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ABSTRACT

This manual is designed to provide guidance for local school districts in planning for the use of computers in the classroom, both as a subject for study and as a tool for teaching and learning in other subjects. Topics covered include goals and objectives, defining strategies for implementation, evaluating equipment and programs, training staff, and establishing fiscal support. The first of nine chapters discusses the educational application of computers and provides information on computer use in Connecticut public schools including the number of computers available for instruction and the brand of computers used. Chapters 2 and 3 cover planning committees, needs assessment, and developing a philosophy, goals, and objectives. Some considerations that are unique to planning for computers are noted, and examples are provided. Issues involved in the development of a computer literacy curriculum are discussed in chapter 4, and several examples of curriculum scope and sequence are provided. Chapter 5 outlines the different ways in which computers can be employed to strengthen instruction in subject areas and reviews examples of such use. Chapter 6 considers how to implement both a computer literacy program and computer use in subject areas, and chapter 7 focuses on the resources needed. Chapter 8 outlines evaluation considerations, and chapter 9 examines the future of educational computing. Appendices provide sources for documents used in production of the manual, a sample needs assessment survey, an outline for an advanced placement computer science course, and endnotes for each chapter. (JB)

A GUIDE TO COMPUTERS IN EDUCATION:

INSTRUCTION

STATE OF CONNECTICUT BOARD OF EDUCATION—1985

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A Guide to Computers in Education: Instruction is the first State Department of Education publication to be produced with the aid of current telecommunications technology. Text was transmitted electronically from the Department's Publications Office directly to the typesetting equipment, using telephone modems at both locations. The equipment automatically translated the electronic signals received by telephone into the printed words contained in *A Guide to Computers in Education: Instruction*.

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Foreword

A Guide to Computers in Education: Instruction is one of many examples of Connecticut's commitment to equity and excellence in public education. It continues the Department of Education's practice of providing technical assistance to local school districts in developing curricula and instructional materials. Other publications that exemplify this commitment are the guides to curriculum development in each of eleven mandated subjects and a supplementary guide to school library media programs.

This guide to the instructional uses of computers follows the recommendation of the Joint Committee on Educational Technology and the subsequent policy statement on computer technology adopted by the State Board of Education. "The . . . Board . . . in recognition of the growing influence of computers on society and the potential of the computer for improving the quality of education, encourages the use of computer technology in education."

Because all citizens are experiencing the impact of the computer in their personal lives as well as in the workplace, public schools have an important role to play in developing computer-literate citizens. The schools also have a responsibility to manage computer technology to improve the teaching-learning process. This will require careful planning; the involvement of staff and parents in planning and implementation; and some research and evaluation of the successful programs already in place in other schools.

A Guide to Computers in Education: Instruction provides guidance for local districts in planning for the instructional use of computers including setting goals and objectives, defining strategies for implementation, evaluating equipment and programs. training staff and establishing fiscal support. The guide provides references to successful practices and programs from current literature and from Connecticut schools. Although the need to know about the computer – how it works and what it can do – is necessary, the overriding goal is the improvement of education in the basic skills and in all the mandated subjects in the curriculum.

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The guide, while necessarily temporal in nature, establishes a framework for future developments and suggests procedures for ongoing, systematic review and updating of computer applications in the curriculum.

The computer in instruction is not a panacea. It will not replace teachers. It is a technology that, in the hands of creative, talented and committed teachers, holds the promise of becoming a powerful force in shaping the teaching-learning process for all children.

Gerald N. Tirozzi
Commissioner of Education

Acknowledgments

Suggestions from educators throughout Connecticut, including those who participated in a statewide convocation on computers, and from subject area consultants within the Connecticut State Department of Education, have helped in the development of *A Guide To Computers In Education: Instruction.*

The individuals who served on the advisory committee for the development of this guide deserve special recognition for their contributions. They are as follows:

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Preface

A Guide to Computers in Education: Instruction is an outcome of the fall 1983 report of the Joint Committee on Educational Technology which was established by the State Board of Education and the Board of Governors for Higher Education pursuant to Public Act 82-266, An Act Concerning Coordination and Planning for Educational Technology. In this legislation the General Assembly directed the two boards to establish, with the assistance of the State Library Board and the Connecticut Education Telecommunications Corporation, a joint committee to provide advice on the effective use and coordination of educational technology in the state's schools and colleges.

In November 1983, the State Board of Education adopted as policy the following recommendations of the Joint Committee:

> The State Board of Education shall develop by June 1984 state guidelines for computers in education and shall identify common and successful models of the education uses of computers for dissemination among Connecticut's schools.
>
> The State Board of Education and the Board of Governors for Higher Education shall strongly encourage each local school district and public institution of higher education to develop as soon as possible, and by January 1985 at the latest, a comprehensive long-range plan to be updated as necessary on the use of computers. Based on state guidelines, these plans shall include goals, objectives and strategies for implementation and evaluation [and] shall describe staff training efforts and proposals for fiscal support.[1]

This guide represents State Board of Education implementation of these policies.

Connecticut is not alone in this effort. According to a November 1983 survey conducted by *Electronic Learning*, 17 states have laws recommending or requiring some form of computer literacy instruction in the K-12 curriculum and similar legislation is under consideration in many other states. Connecticut's schools have enthusiastically accepted the challenge to adopt computers for educational purposes.

Many Connecticut school districts have developed, or are in the process of developing, plans for computer use. The experience of these districts has proved helpful in the development of this guide. (A listing of some of these districts is provided in Appendix A.) The State Board of Education's promulgation of guidelines and call for long-range plans is not intended to supersede local initiatives in this area, but rather, to assist districts as they develop long-range plans to meet their own needs. It can motivate districts which have not yet acted and districts which have, or are developing, plans to assess their efforts against the guide. Clearly it will be more useful to districts without plans.

Equally clear, this guide will become outdated as technology advances and as children learn more about computers at an earlier age. No one can be certain how quickly change will happen, but it will, and probably sooner rather than later. The fact that this is an unsettled area is not, however, an excuse to postpone planning.

Just as the computer is not a panacea for all the problems facing education today, this guide does not offer resolutions for all the complex issues individual districts must address as they seek to teach students about computers and to incorporate the technology in teaching a variety of subjects and skills. It can, however, be used as a resource for planning, implementing and evaluating the instructional uses of computers in local school districts.

This guide focuses on uses of the computer in the classroom—both as a subject for study and as a tool for teaching and learning in other subjects. Modeled in part on the State Board of Education's successful series of guides to curriculum development, this guide addresses process and substance, but does not mandate local curriculum content. The State Board of Education believes that local boards of education, administrators and teachers are best qualified to formulate curricula which reflect local needs and aspirations.

By developing plans, local school districts can harness the experience of knowledgeable teachers, administrators, students and parents and at the same time dispel the unfamiliarity and misgivings of others who may be skeptical or even intimidated. As plans are implemented, many more of Connecticut's students will be afforded the opportunity to learn about this powerful, and developing, technology which will impact on virtually every aspect of their lives.

The Computer, Society and Education 1

A major theme of futurist John Naisbitt's best-seller *Megatrends* is that America is moving from an industrial-based to an information-based economy and that the transition will have a profound impact on virtually every aspect of our lives. The computer, notes Naisbitt, is the key element in this transition: "Computer technology is to the information age what mechanization was to the industrial revolution."[2]

As recently as a decade ago, computers were used primarily by highly trained specialists; today children can operate them. Not too long ago few people had actually seen a computer; today, microcomputers are standard office equipment and microchips are found in automobiles and a host of household appliances. With the advent of the transistor and large-scale integrated circuits, the development of powerful, compact, inexpensive computers has progressed at unprecedented speed. "If the aircraft industry had evolved as spectacularly as the computer industry, a Boeing 767 would cost $500 today and it would circle the globe in 20 minutes on five gallons of fuel."[3]

According to John Kemeny, former president of Dartmouth College and computer pioneer, "In the next three decades, intelligence will be built into most manufactured objects, and those who lack even minimal computer literacy will have difficulty functioning in everyday life."[4] Focusing on education, Naisbitt echoes Kemeny in his assessment that "although computer use in education is still in its infancy, schools around the nation are beginning to realize that in the information society, the two required languages will be English and computer."[5] Unfortunately for educators who want to translate the informed opinions of these, and other, respected thinkers into practical policies, there is no universally accepted definition of computer literacy, nor any agreement on the best ways to integrate the computer into the traditional curriculum

Yet even if much of the task is clouded, it remains clear that education will play a central role in preparing society to meet the challenges and opportunities of the information age. American education is a responsive institution and if the computer is becoming a dominant force in American life, education will accommodate the new technology. If Americans must learn to use computers, public schools will prepare them to do so.

. . . Even if much of the task is clouded, it remains clear that education will play a central role in preparing society to meet the challenges and opportunities of the information age.

Many educators are optimistic about computers because they believe the machines have the potential to teach students logic, to spark inventiveness and creativity, and to individualize instruction and teach higher level conceptual subject matter. Certainly computers may accomplish these things and more. What is less certain is how computer technology may change education itself in fundamental ways.

It is not yet clear if computers will be used simply to foster traditional educational goals or if they will alter the substance of education. Although some educators suggest that the computer has the potential for dramatically changing the content of instruction in many subject areas, many questions about the impact of technology on instruction have yet to be answered. For example, should students spend months practicing long division arithmetic when, after mastering the concept of long division and estimation skills in a relatively short period of time, they can use computers to do computation? And similarly, with spelling verification a feature of most word processing programs, how much spelling should be taught? For virtually every subject in the curriculum, questions such as these may be posed.

The first uses of the computer in education were primarily central office administrative functions such as payroll, purchasing and scheduling, automation largely along lines developed first in business and industry. The computer in the classroom, a more recent phenomenon, is the focus of this guide.

Advances in computer technology have made possible the practical application of the computer in education. Microcomputers are affordable for most school systems and easy to operate. New computer languages are also easy to learn and the availability of educational software has increased dramatically. Although not yet universal, computers are not uncommon in today's classrooms. A 1983 Connecticut State Department of Education survey indicated that between 1979 and 1982 access to computers in the state's elementary schools increased by 600 percent, 300 in middle/junior high schools and 15.7 percent in senior high schools.[6] Tables 1 and 2 summarize survey results.

Table 1
Computers Available for Instruction In Connecticut Public Schools

	Number of Districts	Number of Computers and/or Terminals
Elementary	105	906
Middle School/Junior High	96	683
Senior High	118	1,820
	Total	3,409

Eight districts (with only elementary schools) reported no computers

Table 2
Computer Use in Connecticut Public Schools

		Number of Computers/Terminals		
	Manufacturer	Elementary	Junior High	Senior High
Micro-computer	Apple	337	269	516
	Radio Shack TRS-80	262	196	706
	Commodore	193	177	133
	Atari	57	4	33
	Texas Instruments	1	3	9
Mini-computers or Macro-computers (Main-Frame)	Digital Equipment Corp	3	19	198
	International Business Machine	1	1	47
	National Cash Register	–	–	12
	Burroughs	–	–	4
	Wang	–	–	38
	Instructional Systems	24	8	–
	Zenith	16	3	–
	Western Union	12	2	–
	General Data	–	–	10
	Computer Enhancement Corp.	–	–	4
	Hazeltine	–	–	4
	North Star	–	–	10
	Data Point	–	–	6
	Inteltek	–	–	4
	PRIME	–	–	45
	Univac	–	–	15
	Hewlett-Packard	–	–	3
	Other	–	1	23
	Total	906	683	1,820

Source: Connecticut State Department of Education
Instructional Uses of Computers in Connecticut Public Schools (Surv , 1983)

The common instructional uses of computers, as shown in Figure 1, fall into two general categories: the study of computers (computer literacy and computer science), and the computer as a tool for teaching other subjects (computer applications in subject areas). There are similarities between the two; both, for example, bring students into contact with computers, require hardware and software and staff development programs. In other ways, however, the two are dissimilar. The issues involved in developing a computer literacy curriculum – issues such as when to begin instruction and who will be responsible for teaching it – are substantively different from those encountered in identifying ways to use the computer as a tool in teaching traditional subjects. In the latter some of the concerns are what kind of software is available and what should be used? This guide addresses both categories of computer use. Chapters 2 and 3 concem the planning process itself, covering topics such as planning committees, needs assessment and developing a philosophy, goals and objectives. Where appropriate, consider-

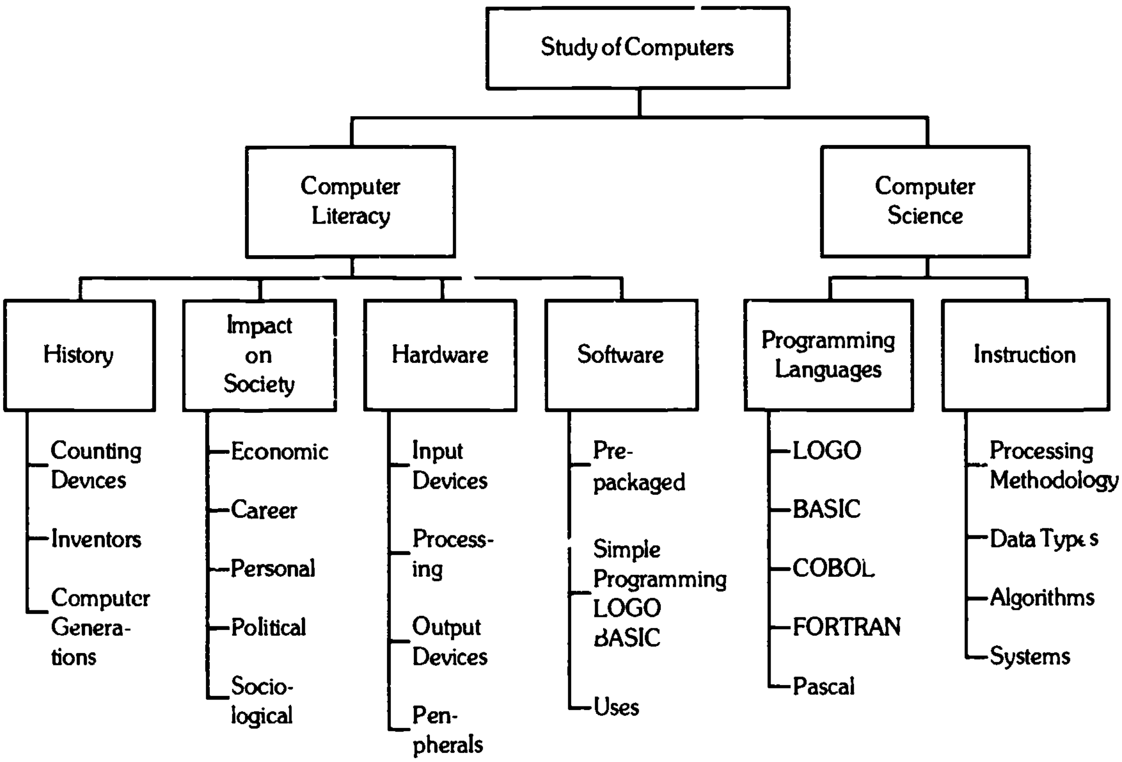
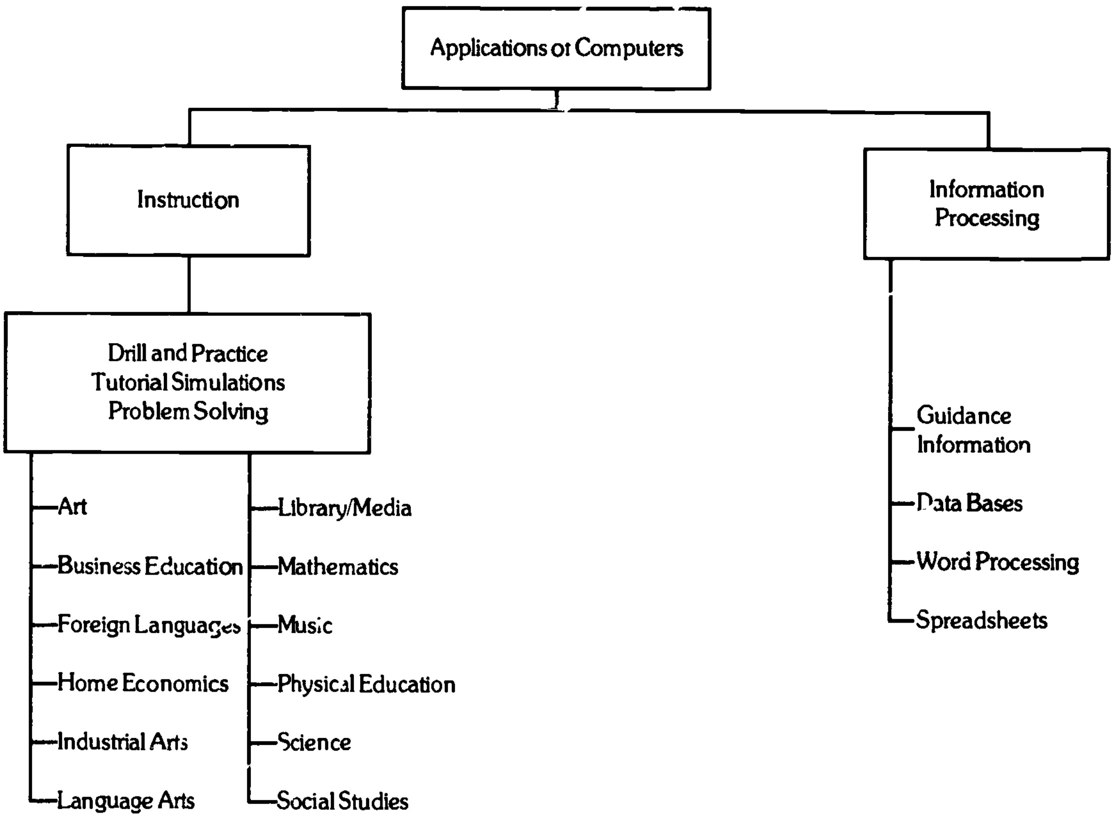


