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ABSTRACT

This qualitative assessment of computer-based innovations found in current educational programs across a variety of academic institutions was designed to help administrators and faculty of educational institutions in making decisions about the nature, scope, and magnitude of computer facilities and learning materials that could benefit their institutions, as well as to assist government planners in determining what computer innovations could be adapted to particular educational settings and goals. The report includes explanations of how candidate institutions were identified and chosen, a discussion of data gathering techniques used, a list of procedures used to identify and examine 107 "exemplar" institutions, and the processes used for selecting 21 of these institutions for further in-depth case study analyses. Observations and recommendations regarding case study methodology and specific areas of assessment are also provided. (Author/MER)

FR-ED-79-1

FINAL REPORT

ASSESSING THE IMPACT, BENEFITS, LIMITATIONS AND COSTS OF COMPUTER INNOVATIONS IN EDUCATION:

A Retrospective Case Study Approach

by

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FINAL PROJECT REPORT
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PART I–PROJECT IDENTIFICATION INFORMATION

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Assessing the Impact, Benefits, Limitations and Costs of Computer Innovations in Education: A Retrospective Case Study Approach

PART II–SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

The overall objective of the CASES project is to provide qualitative assessment of impact, benefits, limitations, and costs of computer-based innovations found in current educational practice. This assessment will (1) help administrators and faculty of educational institutions to make decisions about the nature, scope, and magnitude of computer facilities and learning materials that will most benefit their institution and students; and (2) assist federal, state and local government planners in deciding whether and what computer-based innovations would be productive for particular educational settings and goals. To accomplish this, a four-stage procedure was implemented to select the institutions to participate in the study:

1. Search for candidate institutions.
2. Gather data on candidate institutions.
3. Select Exemplar institutions.
4. Study case study institutions.

Invitations to nominate institutions that successfully use the computer for teaching and learning were sent to 7000 educators and technologists. Three hundred and seventy institutions which met our criteria were nominated. Eligible institutions included individual elementary and secondary schools, public school districts, community colleges, colleges, universities, and public access institutions. The results of our telephone interviews with each of these institutions are published in the Academic Computing Directory. Of these candidates, 107 institutions were selected as "exemplars" in one or more of the following categories:

1. Student Accomplishments
2. Institution Productivity
3. Spectrum of Applications
4. Computer Literacy
5. Computer Science and/or Data Processing
6. Outreach
7. Model

Twenty-one of the schools were then selected for more in-depth study. Case studies are available for Rutgers, Worcester Polytechnic Institute, Mankato, Denison and 10 pre-college schools and districts.

PART III–TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
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a. Abstracts of Theses					
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FOREWORD

The project was conducted at HumRRO's Eastern Division, Alexandria, Virginia. The work was supported by the National Science Foundation, Grant No. SED 76-15399, Dr. Robert J. Seidel, Principal Investigator, and Beverly Hunter, Co-Principal Investigator. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Some of the Appendices mentioned in this report are available from the HumRRO Publications Office.

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I. OBJECTIVES AND SCOPE OF THE STUDY

The overall objective of the CASES project is to provide qualitative assessment of impact, benefits, limitations, and costs of computer-based innovations found in current educational practice. This assessment will (1) help administrators and faculty of educational institutions to make decisions about the nature, scope, and magnitude of computer facilities and learning materials that will most benefit their institution and students; and (2) assist federal, state and local government planners in deciding whether and what computer-based innovations would be productive for particular educational settings and goals.

To accomplish the above, specific project objectives are as follows:

1. On the basis of a systematic search process, select eight educational institutions that have successfully and productively implemented computer-based innovations for learning and teaching. We will seek exemplary cases from all levels of education, in which computer innovations have a high impact on the students, curriculum content, program objectives, learning styles, teaching methods and management of education.

2. Obtain information on the characteristics, benefits, limitations, impact, and costs of the computer-based innovations in these exemplary cases.

3. Trace the history of significant and decisive events leading up to the implementation of computer-based innovations at each case institution.

4. Identify and assess the importance of various technological, social, institutional and economic factors influencing the significant events, within and across cases.

5. Document the case information in a manner useful to educational and government decision makers.

6. Disseminate the findings of the study to educators and government planners who have a need for the information.

The objective of this study is to provide context-specific information regarding the nature, benefits, costs and limitations of the computer-based innovations.

