware failures and occasional signing on and off between users. These student users are not just a small hard-core, either. We have found that the number of students using the machine, at least occasionally, is around 25 percent of the total high school population. This figure is extraordinary when you consider that, for most of the schools, there was only one person to teach them the BASIC language.

Classroom usage

One of the project's objectives is to demonstrate that the computer can be a significant contribution to class work already found in existing school curricula. Classroom use was significant. Our first-year teachers wrote a set of Topic Outlines documenting their class use. Each outline is an explanation of how they used the computer in conjunction with regular classroom work. These outlines range from a three-class demonstration
to a whole-semester course. Their titles are listed in Appendix A. Since the majority of the first-year teachers were math teachers, most of the topic outlines concern mathematics. There are several explaining science usage and three or four in other fields (notably business and teaching BASIC).

Because of the fourfold increase in project teachers, this year should see a large increase in class usage and documentation, especially in fields other than mathematics.

During the 1967-68 year, the following class-usage patterns have emerged:

* Mathematics use is heavy. However, some courses see more usage than others (calculus, for instance, as opposed to geometry). The computer lends itself to convincing classroom demonstrations in many topics such as logarithms, limits, and equation solving. Teachers use it to illustrate concepts usually taken on faith because of the massive calculations involved. Some courses were expanded to include topics which were easily adaptable to computer applications (matrix algebra for example).

Teachers note an immediate transfer of enthusiasm from a successfully written computer program to the mathematics involved. Many more students than ever before are going beyond their normal classroom work and studying advanced concepts on their own. Concepts which they needed to know in order to write a program.

Many teachers are turning to program writing as a method of teaching in mathematics courses which stress pattern recognition and teaching BASIC. Some social studies classes have done election surveys and analyzed the results via computer. One English teacher uses it to help students learn literature concepts and write creatively by generating random metaphors and phrases. However, most of the work in the social sciences and humanities was done by students for special projects or on their own.

SUMMARY

Eighteen secondary schools throughout New England are involved with Dartmouth College's Kiewit Computation Center in a two and one-quarter year project supported by the National Science Foundation. The main purpose of the project is to demonstrate that the computer can be a significant contribution to secondary education within the existing curriculum and without extensive teacher retraining. Important outcomes are the demonstration that computing encourages students to think creatively, and the publishing of materials to serve as guidelines to others in the utilization of computers in education.

In its role as a regional computer system, Dartmouth provides auxiliary services for the schools. These include aid with malfunctions and programming problems, fostering communication among the participants, and sponsoring conferences and training sessions.

After its first year, the project has been highly successful. Hundreds of students have been trained in BASIC and are using the computer creatively on their own. Teachers have written a considerable number of outlines for classroom work and 1968-1969 will see the results of the previous year continued with greater emphasis on materials for science, business, and below-average students. The project findings are being published for general distribution to those who are interested in the potential of computers in education.
APPENDIX A

Index of topic outlines according to grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>Title</th>
</tr>
</thead>
</table>
| 4     | Four Classes with Fourth Graders—Introduction to BASIC  
William A. Smith, Lebanon High School |
| 7-12  | Some Suggestions for Student Programs  
Jean Danver, Dartmouth College |
| 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, Lebanon High School  
David Penner, Phillips Exeter Academy |
| 9     | Solution of Simultaneous Linear Equations  
John Conover, St. Johnsbury Academy |
| 9     | BASIC in 10 Minutes a Day  
Louis Hoitsma, Phillips Exeter 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 (t) (An Iterative Technique)  
John C. Warren, Phillips Exeter Academy |
| 10-11 | The Circular Function  
John C. Warren, Phillips Exeter Academy |
| 10-12 | The Use of the Computer in Air Pollution Study  
John Conover, 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 |
| 12    | 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 B

Summary of NSF-proposal objectives

I. Meeting Objectives

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

1. 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 as testified in the main body of this paper. These subjects include all of the high school sciences, modern languages, social studies, English, and several business courses.

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.

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

Literally hundreds of programs received from students testify to the student's creative ability. 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 own work. They made them and they work.

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

The 1967 four-week training session for teachers was shortened to two weeks in the summer of 1968. This speaks for itself. Commentary on teacher and student training during Teachers' Conferences also confirm the ease and speed with which computing can be introduced into schools.

4. 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 30 Topic Outlines written by teachers themselves we now have available.

5. 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, the First Year Report, and the collection of Topic Outlines should allow other schools to take full advantage of our experience.