Figure 1
Computers in the Curriculum: Subject of Study and Tool for Learning Other Subjects

ations which are unique to planning for computers are noted and examples are provided. The remainder of the guide focuses on topics directly related to computers.

Chapter 4 is devoted to computer literacy while Chapter 5 covers computer use in subject areas. In the former, issues involved in the development of a computer literacy curriculum are discussed and several examples of curriculum scope and sequence are provided. In Chapter 5 the different ways in which computers can be employed to strengthen instruction in subject areas are outlined and current uses of computers in various subject areas are reviewed. Chapter 6 considers how to implement both categories of computer use and Chapter 7 focuses on the resources–software, hardware, personnel and funding–needed. Chapter 8 outlines evaluation considerations and Chapter 9 takes a look at the future. The appendices provide additional information.



2 Organizing for Planning

While the advent of microcomputers has made computer technology affordable for most school systems, the purchase of computers still constitutes a major expenditure. And if computers are made accessible to all students in a wide range of subjects and classes, significant dollars will be required. Expense alone then constitutes a compelling rationale for careful planning, but it is not the sole reason. Introducing computers into the classroom has the potential for exerting profound changes in teaching and learning and will require the involvement of teachers, administrators, parents and students. Planning must encompass the computer's potential influence on how and what is taught in many subjects and on preparing current staff to use the new technology.

The effectiveness of a school district's plan for the instructional uses of computers will depend in large part on the quality of the planning process. Careful planning can improve the substantive quality of new programs and also increase the likelihood of successful implementation.

This chapter discusses some planning strategies which have proved successful in curriculum planning and in planning for the instructional uses of computers as well. The major topics covered in this chapter are:

- defining key elements in the planning process;
- acquiring leadership support, and
- establishing planning committees.

The planning process

The State Board of Education's 1981 publication, *A Guide to Curriculum Development: Purposes, Practices and Procedures*, provides an excellent detailed examination of curriculum development which is applicable to planning for the instructional uses of computers. Although much of the material presented in this chapter is drawn from the curriculum development guide, the reader may want to refer also to the original source.

The effectiveness of a school district's plan for the instructional uses of computers will depend in large part on the quality of the planning process. Careful planning can improve the substantive quality of new programs and also increase the likelihood of successful implementation.

Key elements of the planning process are:

- analyzing – diagnosis of need, review of existing curriculum and study of the current literature;
- planning – formulation of objectives and selection of content and experiences,
- programming – development of curriculum including organization of content and learning experiences;
- implementing – pilot testing of curriculum, revision if necessary, and
- evaluating – evaluation before piloting, after piloting, and periodic monitoring and evaluation after implementation.[7]

It is important to recognize the interdependence of these elements, they are not unrelated, discrete tasks. Rather, each forms the foundation for the next and thus, as noted in *A Guide To Curriculum Development*, the planning process is circular. The circle forms a planning cycle[8] which must be repeated on a regular schedule to insure that curricula are relevant (see Figure 2).

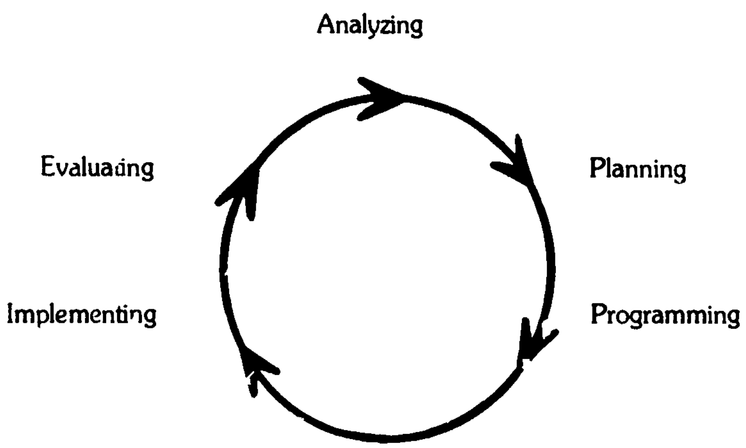


Figure 2
The Curriculum Development Process

The concept of planning cycles is particularly cogent in planning for the instructional uses of computers. Unlike traditional subject areas and pedagogic tools, the computer is new and its technology is still evolving rapidly. As more students learn about computers at an earlier age, and as advances in technology merit adoptior computer literacy curricula will require revision. It is even possible that one day teaching computer literacy will not be necessary. Similarly, dramatic advances in the use of computers as a tool for teaching traditional subject areas are predictable since this methodology is just now in the initial stages of development.

Planning cycles must reflect the likely evolution of computer use in education. A long-range planning cycle probably should not exceed five years; three years may be a more realistic time frame in an area as rapidly changing as computers. Short-range planning, the incremental steps through which long-term goals are implemented, must, in turn, be revised as long-range plans change.

Leadership support

Many districts that are front-runners in teaching computer literacy and in integrating computer use in a broad range of subject fields have strong support from the local boards of education. In some cases, the board adopts a policy on computers (developed by adm istrators or board members) that provides the rationale for in-depth planning. others, the board endorses a detailed policy, or an entire plan, developed by system administrators. Thus, some board policy statements are relatively general statements, others are more specific.

The Windsor Board of Education, for example, adopted the following policy statement in June 1981:

> The Windsor Board of Education recognizes that today's students will grow up in a technological society in which computers will play a major role. To prepare students to be successful and contributing members of such a society, the Windsor Schools have an obligation to provide students, K-12, with the experience necessary to understand and use the computer.
>
> It is the commitment of the Board that students and staff be provided the opportunity to acquire computer literacy.
>
> In addition, other applications for computers in the schools may be explored. These may include. but not necessarily be limited to, monitoring student progress, computer-assisted instruction and the use of the computer in school management. The superintendent and staff are directed to develop programs toward these ends.[9]

The advantages of board support are several. First, it furnishes maximum credibility for the planning process and for implementation. Also, when the board endorses computer literacy and the use of computers to improve and strengthen instruction in other subject areas, its support paves the way to obtain necessary funding and staff commitment.

Establishing planning committees

In all but the smallest districts, it is advisable that planning for the instructional uses of computers involve committees. When possible a district-wide committee and a computer literacy subcommittee as well as subcommittees for subject areas (which may well be existing curriculum committees) should be established.

Figure 3 shows the relationship of these committees and responsibilities which may be assigned to them.

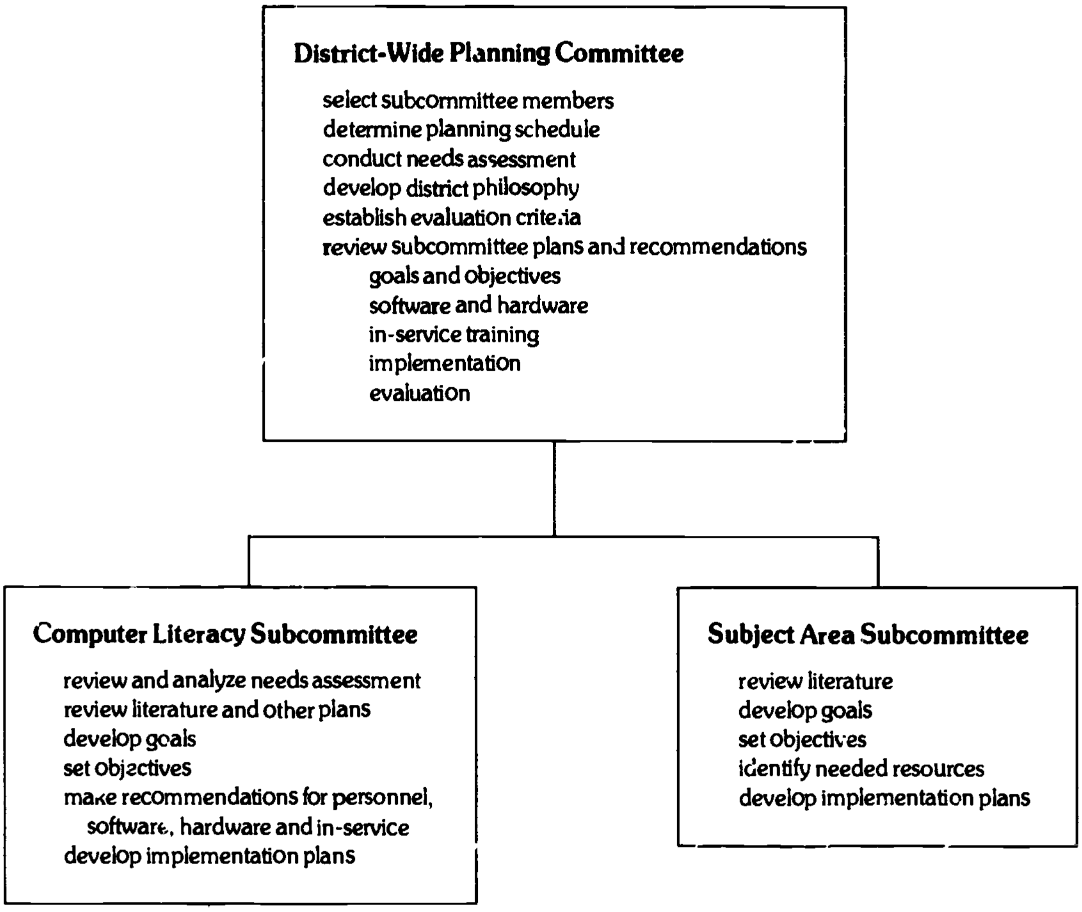


Figure 3
Planning Committees and Their Responsibilities

Some districts may wish, in addition, to establish committees charged with planning for computer use for specific areas such as spec .l education, classroom management, staff training, and evaluation.

Depending on the district's policies, these committees may be appointed by the superintendent or the board of education. Whoever appoints members may also wish to identify one school official as responsible for overseeing the planning process. Of course, in some small districts, planning on the scale just described may be impossible and as few as one or two administrators and a few teachers may well constitute the entire membership of the planning committees.

Broadly based participation is encouraged because it can facilitate effective planning. Including represer tative of all school constituencies – administrators teachers, library media personn board of education members, parents and community members – in the pl ing process not only helps to ensure that the final product reflects the needs a d concerns of those who will be responsible for implementation, but also can promote understanding of, and support for, the programs de loped. In addition, involving as many individuals as practicable can help dispel a commonly held misconception about computers, that is, the idea that the computer is just a novelty, or at best, a curriculum add-on "someone else" must know about.

District-wide planning committee

The size and precise composition of a district-level planning committee must be tailored to the individual district's characteristics. Absolute numbers are not as important as the representativeness and the dedication of individual members to the tasks at hand. While all committee members need not be expert in either curriculum development or the instructional uses of computers, they should be willing to learn about both. In fact, with regard to knowledge about computers, it may be desirable to avoid recruiting only the district's "experts," especially if they are all from one department or school, the high school mathematics department, for example. Diversity in background among the members can result in a stronger committee, one more likely to develop a plan that realistically addresses the concerns of all teachers, those who are interested in and knowledgeable about computers as well as those who are not. In addition, committee members can play an important role in communications with all constituencies and thereby assist in coalescing the support necessary for successful implementation.

Because not all committee members will share the same degree of understanding about computers and their educational uses, one or more background briefing sessions to bring all members to a common ground of understanding about computers should be planned. A reading list might be developed and, if possible, individuals lacking the experience might be afforded a hands-on session or two with a computer. Field trips to districts with more advanced programs for computer use could also prove informative. As appropriate, subcommittee members may be included in these sessions or similar briefings provided for them.

The experience of some districts with noneducator committee members suggests that a few words about the use of consultants, volunteer and paid, may be in order. Some school districts have benefited from the participation of local business and industry representatives, these people can be a rich source of information, but if they are asked to participate a few cautions should be considered. In a few cases technical experts have inhibited the participation of other committee members; also private sector personnel sometimes lack understanding of education's unique needs. Usually, however when noneducator committee members are given sufficient orientation, they are excellent resources. Similar cautions apply to the paid consultant or manuf[illegible] representatives. While there are many knowledgeable computer consul[illegible] and some who specialize in education, a few are not as expert as they repre ent themselves. Any district considering the use of a paid consultant should carefully screen credentials and ask for references from other school districts. The potential problem with manufacturers' representatives is that, in many cases, they are primarily salespeople with a vested interest in a particular brand of computer.

The responsibility of the district-wide planning committee is to manage the planning process and to set overall planning guidelines for subcommittees Additional assignments for the district-wide committee might include insuring that the district is also planning for the use of computers in special education and for the gifted and talented, and for classroom management. The computer can afford significant benefits in these areas and they should be incorporated in the long-range plan.