II. PROJECT METHODS

Case Institutions were selected through a four-stage procedure:

1. Search for candidate institutions
2. Data gathering on candidate institutions
3. Selection of Exemplars
4. Selection of Case Institutions

SEARCH FOR CANDIDATES

First, we conducted a systematic search for institutions that are regarded as outstanding in their uses of computers for learning and teaching. Invitations were mailed to seven thousand educators and technologists who belong to professional organizations concerned with educational computing. (See Appendix I.)

The package of materials and nomination forms was tried out initially with 20 experts in the field. The package was revised and mailed to approximately 3500 persons on the mailing lists of the Association for Development of Computer-Based Instructional Systems (ADCIS) and the Association for Educational Data Systems (AEDS). Approximately 3400 additional packages were mailed to members of Association for Computing Machinery Special Interest Group on Computer Uses in Education (SigCUE), directors of academic computing centers, and chairmen of computer science departments of universities, colleges, and community colleges. In addition, announcements were published in various association newsletters such as NEA NOW, and magazines such as THE Journal and Educational Technology. Additional invitations were mailed to individuals who had previously responded to the survey of secondary schools by American Institutes for Research. These individuals were invited

to nominate one or more edudational institutions that they regard as outstanding. Nominators were asked to give specific reasons why the school should be considered, given the objectives our our study. These reasons were then verified along with the other data items for each entry by telephone and mail contact with the candidate institution.

The variety of reasons includes, but is not limited, to the following:

- Outstanding student accomplishments
- Accomplished a lot on a small budget
- An exemplary computer science curriculum
- Excellent computer-based learning materials
- Extensive integration of computer use into the traditional disciplines
- High quality computing services
- Broad based computing literacy program
- Facilities available to all students
- Community outreach
- Cost-effectiveness studies performed
- Strong community, administrative or faculty involvement
- An exemplary data processing curriculum
- Outstanding faculty development program
- Large proportion of student users
- Long history of academic computing
- Supports independent study program

Over 400 individuals responded, nominating 370 institutions that met our criteria. Eligible institutions included individual elementary and secondary schools, public school districts, community colleges, colleges, and universities, and public access institutions such as museums.

CHARACTERISTICS OF THE NOMINATORS

Four hundred and five nominators responded to our solication. Four large categories of nominators made choices: computer industry representatives (77), computing center personnel (70), administrators (60), and faculty (53). The majority of the nominators (345) chose schools, school districts, or colleges. This is not surprising in that it probably reflects the character of our mailing lists. Self-nominations were permitted as well as nominations of

other institutions. At the college and university level, the numbers of self-nominators and external nominators were approximately the same (49 and 51 percent). For Community Colleges, the split was 60-40, with external nominators in the majority. The ratio was even more pronounced in the Schools and Districts, with over 70% of the nominators external to the named institution. All eleven of the nominations for Public Access Institutions came from external sources. The details by category are as follows.

Elementary and Secondary Schools. The total number of nominators was 81. Over a quarter of those were self-nominations; however, the bulk (73%) was from nominators outside the institution named. The major sources of outside nominators were other public schools, colleges, computer industry representatives, and individual consultants knowledgeable about specific schools. Self-nominations came principally (50%) from the administrators (including department heads) with the remainder from faculty and instructional computing specialists.

Public School Districts. The number of nominators was 94, and the categorizations were similar to the Schools. Seventy percent (70%) were external to the Districts. The classification of major sources was the same.

Community Colleges (49 nominators). The major contributors (11) were computer industry representatives. The remaining external nominators were principally from faculty, staff, computing centers, and administration at universities and colleges. Half the self-nominators were administrators and the rest faculty and computer center representatives.

Colleges/Universities (170 nominators). External nominations came mainly from computer industry representatives (27) and other university computing centers (19) or faculty (14). The self-nominations came principally from the computer center (31) and, to a lesser degree, the administration (16).

CHARACTERISTICS OF THE INSTITUTIONS

Size and Type

Elementary & Secondary Schools (Public & Private)	94
Public School Districts	71
Community Colleges	37
Colleges & Universities under 6000 Enrollment	87
Colleges & Universities over 6000 Enrollment	71
Public Access Institutions	7
Total Entries:	367

The vast majority (80%) of the schools are represented by the secondary schools. The remaining few entries are equally distributed across elementary, junior high and K-12 schools.

Representation of school districts encompasses a spectrum from under 5000 students (17%) to greater than 100,000 (17%, generally cities like Los Angeles, Atlanta, Chicago, etc.). Largest representation is in the catagories 5000 to 20,000 (30%), and 20,000 to 50,000 (29%).

The size of Community College entries varies from less than 3000 to greater than 15,000 students. Separation into increments of 3000 to 5000 revealed roughly equal representation by size.

Geography

Solicitations were made to institutions in all States and Puerto Rico. Forty-four States in the continental U.S. are represented to some degree. States with the largest number of entries are: California, New York, Texas and North Carolina. A summary of the geographic distribution is as follows:

1. Public School Districts: Total 71

   Largest number by State: California (10); Texas (8); Minnesota (6); New York (6). The other 41 are distributed among 23 States.

2. Elementary and Secondary Schools (Public & Private): Total 94

   Largest number by State: Massachusetts (16); Minnesota (13); New York (12); California (7); North Carolin (6); Oregon (6). The other 34 are distributed among 17 States.

3. Community Colleges: Total 37

   California (7). The other 30 are distributed among 19 States.

4. Colleges and Universities under 6,000 Enrollment: Total 87

   New York (9); Indiana (5); North Carolina (5); Ohio (6); Pennsylvania (5); Texas (5). The other 52 are distributed among 27 States.

5. Colleges and Universities over 6,000 Enrollment: Total 71

   California (9); Texas (6); Illinois (5). The other 51 are distributed among 29 States.

6. Public Access Institutions: Total 7

TELEPHONE INTERVIEWS

Second, we contacted, at each nominated institution, an individual who has a purview of instructional computing activities. In many cases, this individual is the Director of the Computing Center or a Coordinator of Instructional Computing. The nominated institutions were happy to participate, and provided information about their activities via a telephone interview with a member of our staff. The product of this stage is an Academic Computing Directory, published by HumRRO, that gives brief information on the reasons for nomination, enrollment, typical computer applications, make and model of main computer(s), number of terminals on campus, and persons to contact. (The Directory is shown as Appendix II to this report.)

COMPUTING EQUIPMENT

Across all institutions listed in the Academic Computing Directory, the highest reported computing manufacturers are IBM (38%) and DEC (36%). Next is Hewlett-Packard (23%), then UNIVAC (12%), and CDC (6%).

IBM has the highest representation in the 37 Community Colleges. Because of the fact that the equipment mentioned at the large universities represented only the central computing center machines, these findings are not considered representative and therefore are not being reported. DEC computers were the most frequently reported in the Directory at Schools and Small Colleges. Hewlett-Packard representation was strongest below the college level (65% Hewlett-Packard equipment).

One other interesting finding relates to the sharing of computing equipment at the various educational levels. In comparing outreach programs versus use of other Directory institutions' facilities, a greater percentage of elementary and secondary schools (49%) use facilities from other institutions than those who provide a resource for computing (29%). This relationship reverses at the public school district level. Thirty percent use other facilities versus 35% in an outreach mode. Community colleges show a result similar to the public school districts--24% versus 32%. The outreach or offering of computing services to others is even stronger at the college and university level with 26% of the small colleges using facilities provided by others, whereas 44% of those institutions offer their own services to outside institutions. At the large universities, only 20% use services provided by others, whereas 48% of the large universities provide computing facilities for other institutions.

IMPACT

A qualitative estimate of the impact computing has on an institution can be made by noting the number of users as a percent of total enrollment, absolute number of terminals, and the student/terminal ratio. Some general findings are:

- Colleges and universities under 6000 have the greatest number of annual users.
- Colleges and universities over 6000 have the greatest number of interactive terminals.
- Student/terminal ratio seems to be equivalent across all institutional categories which implies that accessibility is also identical for all, however
- at elementary and secondary schools, 30% have only one terminal.
- Community colleges, school districts and colleges and universities under 6000 appear to have approximately equal numbers of terminals (between 10 and 49 for the majority).

The specific results are summarized below by institutional category. Across all categories of institution, at least one-fourth or more of the student body are computer users in over half the Directory institutions (see Figure 1).

Elementary and Secondary Schools

Most schools (59%) have four or fewer interactive terminals and half of these (or 29% of the total) have only one (usually this terminal is located in the math department). Sixteen percent (16%) have 10 or more terminals.

The student/terminal ratio is greater than 1000 to 1 for 21% of the schools; and for 40%, it is 500 to 1 or higher. An additional 43% of the schools have a ratio between 100 and 500 to one.

If we accept our tallies as typical (albeit not exhaustive), then we can infer that growth in number of terminals for instructional purposes has occurred in schools over the last few years (since the Bukoski and Korotkin study, 1975). Bukoski and Korotkin found the median number of terminals to be close to one per school.