Computer literacy subcommittee. The computer literacy subcommittee may be comprised of district-wide planning committee members, other individuals, or a combination of both. Each approach has advantages and the choice will depend on individual district preferences and the availability of personnel. Having members of the district-wide committee on the subcommittee can facilitate communication between the two, while having different members increases participation in the planning process; a combination accomplishes both.

No matter which approach is selected. committee membership should include representatives of the constituencies noted above and teachers from as many disciplines as possible to provide breadth of experience. Social studies teachers, for example, may provide a better perspective than mathematics teachers about the social and ethical implications of computers, while mathematics teachers may have greater expertise about programming issues.

The development of a computer literacy curriculum should be the primary responsibility of the subcommittee.

Planning for subject area applications. In addition to planning a computer literacy curriculum, a long-range plan for the instructional uses of computers should include plans for incorporating computer use in teaching and learning in all other subject areas in the curriculum. Some districts may wish to establish special committees to do this; another approach would be to assign the responsibility to existing groups such as departments or curriculum committees. Some districts may choose to have all subject areas undertake planning at the same time, working in parallel with the computer literacy subcommittee, while others may defer planning for any particular subject area until the next review of the subject area according to the district's master schedule for curriculum planning.

Planning for computer applications in subject areas is a challenging assignment. The goal is to identify ways in which computers can enhance teaching and learning in subject areas. While there is a wide range of potential uses of computers (drill and practice, tutorial, games, simulations and applications such as word processing, to name a few), the state of the art is not highly refined; new and improved applications are released frequently.

3 Determining Needs Philosophy and Goals

Although the need to initiate or expand the instructional use of computers may be generally agreed upon, planning can be strengthened by conducting a formal needs assessment. The results of the needs assessment provide useful input for the development of philosophy, goals and objectives. The chapter discusses the rationale for including these key elements in the planning process and offers general guidance about how to undertake them.

Conducting a needs assessment

Conducting a needs assessment is a helpful first task for the district-wide planning committee. A needs assessment may be a formal, detailed survey of all school constituencies, or a simpler random sampler.

A needs assessment can yield useful information such as:

- current uses and users of computers
- opinions about potential uses of computers
- suggestions for goals and objectives

In addition, conducting a needs assessment can extend participation in the planning process and stimulate broad-based thinking about computers.

The magnitude and sophistication of any district's needs assessment will depend on factors such as district commitment to computers, time and resources available. In most districts, it should be possible to undertake some type of activity to gather opinions about current and future uses of computers. In all cases, a needs assessment should be based on a clearly defined end use. A sample needs assessment survey is provided in Appendix B.

A Guide to Curriculum Development: Purposes, Practices and Procedures as well as curriculum development texts and the district's own personnel are all sources of information about conducting a needs assessment and should be consulted by the district-wide planning committee.

Developing philosophy, goals and objectives

Philosophy, goals and objectives are all concise expressions of what a school district intends to accomplish. Formulating philosophy, goals and objectives is the heart of the planning process; these statements document the outcomes of planning.

One value of developing written statements is that the process requires planners to select a finite number of desired program outcomes from a large number of possibilities. The result is clearly defined ends toward which the district will direct limited resources. Other benefits include the ability to better implement, evaluate and revise programs. With direction provided by specific philosophy, goals and objectives, implementation proceeds in a logical fashion, evaluation is based on measurable criteria, and revision, if necessary, departs from a known precedent.

Philosophy, goals and objectives differ in degree of specificity. A philosophy statement is a broad statement of purpose, goals are more specific and objectives precise. Because philosophy statements are all-encompassing, they should be developed by the most broadly representative planning group, the district-wide planning committee. Goals too are best developed at the district level. The computer literacy and subject area subcommittees should formulate learning objectives based on guidelines provided by the district-wide committee.

Writing a philosophy statement

A philosophy statement should define, in broad terms, the purpose of instruction for a given program of study and provide justification for its inclusion in the district's overall curriculum. Goals follow from the philosophy; they are more specific statements about what the district intends to achieve through a program of instruction.

Districts may wish to develop one philosophy statement concerning all instructional uses of computers. The Windsor Board of Education's policy statement (quoted on page 8), for example, covers both computer literacy and applications of computers in subject areas.

Another approach is to develop two philosophy statements, one for computer literacy, a second governing computer use in subject areas. Depending on a plan's organization, any number of philosophy and goal statements may be developed. The East Lyme Public School's plan, for example, distinguishes among computer awareness, computer science and computer-assisted instruction and has philosophy and goals statements for each. The district's plan features seven philosophy statements with accompanying goals. In addition to a single philosophy and goals for the K-12 computer awareness curriculum, there are individual philosophy and goals statements for computer science and computer-assisted instruction at the elementary, junior high school and high school levels of instruction. All of these are good examples and three are quoted here for illustration.

Computer Awareness Curriculum Philosophy

It is the intent of the East Lyme Public School System to educate all students in computer awareness so that they may better control their lives in a computerized society. With an understanding of the ethical and legal considerations and knowledge of society's expectations for future employment and education, East Lyme students will become critical consumers and informed, alert citizens.

Goals

- To develop an historical perspective on computers
- To evaluate the advantages and disadvantages of computers
- To gain knowledge of computer types and their component parts
- To discover the level of computer expertise required by his or her individual career and educational goals
- To learn languages and the numbering systems which operate computers
- To analyze the present and future impact of computers on society and the individual

Elementary Schools
Computer Science Curriculum Philosophy

The purpose of programming at the elementary level is to enhance the student's ability to analyze problems and devise solutions. Programming is a means, not an end, to achieving this fundamental purpose.

A secondary purpose for programming instruction is to enable students to use the computer in an enjoyable, s sfying way. For this reason, elementary children will have the opportunity to create programs without the restriction of a tightly controlled vocabulary. Turtle graphics will be used with the emphasis placed upon manipulation and experimentation.

Goals

- To develop inductive and deductive reasoning skills and the ability to define and solve a problem
- To acquire the fundamentals of operating a computer by using introductory vocabulary and processes of a structured language (turtle graphics)
- To discover the multiple capabilities of the computer
- To learn and develop geometric concepts
- To reinforce language arts skills

High Schools
Computer-Assisted Instruction Philosophy

At the high school level CAI will facilitate the development of creative and analytical capabilities. The machine, as a tool with its unique tutorial and individualized possibilities, also will be emphasized.

Goals

- To gradually integrate computers into all instructional areas as a tool for broadening and improving upon the quality of education
- To utilize the computer as a management tool for teachers[10]

While information derived from a review of current literature or other sources such as visits to other school systems can prove useful to the district-wide planning committee as it develops philosophy and goal statements, local needs and aspirations should be the primary source of input.

Setting objectives

Well formulated program objectives introduce a desirable degree of specificity into the plan. Objectives identify what students should learn.

A Guide to Curriculum Development: Purposes, Practices and Procedures notes that there are many ways to write objectives and each district must determine which is best suited to its purposes. No matter what method is employed, however, the resulting objectives should indicate a clear relationship to the philosophy and goals and "focus on the outcomes of learning experiences rather than on the instruction or the process."[11] Also, whenever possible, objectives from each of the three domains of instructional objectives – cognitive, affective and psychomotor – should be included. The clarity of objectives in terms of desired pupil performance is essential for giving teachers direction and for evaluation.

Well written objectives have the following characteristics:

- indication of a desired outcome
- inclusion of an action verb
- statement in terms of pupil performance
- statement in terms of learning result
- statement of clarity and conciseness
- inclusion of only one outcome[12]

. . . objectives should indicate a clear relationship to the philosophy and goals and 'focus on the outcomes of learning experiences rather than on the instruction or the process.'

The formulation of precise program objectives for computer literacy will, of course, depend in large part on the specific curriculum scope and sequence established. In addition, as noted in Chapter 3, program objectives must be supplemented with more specific instructional and learning objectives geared to the grade level of students.

The following computer literacy instructional objectives were developed for third graders in the East Hartford Public Schools. The subject areas shown parenthetically "may be appropriate places to develop the objective."

1. The student will be introduced to the applications of the computer in society now, both positive and negative, and its potential for the future.

   (a) The student can describe the computer as a machine or tool that can help solve problems (with words or numbers) quickly and easily. (Language Arts)

   (b) The student can describe realistically what a computer can and cannot do for humans. (Social Studies)

   (c) The student will list speed, accuracy, and "repetitious activity" as advantages of a computer. (Social Studies)

   (d) The student will understand the computer as an impersonal, literal machine with no feelings or emotions. (Social Studies, Science)

(e) The student can identify several roles the computer plays in our daily lives. (Social Studies, Science, Math)

2. The student will develop an understanding of proper computer ethics.

   (a) The student will understand that people control computers, not vice versa. (Social Studies)

3. The student will learn the basic components of computer hardware and their applications.

   (a) The student can name the parts of a computer, including input, output, memory, and central processing unit. (Language Arts)

4. The student will learn the proper use and safe operation of computers.

   (a) The student can locate and identify the letters, numerals, and special keys for operations and commands on the keyboard. (Language Arts)

5. The student will develop an understanding of computer language immediate mode commands.

   (a) The student can identify and use the BASIC language direct commands LOAD, LIST, RUN, and PRINT. (All Subjects)

   (b) The student can identify and use the special graphics character keys on the Commodore 64. (All Subjects)

   (c) The student can use the cursor arrow keys to control cursor placement on the screen. (All Subjects)

6. The student will learn to utilize available software for remediation, tutorial work, and self-instruction.

   (a) The student can load and run a commercial or teacher-made program on the computer, emphasizing drill and practice programs and simulation programs. (All Subjects)[13]

4 The Computer Literacy Curriculum

As noted previously, the instructional uses of computers may be grouped in two general categories: computer literacy (discussed in this chapter) and computer applications in subject areas (covered in Chapter 5).

While distinguishing these two categories can facilitate some aspects of planning, it should be recognized that they are not mutually exclusive. Concepts learned through computer literacy instruction will benefit students who use computers in other subjects, and conversely, computer applications in other subjects will reinforce computer literacy concepts. All students should receive computer literacy instruction and also be afforded the opportunity to use computers in studying other subjects. In addition, more advanced, elective computer courses are recommended.

Before discussing the content of a computer literacy curriculum, this chapter addresses some issues which complicate curriculum development in this new area.

Computer literacy issues

Developing a computer literacy curriculum is complicated by lack of consensus among educators about many issues, major and minor, concerning this new addition to the curriculum. Although diverse opinions are held on a variety of topics ranging from whether, and if so when, to teach keyboarding skills to which programming languages should be taught, this section highlights two major issues: the definition of computer literacy and grade sequencing.

Perhaps the most fundamental issue concerns the definition of computer literacy. At present, there is no universally accepted definition of computer literacy. Indeed, there is much debate – which has been heated at times – about how to define this new addition to the school curriculum. Moreover, problems of definition are further muddied by the fact that any definition is certain to change, to evolve as technology advances and the uses of computer technology increase. There is also dispute about the best approach to grade sequencing.

Defining computer literacy

The debate about the definition of computer literacy centers on the degree of emphasis placed on programming skills. Some educators equate computer literacy with programming skills. Others believe computer literacy means understanding computer applications and uses, knowing about the history of computers, and awareness of the social, economic and political impact of computers on society. While neither approach is right or wrong, there does appear to be growing consensus toward a de-emphasis on programming skills for the majority of students (although most educators would encourage schools to provide structured programming courses at the high school level for some students).

Today most educators generally agree that the goal of computer literacy is not to make all students proficient programmers. Rather, the widely accepted goal of computer literacy instruction is to teach enough about computers and their uses to enable all students to use computers as problem-solving, information accessing and information processing tools. These skills define computer literacy and will prepare students to function effectively in the complex, high technology information society in which they will live their adult lives.

The widely accepted goal of computer literacy instruction is to teach enough about computers and their uses to enable all students to use computers as problem-solving, information-accessing and information-processing tools.

Supporting the apparent move toward de-emphasizing programming is the expectation that, as Glen Polin, educational marketing director of Apple Computers, predicts, "future applications will be user-friendly and will not require an intimate knowledge of the computer. The software evolution of the last three or four years bears that out. We have packages on the market today that can be used by a total novice . . . and that trend is accelerating. When you go out into the world, you're not going to be asked to do basic programming unless you choose that as a vocation."[14]

Thus, if taught within a computer literacy curriculum for all students, one purpose of programming instruction in many schools today is to instill in students the understanding that people control computers and without human input, the machines can do nothing. Another goal is to enhance students' logical reasoning skills (a primary motivation in the teaching and use of LOGO for example). To meet these objectives, programming instruction in a computer literacy curriculum for all students may be limited to writing very simple, short programs, in languages such as BASIC or LOGO, which give students an understanding of how the computer needs "instructions" to operate.

Grade sequencing

In addition to debate about the definition of computer literacy, there is disagreement among educators about the best method of grade sequencing. Many educators believe computer literacy should be integrated throughout the K-12 curriculum, while others call for instruction concentrated at one grade, usually at the middle/junior high school level.

Many school districts in Connecticut and around the country have adopted a K-12 computer literacy curriculum. In this model (as can be seen in the scope and sequence examples in Chapter 4), computer literacy concepts are introduced in the earliest grades and then are reinforced and expanded upon in later grades. The rationale for this approach is grounded in the belief that the sooner children are taught about computers the better, and that students' overall logical/reasoning abilities are strengthened through computer literacy instruction.

In the April 1984 issue of *Electronic Learning,* Arthur Luehrmann, a nationally recognized leader in the field of educational computing, argues against the K-12 approach calling it "the most difficult strategy I can imagine for assuring that all students become computer literate."[15] As an alternative, Luehrmann recommends "(1) defining computer literacy goals, (2) creating a computer literacy class, (3) assigning responsibility to one or two teachers, and (4) measuring the learning that takes place in the computer class."[16] He suggests grades 7-9 for computer classes, noting that students may need some preliminary skills – keyboarding, for example – before they are ready to work productively in the computer class and that a certain amount of elementary programming – in LOGO or BASIC – might be introduced in the early grades.

There is no definitive, research-based conclusion about the best way to grade sequence computer literacy instruction. The fact that many students are learning about computers outside of school complicates the issue. While some school districts have adopted a K-12 curriculum, others have opted for concentrating instruction at one grade level. The Hartford Public Schools, for example, motivated in large part by practical considerations, established a minicourse in the middle schools "because pupils, at this time, are offered exploratory courses as part of the middle school program. This course will fit the present pattern more easily and will not require a major shifting of schedules or promotion requirements."[17]

Computer literacy for all students

The first task in developing computer literacy for all students is to develop a working definition of computer literacy for the district. This definition may be embodied in the goal statement. The following is a definition expressed as a goal.

The goal of computer literacy instruction is to enable students to define, demonstrate and/or discuss:

how computers are used;

how computers do their work;

how computers are programmed;

how computers affect our society.[18]

Once the district has defined computer literacy, it is possible to develop the scope and sequence of instructional objectives which will bring students to achieve literacy as defined. Examples of computer literacy curricula appear in Table 3, 4, 5 and 6.

Curriculum scope and sequence

A curriculum scope and sequence is nothing more than a plan for what will be taught – specific knowledge, skills and attitudes – and in what order based on the cognitive, motor and emotional development of children. When it comes to computer instruction, however, sequencing is complicated because schools are finding wide variations in student interest, experience, and capability with the computer. It is not unusual, for example, to find a 4th grader capable of working with a 7th grader on the same task. Therefore, although a grade-level sequence should be developed, the framework must allow flexible adaptation to individual students' achievement.