More than half the enrollees are annual users in 31% of the schools, while under a quarter of the student body are annual computer users in approximately two-fifths of the schools. These numbers are probably not completely accurate since most schools do not keep separate account numbers for each individual student.

Public School Districts

The majority of school districts have between 10 and 100 interactive terminals with 29% showing from 20-49. Accessibility is difficult to assess since the purposes for using the computer vary (e.g., CMI or 10-minutes per day drill and practice per student). Such differences call for less or more terminals per student, dependent upon the specific application. Half the districts have a student/terminal ratio of greater than 1000 to 1; roughly another quarter (27%) show a ratio in the range of 100-499 to 1.

Like the schools, 25% of the districts by and large affect more than half of the enrolled students. Again, similar to the schools, approximately half of the districts (45%) report one-fourth or more of the enrolled students as annual users.

Community Colleges

Greater than three-fifths of these institutions mentioned between 10 and 49 interactive terminals. Accessibility seems higher than that for schools or districts with close to half the community colleges having a student/terminal ratio between 100-399 to 1. A slightly higher percentage of these institutions (36%) than either schools or districts report between 25-49% of the enrollees as annual users. Because of the small sample and problems with accuracy on individual student records, this advantage should be treated as suggestive not conclusive.

Colleges and Universities Under 6000 FTE

This group reflects almost the same picture of terminal accessibility as the Community Colleges. However, percentage of students affected is higher. Fully 37% of these Directory institutions reported reaching more than half of the student body.

Colleges and Universities Over 6000 FTE

These institutions reported the largest number of interactive terminals. The majority ranges across a braod spectrum from 20 up to 500 terminals with peaks of 24% in the 20-49 category and 23% in the 200-499 category. Terminal accessibility indicated by student/terminal ratio is about the same as the smaller colleges, 62% in the range 100-499 to one. Thirty-three out of 44 institutions in this category or 46% of the total have an even better range of 100-299 students per terminal. Despite this relatively favorable index of accessibility, the same percentage of these institutions (58%) report one-fourth or more of the students enrolled as annual users.

	# Interactive Terminals							
	<2	2-4	5-9	10-19	20-49	50-99	100-199	200-499
Schools	.29	.30	.24	.12	.03	.01	-	-
School Districts	.06	.01	.09	.15	.29	.18	.06	.06
Community Colleges	.03	.06	.14	.34	.29	.06	.09	-
Colleges & Universities < 6000	.06	.06	.14	.26	.33	.06	.04	.04
Colleges & Universities > 6000	.03	.01	.01	.05	.24	.20	.17	.23

	Number of Students per Terminal					
	≥1000	500-999	100-499	50-99	10-49	<10
Schools	.21	.19	.49	.05	.04	.01 (1)
School Districts	.50	.19	.27	.02	.03	-
Community Colleges	.17	.17	.51*	.11	.03	-
Colleges & Universities < 6000	.08	.01	.56†	.18	.14	.03 (2)
Colleges & Universities > 6000	.08	.11	.62+	.15	.03	-

	Proportion of Institutions Annually Affecting Percent of Enrolled Students				
	% 0-24	% 25-49	% 50-74	% 75-99	% 100
Schools	.41	.28	.20	.08	.03
School Districts	.55	.20	.12	.04	.09
Community Colleges	.50	.36	.06	.08	-
Colleges & Universities < 6000	.33	.30	.18	.12	.07
Colleges & Universities > 6000	.42	.37	.18	.03	-

(1) >500 terminals
1 School District
2 Colleges & Universities > 6000

(2) *17/18 between 100-399
†34/44 between 100-299
+33/44 between 100-299

Public Access
3 have only one interactive terminal
3 have between 10-19 interactive terminals
1 has 5-9 (?)

4 at ≥ 1000 to 1
1 at 10-49

Figure 1. Indicators of Impact

CATEGORIES OF EXCELLENCE

By analyzing the reasons for nomination discussed earlier, we constructed a framework of "categories of excellence." The rationale here was that no one institution would be likely to represent advances in computer use along all dimensions of interest.

The nominees were invited to respond to one or more of a series of open-ended questionnaires corresponding to the following Categories of Excellence:

1. Institutional Commitment to Instructional Computing
2. Student Accomplishments
3. Institution Productivity
4. Spectrum of Applications
5. Computer Literacy
6. Computer Science and/or Data Processing Programs
7. Outreach
8. Model

The questionnaires are shown as Appendix III to this report.