As discussed above, there are differences of opinion about when computer literacy should be taught and the first decision a district must make is whether or not to develop a K-12 curriculum. It should also be noted that, if a K-12 curriculum is selected, as computer literacy is introduced into the curriculum, it may be necessary to develop interim grade sequencing strategies such as those discussed in Chapter 6, as well as the flexible approach just described.

Finally, districts should keep in mind that over the long term, as students learn more about computers outside the schools, grade sequencing will likely require revision.

Although the scope and sequence of computer literacy curricula among Connecticut schools vary in many ways, there are several topics which are common to virtually all. The following goals for computer literacy – well expressed as student objectives – were developed cooperatively by ten towns with the Area Cooperative Educational Services (ACES) and include key elements found in most curricula:

- know what computers are, how they work, and how they are used;
- be aware of the evolution of computer hardware and software;

Table 3

Computer Literacy Scope and Sequence

Computer Awareness

	Topics	K	1	2	3	4	5	6	7	8	9	10	11	12
K	What a Computer Is	IA	C	C	C	C	C	C	C	C	R	R	R	R
K	Following Directions	IA	C	C	C									
K	Vocabulary	IA	C	C	C	C	C	C	C	C	C	C	C	C
K	Programming Programmable Devices													
K	Turtle Graphics (Making Shapes)													
1st Grade	What a Computer Can Do		IA	C	C	C	C	C	C	C	R	R	R	R
1st Grade	Learning to Use a Computer		IA	C	C	C	C	C	C	C	C	C	C	C
1st Grade	Using the Keyboard		IA	C	C	M								
1st Grade	Turtle Graphics (Moving Shapes)													
2nd Grade	Computer Advantages			IA	C	C	C	C	C	C	C	C	C	C
2nd Grade	Computer Disadvantages			IA	C	C	C	C	C	C	C	C	C	C
2nd Grade	Computers in Our Lives			ID	C	C	C	C	C	C	C	C	C	C
2nd Grade	Everyday Applications			ID	C	C	C	C	C	C	C	C	C	C
2nd Grade	Future			ID	C	C	C	C	C	C	C	C	C	C
2nd Grade	Turtle Graphics (Rotations, etc.)													
2nd Grade	LOGO (Sprites)													
3rd Grade	History				ID	C	C	C	C	C				
3rd Grade	Logic				IA	C	C	C	C	C	C	C	C	C
3rd Grade	How a Computer Works				IA	C	C	C	C	C	C	C	C	C
3rd Grade	Parts of a Computer				IA	C	C	C	C	C	C	C	C	C
3rd Grade	LOGO Programming													
3rd Grade	Problem Solving with LOGO													
4th Grade	Hardware					ID	C	C	C	C	C	C	C	C
4th Grade	Software					ID	C	C	C	C	C	C	C	C
4th Grade	Flowcharting					IA	C	C	C	C	R	R	R	R
4th Grade	Storyboarding					IA	C	C	C	C	R	R	R	R
4th Grade	BASIC: PRINT & REM													
4th Grade	BASIC: LET													
4th Grade	BASIC: INPUT													
4th Grade	BASIC: GO TO													
4th Grade	Formulas (Variables & Constants)					IA	C	C	C	C	C	C	C	C
4th Grade	String Data													
4th Grade	Relations					IA	C	C	C	M				
4th Grade	Binary Numbers					IA	C	C	C	C	C	C	C	C

Programming

	Topics	K	1	2	3	4	5	6	7	8	9	10	11	12
K	What a Computer Is													
K	Following Directions													
K	Vocabulary													
K	Programming Programmable Devices	IA	C	M										
K	Turtle Graphics (Making Shapes)	IA	C	C										
1st Grade	What a Computer Can Do													
1st Grade	Learning to Use a Computer													
1st Grade	Using the Keyboard													
1st Grade	Turtle Graphics (Moving Shapes)		IC	C	C									
2nd Grade	Computer Advantages													
2nd Grade	Computer Disadvantages													
2nd Grade	Computers in Our Lives													
2nd Grade	Everyday Applications													
2nd Grade	Future													
2nd Grade	Turtle Graphics (Rotations, etc.)			IA	C	C	C							
2nd Grade	LOGO (Sprites)			IA	C	C	C	C	C	C	C	C	C	C
3rd Grade	History													
3rd Grade	Logic				IA	C	C	C	C	C	C	C	C	C
3rd Grade	How a Computer Works													
3rd Grade	Parts of a Computer													
3rd Grade	LOGO Programming				IA	C	C	C	C	C	C	C	C	C
3rd Grade	Problem Solving with LOGO				IA	C	C	C	C	C	C	C	C	C
4th Grade	Hardware													
4th Grade	Software													
4th Grade	Flowcharting					IA	C	C	C	C	C	C	C	C
4th Grade	Storyboarding					IA	C	C	C	C	C	C	C	C
4th Grade	BASIC: PRINT & REM					IA	C	C	C	C	R	R	R	R
4th Grade	BASIC: LET					IA	C	C	R	R	R	R	R	R
4th Grade	BASIC: INPUT					IA	C	R	R	R	R	R	R	R
4th Grade	BASIC: GO TO					IA	C	R	R	R	R	R	R	R
4th Grade	Formulas (Variables & Constants)					IA	C	C	C	C	C	M		
4th Grade	String Data					IA	C	C	C	C	C	C	R	R
4th Grade	Relations					IA	C	C	C	M				
4th Grade	Binary Numbers													

Legend

IA – Introduction with Activities **R – Review**

ID – Introductory Discussion **M – Mastery**

C – Expansion of Discussion from Previous Grades

Source: "Computer Literacy Scope and Sequence," *Electronic Learning*, September 1982, pages 62-63.

		Computer Awareness													Programming												
	Topics	K	1	2	3	4	5	6	7	8	9	10	11	12	K	1	2	3	4	5	6	7	8	9	10	11	12
5th Grade	Computer Generations						ID	C	C	C																	
	Counters						IA	C	C	C	M									IA	C	C	C	C	C	C	C
	BASIC. IF-THEN																			IA	C	R	R	R	R	R	R
	BASIC: ON-GO TO																			IA	C	R	R	R	R	R	R
	BASIC. READ-DATA																			IA	C	R	R	R	R	R	R
	Word Processing						IA	C	C	C										IA	C	C	C	C	C	C	C
6th Grade	Computer Types							ID	C	C	R	R	R	R													
	Data Handling							IA	C	C	C	C	C	C													
	Computer Languages							IA	C	C	C	C	C	C													
	Looping							IA	C	C	M										IA	C	C	C	C	C	C
	BASIC FOR-NEXT																				IA	C	C	C	C	C	C
	BASIC Random Number																				IA	C	C	C	C	C	C
	Problem Solving with BASIC																				IA	C	C	C	C	C	C
	Graphics																				IA	C	C	C	C	C	C
7th Grade	Modeling								IA	C	C	C	C	C													
	Robotics								ID	C	C	C	C	C													
	Social Issues								ID	C	C	C	C	C													
	Data Bases								IA	C	C	C	C	C													
	BASIC. Arrays (One-Dimensional)																					IA	C	C	C	C	C
	BASIC: functions																					IA	C	C	C	C	C
8th Grade	Computer Crime									ID	C	C	C	C													
	Algorithms									IA	C	C	C	C									IA	C	C	C	C
	BASIC. Arrays (Two-Dimensional)																						IA	C	C	C	C
	Graphics (Sound & Color)																						IA	C	C	C	C
9th Grade	Computer Capabilities										ID	C	C	C													
	Computer-Related Fields										ID	C	C	C													
	BASIC Simulation Programming																							IA	C	C	C
	BASIC: Matrices																							IA	C	C	C
	BASIC Files																							IA	C	C	C
	Pilot: Introductory Language Commands																							IA	C	C	C
10th	Prediction, Interpretation, Generalization of Data											IA	C	C													
	Artificial Intelligence											IA	C	C													
	Pascal: Introduction																								IA	C	C
11th	Computer Systems												ID	C													
	Sampling Techniques												IA	C												IA	C
	Statistical Application												IA	C												IA	C
	Pilot: Programming																									IA	C
12th	Computer Survival													ID													
	Invasion of Privacy													ID													
	Pascal: Advanced																										IA
	Data Bases: Advanced																										IA

- be aware that there are different computer languages;
- recognize the impact of computer technology on individuals and society;
- realize the ethical obligations and the legal responsibilities related to computer use;
- operate a computer system;
- develop logical thinking and problem-solving strategies;
- experience the capabilities and limitations of a computer system;
- understand and apply the characteristics of computer languages;
- utilize a computer system as a tool in education, occupational, and recreational pursuits, and
- be able to interact creatively with the computer.[19]

These student learning objectives constitute a comprehensive scope for a computer literacy curriculum. They may be further detailed to provide more

Table 4
Scope and Sequence Computer Literacy K-8

Westport Board of Education
May 1980

		Grade Level								
Grade	**Topics**	**K**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
K	What a computer is	I	D	D	D	D	M			
	Following directions	I	D	D	D	D	R	R	R	R
	Computer vocabulary	I	D	D	D	D	D/R	D/R	D/R	D/R
	Using keyboard	I	D	D	D	M				
1	Using programs		I	D	D	D	R	R	R	M
2	What a computer can do			I	D	D	D/R	D/R	D/R	D/R
	Computer advantages			I	D	D	D	D	D/R	D/R
	Computer disadvantages			I	D	D	D	D	D/R	D/R
	Computers in our lives			I	D	D	D	D	D	D
	Everyday applications			I	D	D	D	D	D	D
	Future			I	D	D	D	D	D	D
	Parts of a computer			I	D	D	D	D	D	M
3	History of computers				I	D	D	D	D	D
	Computer logic				I	D	D	D	D	D
	How a computer works				I	D	D	D	D	M

Legend

I – Introduction **R – Review**
D – Development **M – Mastery**

specific learning objectives and a sequence of learning objectives can be established.

Once the computer literacy scope and sequence is defined and an implementation strategy determined, it is necessary to develop more specific plans for what will happen in classrooms. Instructional and learning objectives must be developed and instructional materials and resources identified. *A Guide to Curriculum Development: Purposes, Practices and Procedures* offers some suggestions for developing good objectives and also for selecting materials and resources. Although the subject matter is new, most experienced educators who know a great deal about the developmental abilities of children should be well prepared to match computer literacy program objectives with appropriate teaching and learning objectives.

High school curriculum

The scope and sequence of many districts' computer literacy curricula for all students spans grades K-12 This does not mean, however, that all students must be limited to the basic computer literacy curriculum at the high school level. Similarly, in districts where all computer literacy instruction is offered at one grade level, additional instruction about computers is recommended at the high school level.

		Grade Level								
Grade	Topics	K	1	2	3	4	5	6	7	8
4	What software is					I	D	D	D	M
	What hardware is					I	D	D	D	M
5	Computer types						I	R	R	R
	Social issues						I	D	D	D
	Word processing						I	D	D	D
	Educational software						D	D	D	D
6	Computer generations							I	D/R	D/R
	Computer crime							I	I/D	I/D
	Data Bases							I	D	D
	Educational software							D	D	D
7	Modeling, simulation								I	D
	Robotics								I	D
	Computer languages								I	D/R
	Educational software								D	D
8	Artificial intelligence									I
	Telecommunication									I
	Computer-assisted design									I
	Educational software									D

When a district has a K-12 computer literacy curriculum, all high school students may continue to study computer literacy topics such as simple programming, social issues and careers in computer-related fields. (High school students should also, of course, use computers in studying other subjects.) But in addition to these computer literacy offerings for all students, the high school curriculum should also include elective options.

By the time they reach high school, some students are ready for more advanced computer topics. Some students will want to take courses that build upon the computer literacy instruction they have already received by learning more advanced programming skills and having more opportunities to work with computers; others, primarily the college bound and academically talented, will want instruction in computer science. And also, because computers are widely used in business and industry today, high school vocational education programs which prepare students for employment and/or for postsecondary study should include training involving computers. For example, office education students should learn word processing and data entry, and drafting courses should cover computer-assisted design and drafting (CADD).

The section which follows out[illegible]es elective courses which may be offered at the high school level. (Note that sir[illegible] he use of computers in vocational subjects

Table 5
Scope and Sequence Computer Programming K-8

Westport Board of Education
May 1980

		Grade Level								
Grade	**Topics**	**K**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
K	Programmable devices	I	D	D	D	R				
	Instant LOGO	I	D	M						
1	Making LOGO shapes		I	D	D	R				
	Moving LOGO shapes		I	D	D	R				
2	Rotating LOGO shapes			I	D	D				
3	Problem solving in LOGO				I	D				
4	BASIC: PRINT, REM					I	R	R	R	M
	BASIC: LET					I	R	R	R	M
	BASIC: INPUT					I	R	R	R	M
	BASIC: GOTO					I	R	R	R	M
	BASIC: CATALOG					I	R	M		
	BASIC: LOAD, RUN					I	R	M		
	BASIC: LIST, SAVE					I	R	M		
	Formulas					I	R	D	D	R
	String Data					I	R	D	D	D
	Relations					I	R	D	D	D

Legend

I – Introduction **R – Review**
D – Development **M – Mastery**

is not the study of the computer, applications of computers in these subjects is covered in Chapter 5.)

Elective high school courses

Elective high school courses might include programming languages, specific applications and computer science.

Programming courses. Full-year or half-year courses in one or more computer languages should be offered. Offerings might include:

BASIC	a common language used with most microcomputers
COBOL	a widely recognized business-oriented language
LOGO	a language for learning how to think
Pascal	the language designated by the College Entrance Examination Board for the Advanced Placement Computer Science Examination (The outline for this course is provided in Appendix C.)

		Grade Level								
Grade	Topics	K	1	2	3	4	5	6	7	8
5	BASIC: IF-THEN						I	D	R	M
	BASIC: ON-GOTO						I	D	R	M
	BASIC: READ-DATA, GET						I	D	R	M
	BASIC: FOR, NEXT						I	D	R	M
6	Flowcharts							I	D	R
	Debugging							I	D	R
	Problem solving in BASIC							I	D	R
	Lists							I	D	R
7	Hi-Resolution graphics								I	D
	Central Structures								I	D
	Arrays (one dimensional)								I	D
	BASIC: INT, RND								I	D
8	Stage of problem solving									I
	Creating original programs									I
	Files									I
	BASIC: ABS, SQR									I

Specific applications. Full-year or half-year courses in specific computer applications such as the following might be offered:

Word Processing	an essential skill for all students
Information Retrieval	techniques for accessing data bases and communicating electronically might be offered since they are useful learning and research skills

Computer science. A full-year course at the 11th or 12th grade might be offered for those students planning to pursue computer studies at the postsecondary level. Two years of college preparation mathematics and completion of courses in two programming languages (one of which should be Pascal if the course follows the College Entrance Examination Board Advanced Placement Program) should be prerequisites for computer science study. The course might be Advanced Placement (AP) or a similar advanced program developed by the school district.

The courses described above are illustrative elective courses which should be offered at the high school level. The high school program in any district will, of course, reflect the district's philosophy, goals and resources.