These questionnaires were quite lengthy and required considerable work on the part of the respondents. By completing one or more of the questionnaires, the respondents demonstrated their willingness and ability to share information. Over one hundred of the nominees responded in one or more categories of excellence. HumRRO staff then reviewed all candidate institutions within each Category of Excellence. We selected as Exemplars in each Category those institutions that had provided complete answers and had demonstrated a high commitment to instructional computing. Consulting experts were called upon to review candidates in specific Categories. The product of this third stage is a list of Exemplary Institutions distributed by HumRRO (shown as Appendix IV to this report).

SELECTION OF CASES

The Case Institutions were selected from among the Exemplars. The following criterion dimensions were used in selection:

1. High institution commitment to academic computing as demonstrated by the survival of instructional computing over several budget cycles; staff support for instructional computing; reform of curriculum to incorporate computer uses; increases in appropriate computing equipment; incentives to faculty for instructional innovation.

2. High degree of computer literacy among students, faculty and administration, as reflected in student accomplishments, spectrum of applications, and number of computer users on campus.

3. Appropriate response to the Model questionnaire, and usefulness of all questionnaire responses.

We sought to represent a wide spectrum of types of institutions, by size, type, and geography. The institutions selected are as follows:

North Salem High School, Salem, Oregon
George Washington High School, Denver, Colorado
Lincoln High School, Bloomington, Minnesota
Ridgewood High School, Ridgewood, New Jersey
Riverdale Country School, Bronx, New York
Huntington Beach Union High School District, Huntington Beach, California
Alexis I. duPont School District, Greenville, Delaware
Chicago Public Schools, Chicago, Illinois
Dallas Independent School District, Dallas, Texas
Lawrence Hall of Science, Berkeley, California
William Rainey Harper Community College, Palatine, Illinois
Golden West Community College, Huntington Beach, California
United States Naval Academy, Annapolis, Maryland
Worcester Polytechnic Institute, Worcester, Massachusetts
Denison University, Granville, Ohio
Evergreen State College, Olympia, Washington
Jackson State University, Jackson, Mississippi
Mankato State University, Mankato, Minnesota
Rutgers, The State University, Piscataway, New Jersey
University of Delaware, Newark, Delaware
University of Texas, Austin, Texas

The process and procedures used for selecting Exemplars and Models are described in the working paper in Appendix V.

PREPARATION OF CASE STUDIES

A detailed review was made of the issues raised in the questionnaire responses and the kinds of data the institutions could reasonably be expected to provide. Opinions of experts were taken into account regarding the important factors in academic computing. For example, Mossman's assessment framework for computing facilities was used to guide the analysis of facilities, and Willey's productivity framework assisted in analysis of student accomplishments. The product of this review was an outline of the topics to be addressed in case study reports. This outline is shown as Appendix VI to this report.

Due to project funding limitations, it was not possible to make site visits to gather case study data. Project staff prepared rough drafts based upon data from the category questionnaire responses. Then, a lengthy series of mail and telephone interactions with the institutions was used to fill in the gaps. This process required many months of interactions with each institution. Project funds ran out long before all case studies could be completed.

Case study booklets were completed and printed for all the precollege institutions, plus the following colleges:

- Denison University
- Mankato State University
- Worcester Polytechnic Institute

The Rutgers case study was completed and prepared in camera-ready copy. Rutgers will probably pay for printing.

The case studies are shown as Appendices VII, VIII, IX, X and XI to this report.

III. ANALYSES AND INTERPRETATIONS

The information gathered from the 370 candidates, 107 exemplars and 21 case study institutions, can be used to shed light on a wide variety of issues and questions of concern to educators. It was far beyond the resources of this project to do justice to this data base. However, several summary and interpretive reports were prepared in those areas in which we had the greatest demand for information.

1. Summary of the Precollege Case Studies. This summary can be found in the Precollege Case Study Book (Appendix VII).

2. Management of Instructional Computing: Advice from Ten Precollege Institutions. This summary, shown as Appendix XII to this report, was submitted to the National Educational Computing Conference.

3. Student Accomplishments from Instructional Computing. Interpretive and summary information on benefits of instructional computing is desparately needed by educators and planners. One fairly superficial summary we prepared on this matter was presented at an AEDS Convention and is shown as Appendix XIII. A preliminary critical analysis of the exemplars' data is shown as Appendix XIV.