Table 6
Computer Literacy Curricula

Grade Level	Computer Awareness	Computer Programming
K-3	II Knowledge of the use of computer hardware including hands-on experiences	
	A Students will be able to turn equipment on/off	
	C Students will be able to load software into the computer system	
	III Knowledge of the use of computer software	
	A. Students will be able to interact successfully with a variety of programs	
4-6	I. Knowledge of the difference between hardware and software	
	A. Students will be able to successfully identify computer hardware	
	B. Students will be able to demonstrate an understanding of software	
	II. Knowledge of the use of computer hardware including hands-on experiences	

Grade Level	Computer Awareness	Computer Programming
	B Students will be aware of minimal troubleshooting techniques	
	D. Students will be able to demonstrate proficiency with the keyboard	
	E Students will be able to demonstrate the use of storage devices	
	1 cassette tapes	
	IV Knowledge of career opportunities involving computer technology	
	B Students will be able to cite examples of computer applications in business, industry and education	
7, 8, 9	I Knowledge of the difference between hardware and software	I Ability to create successful programs appropriate to the student's grade level
	C. Students will be able to demonstrate an understanding of how data is stored in a computer	A Students will be able to determine whether or not a problem is suitable for computer solution
	II Knowledge of the use of computer hardware including hands-on experiences	B Students will be able to create *elementary* BASIC programs involving
	E. Students will be able to demonstrate the use of storage devices	1. the concept of a variable 2 system commands 3 input techniques 4. output techniques 5. unconditional branching 6. conditional branching 7 debugging techniques
	2 diskettes	
	III. Knowledge of the use of computer software	
	B Students will be able to make minor modifications of existing programs	
	V Knowledge of the social and ethical implications of computer technology	
	A Students will demonstrate an understanding of the evolution of computing systems	
	B Students will be able to describe both beneficial and harmful effects of computer applications, i.e., problems of privacy, computer crime, etc.	

(continued)

Grade Level	Computer Awareness	Computer Programming
10, 11, 12	IV. Knowledge of career opportunities involving computer technology A. Students will be able to access career and employment information using computerized guidance information systems	I. Ability to create successful programs appropriate to the student's grade level D. Students will have an opportunity to elect an Advanced BASIC Programming course covering: 1. subscripted variables 2. substrings 3. additional output formats 4. files (sequential and random access) 5. graphics E. Students will have an opportunity to elect an additional programming course covering: 1 advanced problem-solving techniques 2. assembly and/or machine language programming 3. other high level languages, i.e., APL, FORTRAN, PASCAL, COBOL, PLI, RRG, etc. II. Ability to utilize various peripheral devices for programming purposes A. Students will be able to format output using a printer B. Students will be able to create, store, and access data files using a DOS C Students will be able to demonstrate successful use of a word processing system D. Students will be able to access a communications network system through a remote terminal, i.e., GIS, etc. E. Students will have the opportunity to visit computer installations having varied applications

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Computer Applications in Subject Areas 5

Although computer literacy has generated much public interest and sparked lively discussion among educators, the greatest impact of computers on education is likely to result, not from the study of computers, but rather from the application of computers in other subjects. From a long-range perspective, the computer has virtually limitless possibilities for individualizing instruction, changing the substance of what is taught in many subject fields and providing teachers and students with a powerful information and problem-solving tool. This chapter begins with a synopsis of the most common ways in which computers are currently used in subject fields. The second half provides information about how computers are currently used, and in some cases how they may be used in the future, in the following subject areas:

- art
- business and office education
- foreign languages
- home economics
- industrial arts
- language arts
- library media uses
- mathematics
- music
- physical education
- science
- social studies

How computers can be used

Consideration of computer applications in teaching and learning in subject areas must focus primarily on software. Since computers require software, the ways in which they are used is a function of the software available.

Based on the instructional objectives, several general types of educational software may be distinguished. Henry F. Olds, Jr. has outlined a useful descriptive categorization of software types while noting, ". . . in reality the distinctions get a bit fuzzy at the boundaries."[20]

I. Computer as Instructional Medium (CAI)

A. Drill and Practice – the use of the computer to evoke continued and improved performance in some well-specified skill or knowledge domain. The computer can provide potentially limitless practice exercises and immediate feedback to the user. Effective applications of drill and practice software have been made in math number facts, spelling, foreign language vocabulary, typing, etc.

B. Tutorials – the use of the computer to teach some subject matter directly. At their best, some tutorials use the computer to respond to the user by adjusting both the feedback and the continuing instruction to the user's growing understanding (a process known as branching). A fast learner moves quickly through the material, while a slow learner is given several alternative opportunities to learn. As with drill and practice, tutorials tend to be most effective when the content being taught can be very clearly specified. They also work best when a high level of motivation can be assumed on the part of the user.

II. Computer as Modeling Device

A. Games – the use of the computer to model an interactive environment in which the user is required to outmaneuver, outthink, or outwit other users or the computer. Games challenge the user to reach a full enough understanding of their structure to master playing them. Thus, they may engage and help to develop a wide range of problem-solving skills. Though game elements are frequently used to enliven drill and practice or tutorials, pure games rarely teach directly.

B. Simulations – the use of the computer to model some aspect of reality or some set of real conditions so as to make the reality more amenable to manipulation and study. Simulations may cover a wide range of phenomena, from planetary motion to airplane flight to presidential elections to the battle of Gettysburg. They encourage the user to come to understand the rules that are at play in the model of reality that has been constructed. In theory, an understanding of the simplified model can lead to a better understanding of the more complex reality. Like pure games, simulations rarely teach anything in particular, but they encourage problem solving and frequently stimulate many other kinds of learning.

III. Computer as Tool

A. **Special purpose tool** – the use of the computer to carry out a specific, narrowly defined task, usually a significant task that is frequently repeated. Tool programs of this kind are now beginning to proliferate because of their value in specific applications. For example, there are now numerous spelling programs which, working together with a word processor (a general purpose tool) will check any piece of writing for spelling mistakes.

B. **General purpose tool** – the use of the computer to assist people in carrying out a range of tasks within some general application area. Since the task is not specified ahead of time, it is up to the user to determine what is to be done and then to adapt the tool program to carry out that task. The power of general purpose tools is that the user may repeatedly adapt and readapt them in virtually limitless ways for a multitude of purposes, thereby creating a kit of special purpose tools. Several types of programs fall into this category: word processors, data-base managers, spread sheet programs, graphics utilities, music utilities, etc.

C. **Tool making tool** – the use of the computer to create new tools of either a special or general purpose. Some programs are so broadly general in their scope that they have no immediate use except to create tools. All computer languages serve this function. In addition, there are more and more programs becoming available that are designed specifically to help people design useful tools without having to learn a computer language or become a sophisticated programmer.[21]

At this time, not every category of software is available for each of the subject areas listed above. The types generally available for each are noted in the sections on the subject areas which follow below. It is also important to recognize that the quality of existing software varies greatly. For this reason, the importance of exercising care in selecting education software cannot be overemphasized. Although Chapter 7 features a discussion of software evaluation, the topic merits brief discussion in this chapter also.

Quality of software

Because the use of computers in teaching is new and software developers have not, until recently, given educational software a high priority, the quality of educational software available today is uneven; there is room for improvement. Many of the programs on the market today are little more than traditional workbooks presented on a computer monitor. Using the computer as a page-turning device is a misguided, and expensive, application of technology. Drill and practice type programs are also widely available and while this type of software has legitimate uses – it has, for example, been successfully used in remedial education applications – its advantages are not as promising as those of other types of software. Simulations, for example, have greater potential for substantively improving the quality of instruction and learning. Tutorial programs can present concepts in a variety of learning modes and offer pacing suitable to individual students' needs. Most exciting are the possibilities for fully utilizing the interactive capabilities of computers for the individualization of instruction and combining the computer with other new instructional technologies such as interactive video disks.

Computer use in subject areas

Table 7 illustrates some possible instructional uses of the computer in the elementary/middle school program by grade level within subject areas. Table 8 illustrates specific examples of instructional uses within specific curriculum areas.

The greatest impact of computers on education is likely to result, not from the study of computers, but rather from the application of computers in other subjects.

The sections which follow describe ways in which computers are currently used in subject areas. The illustrations are not exhaustive and are intended to serve only as an initial reference. The Connecticut school districts listed at the end of each example are implementing the programs described and may be contacted for further information.

ART

In art the computer can be used both as a tool for teaching traditional arts concepts – color theory and composition, for example – and also as a medium. In fact, the use of the computer as an artistic medium may, in the long term, be the primary use of the computer in art education.

As a medium, the computer with peripheral graphics equipment can spark creativity and encourage experimentation. Computer graphics can be art works and can also be used as a step in producing art in other media. A computer can be used, for example, to plan patterns for weaving projects or to do sketches for an oil painting. One important consideration in using computers in art education is that teachers must carefully plan class time so that the equipment can be shared in order to give all students sufficient hands-on experience.

Windham Public Schools
Willimantic, CT

West Hartford Public Schools

Table 7
Uses of Computer in Subject Areas

Elementary/Middle School

K	1	2	3	4	5	6	7	8

Drill and Practice
- Mathematics ——— Library Skills →
- Reading →
- Language Arts →
- Music →
- Art →

Simulation
- Historical, Economic →
- Political →
- Science and Environmental

Tutorial
- General Skills →
- Language Arts →
- Mathematics →
- Social Studies →
- Science →
- Health and Nutrition →
- Industrial Arts →
- Art →
- Safety →
- Music →

Word Processing
- Keyboarding →
- Beginning Writing Composition →
- Creative Writing →
- School Newspaper →

Data Bases
- Simple Visicalc-Type Programs
- Historical and Scientific Data Bases
- Local Information

Tool
- **Problem Solving**
- **Calculation**
- Spreadsheet Math →
- Music Composition →

BUSINESS AND OFFICE EDUCATION

In many school systems business and office educators were among the first to use computers in the classroom and are strong advocates of computer literacy. The reason is easy to see: because the purpose of business and office education is to prepare students for employment, students must learn about the computers they are virtually certain to encounter when they are employed. In many business and office education classrooms, computers are replacing typewriters for keyboarding instruction and many students are learning word processing. In addition to word processing, business students are taught how to use other types of software such as spread sheets electronic mail, information management, general ledger, ac-

Table 8
Uses of Computer in Subject Areas

High School

	Drill and Practice	Simulation	Tutorial	Word Processing	Data Bases	Tool Problem Solving Calculation	Inter-facing
Arts	Music	Simulation of instruments	Music – History Rhythm Pitch Art	Musical notation processing	Music Inventory	Music Digital Synthesizers	
Business	Accounting	Accounting Basic Business	Language Arts Math	Typing Office Procedures Business English	Accounting Data Processing Office Practice		
Foreign Language	Vocabulary Practice	Use of written language in games, other simulated situations	Various Instrumental Schemes				
Health and Safety		Nutrition	Various aspects		Records		
Home Economics	Theory and Content	Content Areas	All Content Areas		Nutrition and Growth	Nutrition Analysis	
Industrial Arts		CADD, CAM, CNC Photo-typesetting	Tool Use	Photo-typesetting		CADD, CAM, CDC Microprocessing Analog	

counts receivable and payable, and other types of programs. A small number of business education programs also offer instruction in programming languages such as BASIC and FORTRAN and/or COBAL which are widely used in business.

Danbury Public Schools

Enfield Public Schools

Regional School District No. 8
Hebron, CT

	Drill and Practice	Simulation	Tutorial	Word Processing	Data Bases	Tool Problem Solving Calculation	Inter-facing
Language Arts	Skill Review Grammar		Literature	Writing Process Journalism	Research		
Library Media	Library Media Skills				Searches		
Mathematics	Math Review	Trig Functions Graphing	Math Concepts			Electronic Spreadsheet Number Cruncher	
Physical Education	Game Rules	Games			Records Scores	Movement Analysis	
Science		Biology Genetics	Physics Biology Chemistry		General Data Base Programs	Laboratory Analysis	Laboratory Analysis
Social Studies	Skill Review	Historic Political Economic Events		Research Papers	History Data Bases	Quantitative Methods in History	

FOREIGN LANGUAGES

Foreign language educators are excited, if nonetheless somewhat cautious, about the computer. At present, some public school foreign language programs take an aural-oral, listening and speaking, approach to instruction, with reading and writing the language a secondary goal. In this case, many of the current uses of the computer do not yet match the primary instructional goals. Speech synthesizers available on most computers do not have the capability to accurately reproduce proper accents and inflections; therefore, they are not truly useful for improving listening and speaking skills. Computers can, however, prove extremely useful in other aspects of foreign language instruction.

According to the State Department of Education's *A Guide to Curriculum Development in Foreign Languages:*

> Because of its capacity to interact, the computer promises even more than the traditional language lab. The microcomputer can be programmed to facilitate simulation of any aspect of foreign behavior. It can provide appropriate cues, environmental details and confirmation to assist learners. Games which are already on the market can be adapted for instruction which will provide students with practice that is fun to do.
>
> Most uses of computer-assisted instruction are (in post-secondary education) at the basic language course level and deal with grammar and vocabulary, ranging from simple substitution tasks to exercises in morphology and syntax. Drills are not tedious because of the instant feedback and rapid progress. Users avoid monotonous translation drills, and all agree that students learn more in a shorter time than in the regular courses. Of all the languages, Latin studies have best capitalized on the potential of computer assistance, using it at all levels and including courses in mythology, with objectives in reading for content.
>
> The computer's effectiveness in self-paced learning has resulted in many programs that are completely independent of any course format or textbook. Most language departments use the machine as a supplementary aid on a volunteer basis in traditionally structured courses.[22]

Fairfield Preparatory School — North Haven Public Schools

HOME ECONOMICS

Some home economics classes at middle/junior and high school levels use computers as an aid to instruction, and to prepare students to use computers at home or work when they leave school.

In family and human relations courses, "computers in the home" is a study topic and students learn about the potential uses of home computers. Consumer education courses may include instruction about computer use in personal finance, as an investment tool, and as an aid in comparative shopping. Home economics teachers in one school, for example, developed a program which calculated how much paint would be needed to paint rooms or houses of any size. Child development classes utilize the computer in assessing developmental levels of children in the play school. There are also simulation programs for a variety of home economics topics such as child care, nutrition, home safety, and coping with stress.

Food service courses in vocational home economics education programs teach students how to use computers in the food service industry. Students learn how employment-related tasks such as cost control, inventory, ordering and purchasing, as well as employee scheduling and payroll which are now done with computers in many restaurants and food service facilities.

Danbury Public Schools

Fairfield Public Schools

Manchester Public Schools

Wallingford Public Schools

INDUSTRIAL ARTS

Industrial arts programs grades 7-12 are making use of computers in the areas of computer-aided drafting and design (CADD), computer-aided manufacturing (CAM) and in computerized numerically controlled machines (CNC). Milling machines, lathes, offset printing presses and phototypesetting equipment are examples of CNC uses. Computer-aided portable electric tools are becomming standard equipment for industrial arts programs. In some high school electronic shops, the study of the microprocessor, with emphasis on maintenance and service, provides students with marketable entry-level skills. The acquisition of hardware and applications for existing and new areas is increasing at a rapid pace.

CADD

Regional School District No. 7
Winsted, CT

Windsor Public Schools

CAM

North Haven Public Schools

Putnam Public Schools

CNC

Enfield Public Schools

Glastonbury Public Schools

Phototypesetting

Derby Public Schools

Groton Public Schools

Microprocesser

Bethel Public Schools

Bridgeport Public Schools

LANGUAGE ARTS

Language arts educators believe the computer can have a dramatic impact on teaching language arts skills. The computer is used in language arts classes to teach basic skills such as spelling and grammar with drill and practice programs; other programs are aimed at improving reading comprehension including skills such as identifying the main point, seeing characterization, and making inferences and evaluations. The computer is also used as a tool in diagnostic assessment of student proficiency in basic skills. At the high school level, programs for the Scholastic Aptitude Test (SAT) are used in some schools and the computer is used to access information sources for research papers and reports.

Perhaps the most exciting use of the computer in language arts instruction, however, is its use in word processing. When students have access to word-processing software and computers, it is easier for teachers to emphasize the process of writing – that is the importance of conceptualization, thinking and rewriting – as well as the mechanics of grammar, capitalization and punctuation. This is possible because students are excited about writing on computers and word-processing software facilitates editing and rewriting. Students in even the earliest elementary grades have shown remarkable progress in writing, sometimes as a group effort, on a computer.

Bristol Public Schools

Orange Public Schools

Hartford Public Schools

Ridgefield Public Schools

LIBRARY MEDIA

Because the library media center is an important resource supporting all instructional areas of the curriculum, computer use in library media centers is a major application of computers in the schools.

When computers were first introduced in schools, the library media center was sometimes the location for all, or a majority, of the school's computers. Today, however, computers in library media centers are primarily for library media uses and for student use as a library research tool. Many library media specialists use computers for management/administration (e.g., automated cataloging and circulation, networked circulation, scheduling, etc.) and also to teach students about library skills.

Another significant computer capability is providing access to national data bases and other information resources. Although none of the major national data bases is truly appropriate for students at the K-8 level, high school students can learn to use, or have library media specialists use for them, data bases such as the SOURCE and BRS. National studies have shown that students who have access to data bases use more primary source materials such as periodicals and government reports in school assignments.

On a regional level, microcomputers may be used to access library networks, making available to students information on resources housed in the region's public, academic and special libraries.

Greenwich Public Schools

Simsbury Public Schools

Hamden Public Schools

MATHEMATICS

Until relatively recently, the study of computers was commonly the responsibility of the mathematics department. However, with new definitions of computer literacy and a broad array of available software, there has been increased differentiation between computers and mathematics. While the teaching of many computer literacy topics, including programming, remains linked to mathematics, more and more schools are spreading computer use and instruction across the entire school curriculum. This leaves the computer as an excellent vehicle to enhance ongoing mathematics instruction.

The increased availability of good software provides opportunities for drill and practice of basic skills, and, when employed as a component of remedial instruction, can help students to grasp fundamental concepts. Simulations, games, problem-solving software and experiences with LOGO can also improve the quality of mathematics instruction.

As noted in *A Guide to Curriculum Development in Algebra I, Geometry and Algebra II*, the computer:

> . . . has broad potential to improve both instruction and learning. At its least creative level, the computer, and readily available software, serves the need for drill and practice and/or individualized tutorial work. The computer's ability to consistently provide instantaneous, nonjudgmental feedback to students makes it an especiallu valuable motivator.
>
> At the next level, the classroom computer can serve as an electronic blackboard when, for example, a variety of functions is plotted and compared. Concepts such as slope, divergence, inverse relations, complex numbers, and the nature of exponential trigonometric functions are significantly enhanced with computer-assisted teaching.
>
> At the programming level, the computer provides an excellent opportunity for using problem-solving techniques and logical thinking. Formulating algorithms to solve problems requires and reinforces a full mathematical understanding of the topic and is akin to having each student teach the material to someone else.[23]

It is clear that the computer will have even greater impact than the calculator in mathematics curriculum. Like the calculator, but with far more power, the computer can extend the capability of doing realistic problem solving, provide motivation, and offer access to mathematical ideas not available without it. Moreover, it can extend the range of conceptual understanding by facilitating the mechanics of arithmetic computation and the manipulation of algebraic expressions.

Bristol Public Schools

Stamford Public Schools

Monroe Public Schools

Wilton Public Schools

Ridgefield Public Schools

MUSIC

Music educators believe that computers are an important resource. Some departments have their own computers and others share them with other departments. Among the common uses of computers in music departments are:

Drill and practice. Drill and practice programs constitute the bulk of music software on the market today. These programs typically involve ear training, notation and theory topics. While early programs were relatively primitive, newer ones offer instructional branching, feedback and other capabilities for individualization.

Computer as instrument. Digital synthesizers provide the capability for composition and performance of a wide variety of music. Performance synthesizers have become a familiar and frequently used adjunct to performing groups in school music programs.

New London Public Schools

West Hartford Public Schools

PHYSICAL EDUCATION

The most common use of the computer in physical education is for teacher management activities such as scheduling activities and personnel, keeping track of participation, calculating and storing statistics and developing data banks for physical fitness assessment. There is also some instructional use such as use of drill and practice software for concept learning. As more software becomes available, teachers will undoubtedly make greater use of computers.

A more exciting use combines computer and video technologies for movement analysis to enhance the study of biomechanics, a scientific basis for physical education. Although this use is becoming widespread in higher education, Olympic training and professional sports, the expensive equipment at present limits its use in public schools.

Brookfield Public Schools

North Stonington Public Schools

SCIENCE

Science teachers at all grade levels generally use computers in three ways to enhance instruction.

Classroom management. Computers are useful for keeping science inventories, test information, problems for use on tests and for homework, laboratory activities, and so on. They can also be used to develop pictorial information (such as leaf or animal organ construction) to assist in instruction.

Computer-assisted instruction. Computers are used to assist instruction from simple drill and practice programs (for example, developing graphs of plant growth in the second grade) to relatively sophisticated simulations of various phenomena in physics (the Millikan Oil Drop experiment or constructive and destructive interference of waves for example).

Recorder of information from laboratory activities and as a data reducer. With interfaces, computers can be used to record data from laboratory activities. Used in this manner, they can record temperatures, voltages, pressures, velocities and a host of other phenomena.

Once the data are recorded, the computer can use them to develop tables, graphs or charts to help describe what has taken place in the laboratory activity.

Norwalk Public Schools

Greenwich Public Schools

Canterbury School
New Milford, CT

SOCIAL STUDIES

Computers are influencing social studies education in a number of ways. First, consideration of the impact of computers on society, social, economic and ethical implications, is an appropriate topic for study in social studies classes. Second, computers provide access to a wide variety of data bases and information sources which were previously unavailable to students. Finally, there is software which can aid teaching and learning about many traditional social studies topics. In the study of geography, for example, computers can show three-dimensional maps to increase students' understanding of cartography. There are also drill and practice programs and a significant number of simulations. Many social studies educators are impressed with the latter. One simulation, for example, allows the recreation of any presidential election from 1960 to 1984 to create scenarios of running for office; another requires students to "navigate" ancient ships using sun, stars, ocean depth, climate and trade winds.

East Lyme Public Schools

Regional School District No. 13
Durham, CT

6 Strategies for Implementation

Planning is the key to the successful introduction of a computer literacy curriculum and of computer use in subject areas. There are many ways to implement new programs and the approach selected by any district must be based on careful analysis of local goals, current curriculum and allocation of resources. In many districts, it may not be possible to implement all new objectives at once and a sequential, phase-in approach will be required.

Implementing a computer literacy curriculum

Implementing a computer literacy curriculum involves several steps. The first is to decide which teachers will be responsible for teaching the topics identified as curriculum objectives. Then, once the decision about instruction has been made, it is necessary to determine how the new subject matter will be integrated into the existing curriculum.

Assigning instructional responsibility. Determining which teachers will be assigned to teach the computer literacy curriculum in which subjects will depend on a number of factors including district enrollment, number of schools, interest of teachers, and financial resources. Connecticut school districts with computer literacy curricula have followed one of two general approaches. Either computer literacy is taught as a separate subject, or computer literacy topics are integrated into the teaching of other subjects.

No matter which approach is used, it must be recognized that computer literacy is an "add on" to the existing curriculum and because the hours of the school day are prescribed, it is not possible to add or integrate computer literacy without concomitantly subtracting or condensing in some areas.

Schools which teach computer literacy as a separate subject commonly employ computer specialists to teach most computer-related topics. The advantages of this approach include a decreased need for staff training and greater accountability for student learning. Disadvantages include less total staff involvement with computer literacy and isolating computer skills from other subjects in the minds of students. This separate approach may be especially attractive to larger school districts where the number of teachers to be trained is large and in districts where potentially higher costs for an integrated approach may be prohibitive.

An integrated approach adds computer literacy topics in existing subjects and classes, most frequently in mathematics and English, although social studies and science classes may also be responsible for teaching about some topics. The following "instructional design" for the "computer awareness" curriculum in the East Lyme school system demonstrates one district's plan for integrating computer literacy in a K-12 curriculum:

> Kindergarten through grade 3 students will receive three hours of instructional time in computer awareness. Fourth and fifth grade students will receive five hours of instructional time. At the junior high school level, five hours of computer awareness instructional time have been placed in three of the major disciplines: language arts, social studies and science. The high school level will allot five hours of instructional time in computer awareness in Earth Science, English II, Modern American History, and English IV in grades 9, 10, 11 and 12 respectively.[25]

As with almost all aspects of computer literacy instruction, there is nothing inherently superior or more effective in either instructional approach. The choice for any district will, as noted, depend on philosophy as well as practical considerations such as number of teachers to be trained, teacher interest, and the district's ability to acquire equipment. In some cases, the latter considerations may override philosophical considerations, but no district should choose a separate subject approach simply because the logistics of implementing an integrated curriculum are more complex. It is also possible to develop interim strategies as a practical way to implement an integrated instructional approach.

Introducing computer literacy. The difficulty, or ease, of introducing computer literacy instruction into the existing curriculum will depend on factors such as assignment of teaching responsibility and grade sequencing. Obviously it is easier to arrange for one computer literacy course for the eighth grade than to establish a K-12 curriculum using an integrated approach to instruction.

If a district wishes to adopt an integrated curriculum, there is greater complexity and potentially greater costs involved in staff training and in hardware and software selection and acquisition. These problems, however, are not, insurmountable. In small districts it may be possible to train all teachers at once and to purchase sufficient hardware and software, but in larger districts it may be necessary to develop an incremental approach. For example, while it is theoretically possible to start instruction at kindergarten and work up adding a grade a year, training more teachers and adding more equipment, such a plan is impractical since in reality it would require 12 years to fully implement a K-12 curriculum. A more practical strategy would be to begin instruction in the middle grades, training middle/junior high school teachers first and modifying the curriculum and scope and sequence as appropriate. In the following years instruction could be expanded by training teachers from upper and lower grades and adjusting the curriculum scope and sequence. At the same time some districts could offer full-year or half-year courses at the high school level so that, until the curriculum spans K-12, all graduates will have an opportunity for computer literacy instruction although it may be somewhat condensed and taught at a more rapid pace.

An additional consideration in developing an implementation strategy is whether or not to pilot test the introduction of computer literacy instruction in a small number of classes or schools. While pilot testing is a useful, cost-efficient means of assessing the effectiveness of plans before a large-scale commitment is made, there may be some potentially negative consequences. Potential disadvantages include the tendency of those involved in the pilot to become committed to the new program and to resist subsequent revisions. Also, unless the students involved in pilot tests are representative of the district's overall enrollment, results of the testing may be skewed and the results invalid. By carefully selecting pilot populations and making it clear to the teachers involved that changes in program content may be forthcoming, it is possible to avoid problems. Districts considering a pilot program should carefully consider all potential consequences before a pilot program is initiated.

Implementing computer use in subject areas

Implementing computer use in other subjects is relatively easier than starting a computer literacy curriculum, but it does require planning. Some of the factors influencing the use of computers in implementing a computer literacy curriculum also apply to subject area implementation.

The difficulty, or ease, of introducing computer literacy instruction into the existing curriculum will depend on factors such as assignment of teaching responsibility and grade sequencing.

Important factors are teacher interest and need. (And, it should be noted, teacher interest and perceived need is often a direct outgrowth of relevant experience with computers and in-service training.) In some districts, the use of computers in some classes predates formal district-wide planning for computers. The high school mathematics department, or some elementary school teachers, may already be using computers. If this is the case, a sensible approach may be first to expand the number of existing users. The colleagues of teachers who are successfully using computers are more likely to be receptive to learning how to incorporate the new instructional resources.

Because teachers will require training, ability to accomplish the training needed is another factor which should be considered in deciding how to start using computers in subject areas. If, for example, there are many more language arts teachers than social studies or science teachers, the most manageable plan might be to train teachers a grade level at a time.

The key point in beginning the use of computers in subject areas is to develop a district-wide plan which takes into account factors such as these discussed above. Without leadership, districts are likely to find significant differences in the use of computers among subject areas, and from school to school. Differences can mean inequity.

Placement of equipment

The deployment of computer equipment is also a factor in implementation. Decisions about where to put computers in schools should be based primarily on intended instructional uses and the desire to ensure maximum use. Other considerations which must be addressed include cost and staff training.

There are a number of ways to place computers in schools:

- one or more computers in every (or nearly every) classroom;
- all the school's computers in a single location (computer lab and/or library media center);
- a number of mobile units, and
- a combination of the above, with a central location and computers in classrooms and/or mobil units.

The choice in any school should reflect instructional objectives and teacher input. If computer literacy will be taught as an individual subject at the middle/junior high school level, establishing a computer lab where the computer specialist teaches may be a sensible and cost-effective approach. Subject area teachers could schedule class time in the lab when they wanted to use computers for instruction. If, on the other hand, plans call for an integrated approach to teaching computer literacy and if classroom or subject area teachers plan extensive daily use of computers, computers in classrooms may be the best choice.

The number of computers the district is able to purchase will also influence the placement. In some districts the ideal may be to have one or more computers in every classroom, but budget constraints may require mobile units which might be added to each year until there were sufficient computers for all classes.

Implementing computer use with special populations

An important use of the computer is to facilitate learning for students with special needs. The computer provides students with physical handicaps, such as cerebral palsy, deafness and blindness, a new effective means of communications. Adaptations in hardware – braille keyboards, voice synthesizers, light pens and touch pads – and software make it possible for physically handicapped students to use the computer. More software designed for special students is being developed. Computers not only help students with special needs to learn; they also foster a psychological sense of accomplishment and enhance self-worth. The computer recognizes no handicap so the handicapped student can compete with peers on an equal basis.

Special education. For special education students computers are used, usually on a one-to-one basis, for drill and practice, tutorial programs and, more commonly, word processing. It is an ideal tool for the generating of individual education prescriptions.

Educationally disadvantaged. The computer's potential for individualization of instruction, the nonthreatening environment it creates and the motivation it can engender make it a useful tool for remedial instruction. Good drill and practice programs can be very successful in working with remedial students.

Bilingual. Software programs, in both a drill and practice and tutorial mode, are available for teaching basic skills in the student's native language. Other programs help teach English to speakers of other languages. The computer can individualize the instruction, motivate the student and provide the necessary friendly environment.

7 Resources for Implementation

The resources required to implement, or expand, instructional uses of computers include:

software	personnel
hardware	budget

The specific configuration of resources required in any district will, of course, depend on curriculum goals and objectives, implementation plans and other district priorities.

This chapter provides suggestions about how to select hardware and software and train personnel. It should be noted that to explain the operation of a microcomputer, its component parts and peripheral equipment, or to evaluate specific computers, is beyond the scope of this guide; the focus here is on the process of selection. Similarly, to provide an exhaustive inventory of software is impossible (new programs appear on the market daily); the focus here is on criteria for evaluating software. Helpful books and other publications on the subject of computers and educational software are listed in the bibliography.