4. Computing Literacy. A synthesis of the major components of computer literacy on college campuses was prepared from data provided by the computer literacy exemplars. This composite view of a computer-literate campus was presented at the 1978 CCUC Conference and is shown as Appendix XV.

Information on computer literacy programs at the precollege level was summarized and synthesized in several forms. Brief descriptions of programs were presented at the NAUCAL Conference in 1977. These were refined into a set of Computer Literacy Briefs (shown as Appendix XVI) and elaborated into a set of workshop materials for educators in the Washington D.C. area, funded by the Information Dissemination in Science Education (IDSE) Program.

IV. DISSEMINATION

Over two thousand requests for information and products from this project have been responded to through dissemination of the Academic Computing Directory, the Cast Study Books, the summary papers, the computer literacy workshops, and personal correspondence and briefings.

About 1900 Directories have been distributed, primarily in response to requests through the HumRRO Publications Office for the Case Study Books. The following have been distributed:

Precollege Case Book	1200
Denison Case Book	800
Mankato Case Book	300
Worcester Polytechnic	300

Examples of other kinds of requests for information to which we have responded include providing:

- A list of educators to testify before a House of Representatives Subcommittee on Computers and the Learning Society.
- A list of institutions that use computers with learning disabled children.
- Guidance to the Hartford, Connecticut, Board of Education on strategies for initiating computer-based programs.
- Detailed information to a delegation of visiting German scientists and educators regarding academic computing facilities at U.S. colleges and universities.
- Recommendations to the President's Reorganization Task Force on Data Processing regarding computer literacy.
- Information to the NEA on microprocessor uses in schools.
- Information on student accomplishments from Title I projects to the State of North Carolina.
- Speculations on the future of instructional computing to journalists for the New York Times and other media.

In addition, 200 educators in the Washington, D.C. area are receiving a variety of materials developed in the Cases project through the IDSE project.

V. CONCLUSIONS AND RECOMMENDATIONS

On the basis for the demand for the products from this project and the nature of the feedback from users, the project clearly was successful in meeting the objectives stated in Section I of this Report. The following are some observations and recommendations regarding case study methodology and specific areas of assessment.

1. Case Studies as a Method of Assessment and Communication

- The case study detailed outline provides a useful framework for planning and assessment on the part of an educational institution.
- Case studies that focus on specific innovations or individual academic departments (rather than a total institution) could provide more in-depth insights into decision-making processes, student accomplishments, costs, facility requirements, and other areas of interest.

2. Case Study Methodologies

One original goal of the project was to develop and test a case study method involving retrospective analysis similar to that used in the TRACES studies. The case studies do include a list of significant historical events, and these proved to be of interest as indicated in the Summary of the precollege cases. However, implementation of the full in-depth retrospective methodology was far beyond the resources of this project.

3. Student Accomplishments

Our experience in this project demonstrates conclusively that data and evaluations on the educational outcomes of computer-based applications to learning and teaching are not being provided through educational practice.

Decisions are being made daily at all levels of education regarding the adoption and implementation of these innovations, without any systematic base of information on the expected cognitive, affective, or social outcomes.

The NSF and other government agencies could help to remedy this situation by:

- Requiring and encouraging all supported projects involving computer-based innovations to invest a larger proportion of project resources in systematic collection of data on student learning and outcomes and reporting of results.
- Funding secondary and meta-analyses of existing research, development and evaluation studies related to computer-based learning.
- Supporting projects aimed at finding more useful ways of assessing learning outcomes.

4. Teacher Training

The rapid changes in technology have resulted in a generation of teachers who are unprepared to integrate computer use productively into their teaching practices. This is one reason the case study schools found it to be a very long slow process to integrate computer use into the curriculum.

Schools of Education have been and probably will continue to be slow in modifying their programs to prepare teachers for instructional computing. Therefore, the burden of teacher training falls on the local and state educational institutions. NSF and other federal agencies could help to ameliorate this situation by:

- Encouraging the teacher training institutions (Schools of Education) to participate in such programs as the CAUSE program.
- Supporting development of training and support materials that can be used by individual teachers and local school districts.

5. Dissemination

The lack of a systematic means of distributing useful information of the types collected in this and other analytic studies continues to result in needless duplication of materials development and in the perpetuation of confusion regarding potential uses of instructional computing. The National Science Foundation and other government agencies could remedy this situation by supporting or providing in-house regular clearinghouse functions on a national scale.