SOFTWARE

Through computer literacy education, students should learn the difference between hardware and software, and come to understand that a computer is an inanimate object until it is activated and provided with instructions (programs) by a human being. Without instructions or programming, a computer is useless but, with appropriate programming, it has virtually limitless uses. This concept is also a key in planning for the instructional uses of computers. Successful utilization of computers requires good software.

This chapter identifies sources of educational software and discusses the evaluation of educational software as well as other considerations which may influence software selection.

Sources

Sources of educational software range from teacher-designed programs to complete computer-based curricula developed by major textbook publishers. (The quality of software available also ranges along a wide spectrum and quality issues are discussed in the section on evaluation which follows.) Because more and more educational software is being developed by a variety of sources, the difficulty of simply identifying all the software currently available has increased, in geometric proportions, in recent years. The need for information has led to an increasing number of sources of information about software; some are more helpful than others. *The International Micro-Computer Software Directory*, for example, is extremely comprehensive, listing all programs available, but its very scope renders it impractical for easy use. There are other sources, however, which specialize in educational software. These include:

Data bases and networks. A number of national, regional and local organizations have developed listings of educational software. Some of these, such as the Minnesota Educational Computer Consortium (MECC), also provide evaluation and/or actual programs.

Educational and computer publications. There are a number of periodicals which focus on the instructional uses of computers. *Electronic Learning*, *T.H.E. Journal*, *Classroom Computer News*, and *Computer Teacher* are just a few examples. General audience computer magazines such as *BYTE* and *Creative Computing* also provide some reviews of educational software. Educational journals (for various disciplines such as *Arithmetic Teacher* and for teachers in general such as *Learning)* are beginning to feature articles about computer applications and educational software.

Commercial publishers. Traditional textbook companies as well as newer companies specializing in educational software provide listings of current offerings.

Evaluation

Because the quality of educational software varies considerably, ranging from virtually useless to excellent, school districts and individual teachers must exercise great care in selecting software. Fortunately, the evaluation of traditional instructional materials is something teachers know a great deal about and can readily adapt, with some guidance and in-service training, to evaluation of software. The first, most important and easiest to answer question about any particular piece of software is: Is it compatible with the hardware available? Beyond this, evaluation becomes substantive and qualitative.

Olds has identified several characteristics of good quality software.

- It should be the outgrowth of a fully conceived and carefully articulated "intellectual model of the content domain" (e.g., good science software should represent the best current scientific understanding).
- It should reflect the cognitive developmental needs and capacities of the learner (e.g., younger children need more concrete representational experiences).
- Since the computer provides an environment for interaction, its best pedagogical use should support the inherently interactive nature of knowledge construction for the learner (e.g., the computer is a poor medium for giving a lecture).
- It should make use of the special qualities of computer technology in truly functional ways (e.g., use graphics to make an abstract concept concrete). It should not attempt to carry out instructional tasks better suited to other media (e.g., it should not be a textbook).[25]

Guidance in the selection of specific software programs is available from several evaluation projects. Two of the largest national evaluation projects are Microcomputer Software and Information for Teachers (MicroSIFT) and Educational Products Information Exchange (EPIE). Other sources of evaluations are publications such as *School Microwave Review* and *Courseware Report Card*. Descriptions of these, and other, software evaluation services with very complete reviews, and also samples of evaluation forms as well as an extensive resource listing and bibliography, are contained in *Evaluation of Educational Software: A Guide to Guides* published in 1983 by the Northeast Regional Exchange (every school district in Connecticut has received a copy of this publication).

As helpful as outside evaluations can be, they should be used with discretion. No school district or individual teacher should rely upon a secondhand evaluation to direct software purchase and use. The information provided by evaluation projects may be useful as an initial screen to weed out bad software, but the true meas ? of any program's quality and usefulness can only be made at the local level w... a hands-on evaluation.

To assist teachers with evaluation, local school districts should develop, adapt or adopt, evaluation mechanisms and software selection policies. Having clearly defined procedures and guidelines can provide necessary quality control and also reduce the likelihood of unwise purchases. Many useful, detailed suggestions for software selection guidelines are contained in the Northeast Regional Exchange publication noted above and also in the Pennsylvania Department of Education's *A Guide to Instructional Microcomputer Software* which has been reprinted by the Connecticut State Department of Education and distributed to all the state's school districts.

In addition to substantive quality, there are other factors which must be taken into account in software selection. These factors concern the compatibility of software and hardware.

Unfortunately, any particular software program will not run on every make or model of computer. Because this is true, ideally, hardware and software purchases should be closely coordinated, especially if software is to be used for a large number of classes. And even when software is compatible with the microcomputer, it is also necessary to determine if the software's input format, i.e., cassette, floppy disk or solid state cartridges, is compatible. While it is possible to purchase different input devices for most microcomputers, the expense involved can be considerable. The final factor that must be considered is the potential need for additional peripheral equipment and/or capabilities. The Pennsylvania Department of Education's guide includes the following list of peripheral equipment and/or capabilities which may be required for some software programs:

color monitor	printer
graphics tablet	special musical ability
joy sticks	speech synthesizer

HARDWARE

Although the variety of brands and models of microcomputers available today can make hardware selection somewhat confusing, it means there is wide selection. Competition among manufacturers frequently benefits buyers. In addition, recent product development activities in the computer industry have resulted in advantageous product similarity.

Selecting the right hardware for both computer literacy and computer applications in other subject areas should be guided by the principle of keeping the ultimate uses and implementation plans in sharp focus. Also, depending upon short-term and long-term plans, it is advisable to look for systems with sufficient flexibility/expandability to accommodate new uses/applications in the future (keeping in mind that the estimated useful life of a microcomputer in a school is three to five years). In short, technology should match instructional needs. While price will be an important consideration in most districts, hardware should not be purchased based solely on price; other considerations such as reliability, service and software available may be more important.

The first task in the process of selecting hardware should be to determine specifications for the type(s) of computers needed. Specifications should be based on the capabilities needed to carry out the educational objectives identified in the curriculum scope and sequence, and for the applications identified for subject areas.

It is unlikely that one brand, or the same model, of computer will be the cost-effective choice for all projected uses. Analysis of projected uses may indicate, for example, that a relatively simple, low-cost computer is sufficient for teaching beginning computer literacy, while advanced programming courses may require more sophisticated, and costly, hardware. Conversely, it may be found that some uses and software may require more costly color monitors and graphics capabilities, while for others expensive machines will suffice. In addition to developing computer specifications, it is also necessary to determine what, if any, peripheral equipment will be needed to support intended uses.

At a minimum, for each category of use (e.g., elementary grades, computer literacy, applications in subject fields, higher level programming courses) the following types of requirements should be identified.

Element	**Considerations**
Cost	What is the total cost involved including all peripherals needed to operate the system? (computer, monitor, disk drive or cassette recorder, printer, power source, modem, etc.)
Flexibility	How much does it weigh? Can it be readily moved? Are special electrical outlets or proximity to telephone connections needed?
Mainframe Interface	Does the unit have the ability to interface with available mainframe computers to function as a smart terminal?
Keyboard Layout	Does the micro have a standard typewriter keyboard? Does it have a calculator layout? Is a standard keyboard and calculator layout necessary for your use?
Additional Ports	Are there sufficient ports to accommodate needed peripherals? Do these ports use memory?
Execution Time and Loading Speed	How fast can information be loaded into the unit? How long is the execution time?
Memory Capability	How much memory does the unit have? Is the available space sufficient for the intended use?
System Expansion	Can the system be expanded easily? What are the limits of the expansion? How easily can editing be done?

Element	Considerations
Editing	Can the unit identify specific program errors?
Input and Output Devices	What devices are available, e.g., cassette, disk, monitor, printer, plotter, graphics tablet, light pen, voice synthesizer?
Software	Are there sufficient programs available to suit the users' needs? Are outside companies producing programs for this unit? How easy is it to generate your own software?
Graphics/Characters	Is the unit capable of low or high resolution graphics? How many characters per line are available on the micro? How many lines on the CRT are visible? What is the screen size? Graphics tablet? Light pen?
Color	Is color necessary? If so, is a special monitor needed?
Voice Command and Voice Generation	Does the unit have voice synthesizers, and does it have or can it be adapted to accept voice commands?
Music Generation	Is there music capability? Does it have an internal speaker or separate speaker system for sound?
Servicing	What are the warranties available? What is the cost and availability of a service contract? How close is available service?
User Training	Will vendor provide on-site user training? How many hours will be provided? What is the cost involved?

Carefully documenting instructional uses and specifying equipment needed to support them can result in significant savings by avoiding the purchase of a more sophisticated computer than is needed. Another advantage of detailed specifications is that, when vendors are asked to submit proposals and bids, there is assurance that all responses are comparable.

Of course, as noted, price, even for comparable equipment, is not the only factor to consider. It is also necessary to consider factors such as:

- What have been the experiences of other school systems in using the computers? The vendor should be able to furnish references.
- Are there operation manuals for hardware, operating systems and languages? System documentation should be available and you should review it to determine its clarity and usefulness.
- Will the vendor provide support services? Ideally the vendor will install or set up the computers and provide staff training (and retraining as necessary) for operation, programming and maintenance.

- What are the provisions for maintenance and repair? Compare warranties, find out if service contracts are available, and compare the cost and terms of contracts.

Once specifications have been developed, proposals/bids should be solicited from as many vendors as possible. When responses are in and all the necessary information is at hand, it is possible to evaluate and compare the hardware as well as other factors such as support and service. A convenient, useful checklist format for evaluating hardware has been developed by the Pennsylvania Department of Education and is included in *A Guide to Microcomputers* which has been reprinted by the Connecticut State Department of Education and is available to all Connecticut school districts.

PERSONNEL

Teachers, as well as students, must become computer literate. The return on a school district's investment in computer hardware and software will be fully realized only if the instructional staff is able to utilize the new resources to improve the quality of instruction. In most cases this means teachers must be given the opportunity to learn to use the computer.

While schools of education are beginning to adopt computer education requirements in preservice teacher training, few graduates at present have adequate experience with computers and until they do schools must offer in-service programs. Carefully developed plans for staff training should be a key element in every district's plan for the instructional uses of computers. In addition, some teachers may wish to enroll in one or more courses offered by colleges, schools and professional organizations.

The goals of in-service training for any individual district will depend on instructional and implementation plans, that is, the curriculum scope and sequence, what is to be taught, by whom, and when. Thus, depending upon their teaching assignments, teachers will have different needs for in-service training and not all will require training at the same time. Those who teach computer literacy, for example, will need to know more than those who use computers in teaching other subjects. In-service programs may be established for a number of groups and offered on a repeat schedule. Teachers responsible for programming instruction will require more in-depth computer knowledge than can probably be taught . an in-service program and will have to take college-level computer courses.

No matter how a district chooses to identify groups of teachers to receive in-service education about computers, there are some common decisions which must be made. It is necessary to determine who will provide the instruction, what will be taught, and for how long. Each of these topics is discussed below.

Instructors

The person(s) chosen to conduct in-service computer instruction should be selected with care. The instructor should be sensitive to the needs of teachers, especially those who are "computerphobic," and capable of motivating teachers about the new vistas that are possible with the introduction of computers in the classroom. Of course, the instructors should be knowledgeable about computers and about education. They may be school district personnel from other school districts, or faculty from colleges or universities. It might also be possible to have someone from a local business or industry provide training, though if this option is selected it will be necessary to ensure that the person understands the role of the computer in education as well as the instructional uses of computers.

A computer is an inanimate object until it is activated and provided with instructions [programs] by a human being.

In-service education

The content of the in-service education will depend upon the instructional objectives defined in the curriculum. Those responsible for teaching computer literacy must be thoroughly conversant with the material which is to be taught. Teachers who will use computers as a tool in teaching in other subject areas will need to know how to operate computers and about specific software programs. In addition to in-service education for teachers who will have specific instructional assignments involving computers, it is advisable that all teachers be provided some introductory level in-service instruction – including the opportunity to operate a computer. Using a computer in an instructional setting is usually not sufficient time to allow teachers to become comfortable with the new technology. Teachers should be encouraged to take the computer home on weekends, vacations and during the summer. Bringing all teachers to an acceptable level of computer literacy is important because every teacher should know what children will be learning in computer literacy instruction. Also, basic instruction can provide a foundation for the eventual integration of computers in most classrooms. Similarly, all district administrative staff should be provided the opportunity, if not be required, to achieve computer literacy.

The Monroe Public Schools developed a K-12 computer literacy curriculum and identified staff development goals for three instructional grade levels—elementary, middle and high school. Staff development objectives at each level are linked to instructional goals and objectives and three levels of in-service training are offered. The first level is required for **all** teachers and consists of exploration of the following topics:

- the history and social impact of the computer revolution
- instruction in how to use the computer
- understanding the parts and functionality of the computer
- general maintenance and care of the computer
- training in typical uses of the computer in the classroom

- examination of typical CAI (computer-assisted instruction) and CMI (computer-managed instruction) materials for remediation, enrichment and developmental learning activities.[26]

The second level of training is offered on a voluntary basis and consists of an introduction to programming which is outlined as follows:

- programming activities with geometric emphasis using languages, such as LOGO
- programming activities in BASIC
- programming activities in Pascal
- instructional activities in word processing and CMI[27]

The third level of training consists of "sessions dealing with specified topics as dictated by staff interest and need. Some of this training should be in the form of local seminars to keep the professional staff up-to-date with the technology and its usefulness to educational programs."[28] As noted, any teacher can participate in these programs related to instructional objectives for middle school and high school teachers.

Duration. A single session is not sufficient for in-service computer training. Although many basic concepts can be introduced in a daylong seminar, most teachers (and administrators) will want, and need, a series of classes. The duration of training will depend on the content of the curriculum. For example, in-service education for teaching computer literacy would probably require more sessions than in-service for using the computer in subject areas.

Following the period of formal instruction, it is important to have a resource person on call to answer questions and assist with problems encountered by teachers who are putting their training into practice. In addition, in-service programs can be strengthened by asking participants to evaluate their experiences. Results should be reported and incorporated into planning for future programs. And finally, because computer technology is changing, districts should plan ongoing in-service programs to bring staff up-to-date with recent technological developments in the field.

BUDGET

To secure the funding necessary to support the instructional uses of computers requires development of a precise budget. Care should be taken to include all costs associated with new or expanded programs. Because computers are new for many districts, it is easy to overlook some costs. In addition to fairly obvious expenses for hardware (microcomputers and peripheral equipment), software, personnel and staff training, it is also necessary to budget for items such as supplies (disks are more expensive than paper and pencils), furniture, increased insurance, and service contracts or repair work.

The process of developing the budget should include efforts to identify the most cost-effective means of achieving any given end. There are, for example, a number of ways to provide the equipment maintenance item and each has a different price tag. The district can purchase a service contract from a dealer (for only some, or for all, hardware), or repairs can be paid for on the basis of time and materials; in either case savings may be realized if the district agrees to deliver the equipment rather than having on-site service. Some districts have elected to have a media equipment technician do a substantial amount of maintenance and/or repair work. The costs of each approach must be identified and weighed. Bulk purchasing, or group purchasing in cooperation with other districts are also examples of ways to save which should be considered.

When developing the budget, it is also a good idea to establish alternatives and priorities so that if the level of funding sought is not realized the funds available will be spent on priority items.

Because the costs of widespread computer use in schools can be substantial, gaining necessary funding may require creative and diligent effort. But even in times of tight budgets, experience has demonstrated that when a district has made a strong commitment to computer education funding can usually be secured. Table 9 indicates sources of funding for computers for Connecticut school districts that responded to a 1983 State Department of Education survey.

Table 9
Funding of Computers for Instruction In Connecticut Public Schools, 1983

Source of Funding for Hardware and Software	Number of Districts
Local only	19
Vocational Education only	2
Special Education only	1
PTA/Service Clubs only	1
Chapter II only	4
Local and Chapter II	16
Local and Vocational Education	20
Local and Service Clubs/PTA	5
Local, Chapter II and Vocational Education	21
Local, Chapter II and PTA/Service Clubs	6
Local, Chapter II and Special Education	7
Local, Chapter II and Vocational Education, PTA/Service Clubs	9
Local, Chapter II and Vocational Education, Special Education, PTA/Service Clubs	4
*Other	17

*Six districts report some business and industry funding and eleven districts use some Chapter I funding.

Source: Connecticut State Department of Education
Instructional Uses of Computers in Connecticut Public Schools (Survey, 1983)

As shown in Table 9, a majority of school districts obtain substantial, if not total, financial support for computers from the regular school district budget. Securing funding for computers is most likely when there is widespread and strong support for the new programs. The soundness of the planning process, as well as broad participation, can bolster support. To supplement local funding, some districts have used federal or state aid programs for remediation, special, vocational and bilingual education to purchase computers or support staff. Because the availability of state and federal funds varies from year to year, many districts have central office administrative staff monitor the *Federal Register, Commerce Business Daily* and similar sources to identify grants and other programs for which the district may be eligible. The person monitoring grants should be informed of resources needed.

Other sources of financial support, in-kind services, and equipment are local business and industry and computer hardware and software manufacturers. Although these sources may occasionally approach a district with an offer of assistance, more often donations result from a well-documented request from the district.

8 Evaluation

Because teaching about computers and their use in education is new and still largely untested, evaluation is critical. No matter how carefully new programs are planned, they are likely to require modification and necessary changes are identified through evaluation.

Evaluation is a highly refined science. It is not within the scope of this guide to detail techniques for evaluating computer literacy education and other instructional uses of computers. The purpose of this brief chapter is to highlight a few key considerations concerning evaluation.

The instructional uses of computers must be evaluated from two perspectives, both of which are discussed in this chapter. The first is evaluation of student learning, the second, program evaluation.

Evaluation of student learning

Evaluation of student learning measures whether or not students are mastering subject matter. This process is facilitated when program, instructional and learning objectives are written, as recommended, in terms of pupil performance.

The computer literacy subcommittee and the subject area teachers should be involved in the selection of evaluation instruments for their respective curricula. In addition, districts with personnel in charge of evaluation should also involve these individuals in devising evaluation instruments. Most testing methods – standardized and teacher-made tests, grades, student products, observations of

The instructional uses of computers must be evaluated from two perspectives: evaluation of student learning and program evaluation.

student performance, and inventories and skills continuums, for example – are suitable for evaluating student performance in a computer literacy curriculum. Teachers who are using computers in other subjects can similarly use standard testing methods to determine whether computer-assisted instruction is successful.

Assessing content mastery

Many basic computer literacy skills are best assessed by observation, by watching the student's ability to turn on the computer, input a piece of software, execute the program successfully, terminate the program and shut off the computer. Multiple-choice questions seem to be the most prevalent method of measuring student knowledge of the computer and computer programming. The following include questions to test knowledge in these areas:

Connecticut Assessment of Educational Progress (CAEP) in Language Arts, Grades 4, 8 and 11
Department of Defense Dependent Schools, *Computer Literacy Tests*, Grades 4 and 7
Computer Science Examination, Manchester Public Schools
Micro Computer Course, Grades 8-9 Practice Exercises

Although there is little formal research to document the relationship between computer use and student achievement in subject areas, the question is being addressed and research findings will be forthcoming. A pioneer activity in this area has been the federally funded Chapter 2 (formerly Title IV) project funded in Bristol, Connecticut. In this project, 9th grade students who had not passed the state proficiency test of basic skills were divided into two groups, a control group and an experimental group. The control group was provided traditional remedial instruction in reading, mathematics and language arts while the experimental group was provided computer-assisted remedial instruction in the same three areas. Improvement, as measured by a retest of basic skills in all three areas, was far greater for the experimental, computer-using group.

Program evaluation

Assessment of student learning is an important, but not the only, component of program evaluation. The purpose of program evaluation is to make judgment about program validity and effectiveness. It concerns content and outcomes, involving questions such as: Is the scope and sequence of the curriculum still appropriate? Are objectives addressed at appropriate grade levels? Are all topics still relevant? And are computers being used effectively and efficiently to reach desired instructional outcomes?

Program evaluation should be based on a variety of types of information gathered from a variety of sources. In addition to objective measures such as student learning and progress in implementation, subjective measures such as opinion surveys may also be employed. Opinions about a computer literacy curriculum and computer use in other subjects may be solicited from teachers, parents, school administrators and business people in the community.

Much valuable information can be gained from each of these groups. Teachers, for example, can identify segments of the curriculum in need of revision because students either consistently fail to master the subject matter, or are competent before instruction begins. Parents may report student dissatisfactions heard in the home as well as positive reactions. Administrators might identify problems with current methods of deploying computers – perhaps, for example, noting that hardware breakdowns exceed norms because computers are moved from classroom to classroom – or indicate that current budgets are not adequate to supply all the software teachers request. Business people from the community are in a position to offer opinions about the adequacy of training aimed at providing students with immediate employability skills, the training of word-processing skills in business education, for example, to meet the actual needs of the workplace.

All plans for program or process evaluation should define to whom results will be reported and establish procedures for modifying curriculum if the need to do so is identified. As noted in Figure 2, The Curriculum Development Process in Chapter 2, the results of the evaluation must be analyzed and changes recommended in the plan to make the process more effective and efficient in meeting the specified goals.

Issues for Today and Tomorrow 9

Uncertainty about the full impact of computers on education has been expressed more than once in this guide. From a long-term, and optimistic, perspective, it seems likely that computers can benefit education in many ways. In the introduction to his book *Mindstorms: Children, Computers and Powerful Ideas*, Seymour Papert, mathematician and creator of LOGO, expresses his vision of fundamental changes that computers can bring about:

> This book is about how computers can be the carriers of powerful ideas and of the seeds of cultural change, how they can help people form new relationships with knowledge that cut across the traditional lines separating humanities from science and knowledge of the self from both of these. It is about using computers to challenge current beliefs about who can understand what and at what age. It is about using computers to question standard assumptions in developmental psychology and the psychology of aptitudes and attitudes. It is about whether personal computers and the cultures in which they are used will continue to be the creatures of "engineers" alone or whether we can construct intellectual environments in which people who today think of themselves as "humanistic" will feel part of, not alienated from, the process of constructing computational cultures.[29]

The realization of significant benefits, such as those Papert and others envision, will, however, depend in large part on the resolution of issues that are just beginning to surface. Educators must make choices and decisions. As Papert points out:

> . . . There is a world of difference between what computers can do and what society will choose to do with them. . . . It is hard to think about computers of the future without projecting on to

> them the properties and limitations of those we think we know today. And nowhere is this more true than in imagining how computers can enter the world of education.[30]

The fact that the technology is still evolving – and evolving rapidly – is one issue of the emerging issues discussed in this chapter. Others are equity and the potential impact of computers on the teaching professio:

Shaping the future of teaching

It is nearly impossible to predict what features and capabilities new computers will offer and whether or not they will be useful, and affordable, for education. In the very short time computers have been in the schools, significant reassessments of their place in the curriculum have occurred. As noted in the discussion of computer literacy, the definition initially centered on programming much more than it does today, and not too long ago it was thought that there would be demand for programming skills that could be taught in high school. Now, advances in the computer industry are resulting in increasingly user-friendly computers and computer software; consequently, most students need to know relatively little about programming and there are few, if any, programming jobs for high school graduates.

A lesson may be drawn from this recent history. Educators must realize that when planning for the use of computers in schools, they will confront factors that are largely beyond their ability to control. Not only is the development of technology beyond their control, but so is society's reaction – acceptance or rejection – to technology. Both of these factors will influence how computers are used in the schools and perhaps the role of schools in society.

Because computers can transmit vast amounts of information, they have the potential to educate. For this reason, as home computers become more common, parents and children mav take advantage of the opportunity to learn in the home. An apparent trend toward parental challenges to compulsory education is described by John Naisbitt in *Megatrends* as evidence of a larger trend away from institutional help and toward self-help. The computer could be a powerful force to accelerate this trend and the impact on schools would be significant. In the future, schools may have to share the responsibility for education with parents and other institutions. School may become an institution without walls.

And even within the walls of the traditional school, the computer may radically alter the educational process. The capability of the computer to individualize instruction has been utilized only minimally. In the classroom of tomorrow the ideal may be an individualized program of instruction for each student made possible with a computer for each student.

It is also possible that much of the information now conveyed through textbooks and lectures will be delivered via computer allowing students to better contr flow of material. Computers will also mean that students have access to more up-to-date and varied sources of information through data bases and networks. According to Christopher Dede, professor at the University of Houston:

> Desktop computers will create new types of instruction. Graphics, music, voice output, touch-screen, and voice input will enable the computer to use games, simulations, and "micro-worlds" to teach sophisticated skills. Such devices can motivate extended student concentration and learning without teacher supervision. The computer will even be able to diagnose the learning style and needs of the individual student and gear instruction to match these characteristics as well as collect data on student learning to aid evaluation and research. . . . With such sophisticated machines, students will master many types of material much more rapidly than is possible in current classroom settings because the presentation is individualized.[31]

Greater individualization of instruction made possible with computers may well change many elements of the traditional school. Despite the cries of dehumanizing education and machines replacing teachers, the computer may, in fact, enhance the role of the teacher. The computer itself is an inanimate piece of hardware until it is programmed and controlled by humans. Even computers that "talk" to other computers depend on humans. The role of the teacher may change notably, but the importance of the teacher will be magnified. Teachers will be freed, as never before, from myriad nonteaching duties and will have more time for instruction.

Unlike technological development and a possible trend toward self-education, there are other issues, such as equity and the effect of computers on the teaching profession, which educators may influence. If these issues are resolved now, the likelihood of a very positive role for computers in education increases dramatically. If ignored, they may turn into problems that can undermine any positive impact.

Changes in the teaching profession

Obviously, if anything like the school of the future – described above – materializes, the role of the teaching profession will change. Some educators have already spotted harbingers of change which would only be magnified if the computer plays a larger role in education.

Because local control is important, this guide has called for each school district to develop its own plans with the active participation of teachers. Districts, in turn, should also consider the impact of computer use on how teachers work. Computers can be used to enhance the professional teachers' many skills by performing time-consuming classroom management tasks and can effectively and efficiently teach many types of subject matter. They may also be a force for potentially dangerous homogenization of education which will also sap the creative role of teachers. Districts must facilitate the former while guarding against the latter.

Equity

Equity is another issue which local school districts help shape, though not without some help. The introduction of computers to education has not been completely equitable. Inequities in computer use exist in regard to school districts' economic status, in regard to academic achievement and to sex.

A number of studies have documented that the more affluent a school district, the more likely it is to use computers for instructional purposes. The reason for this situation is clear enough: even with the cost of computers in recent years, putting a computer in every classroom is an expensive proposition, one many rural and urban school districts cannot even consider. This inequity, if allowed to continue, will serve to widen the socially, culturally and economically destructive distance between the "haves" and the "have nots." It seems unlikely that this problem will be solved at the local level. The involvement and, in all probability, funding by state and federal levels of government will be required to ensure that children who are already disadvantaged are not further hindered by lack of exposure to the technology that will shape the future.

Inequities in computer use exist in regard to school districts' economic status, in regard to academic achievement and to sex.

The problem of getting computers into poorer school districts is largely quantitative, but there are also qualitative issues involved. Some educators have expressed concern that there seem to be significant differences in how computers are used in different school districts. Daniel Watt observes:

> When computers are introduced into suburban schools, it is often in the context of computer programming and computer awareness courses. In less affluent, rural or inner city schools, computer use is more likely to be in the context of computer-assisted instruction of the drill and practice variety. Affluent students are thus learning to tell the computer what to do while less affluent students are learning to do what the computer tells them.[32]

This is a potential problem that local school districts, and even individual schools or individual teachers, can do something about. The computer literacy curriculum outlined in this guide is for all students.

Although not as thoroughly documented as economic inequities, some educators have warned that some schools orient computer instruction, and especially more sophisticated instruction, toward gifted and talented students. There is also growing evidence that "the long-documented gap between male and female participation in elective mathematics and physical science courses is now being replicated in computer labs."[33] There are also issues which school districts can acknowledge and address now to avoid the perpetuation of such inequities where they exist. The primary means is to ensure that computer literacy instruction is for all students. Then, at the high school level where elective courses are offered, there must be efforts to encourage female students to choose computer science courses and elective courses for students with a range of academic abilities.

Conclusion

A recent two-year-long study by Education Turnkey Systems, Inc found that "for every computer in public schools, there are more than ten in the homes of students."[34] This fact has significant implications for education. It means that while many students have an opportunity to learn about computers outside of school, others do not. Predictably, the schools will be called upon to redress such inequities. It also increases the likelihood that parents and students will ask for more instruction about computers; for some students the level of instruction sought will be quite sophisticated. In short, it appears likely that sooner, not later, schools will have to take more, not less, responsibility for teaching about computers and their impact on our world.

Computers are here to stay. They are found in workplaces, homes and schools and the technology is a pervasive, powerful force for change in our culture. Although it is impossible to predict the full nature of all the changes that will occur as a result of computers, the fact of change is certain. Education cannot escape, nor can it ignore, computer technology and the changes it will bring. Learning to accommodate more change and faster change than mankind has ever before experienced is a lesson educators must learn; it is also one they must teach their students

Appendix A
Local District Plans, Implementation Strategies, and Course Outlines

	Document	Contact
ACES Amity, Bethany, Hamden, Middletown, North Branford, Orange, Stratford, Wolcott	Computer Education Activities for Elementary Grades	Larry Schaefer
Avon	Computer Literacy Curriculum	Charles Kepner
Bethel	Computer Technology Steering Committee	Robert Gilchrest
Bolton	Computer Programming Philosophy and Objectives Study Committee Budget Proposal	Robert Pease
Bristol	Bristol Computer Education Program	Richard Nolan
Columbia	Program Philosophy Objectives and Activities	William Risley

	Document	Contact
East Hartford	K-8 Computer Curriculum Purchase Projections High School Computer Courses	Geoffrey P. Smith
East Lyme	Computer Education Major Goals and Objectives Computer Education Curriculum, Three-Year Plan, 1983-1986	Mary Jo Kramer
Enfield	Enfield Program in Computers	Barbara Flebotte
Glastonbury	Microcomputer Plan and Implementation Proposal	Laurence Tiven
Greenwich	Computer Literacy A Unit of Study Grades 4-6	David J. Kane
Hamden	Computers in the Elementary Schools	Richard Palleria
Hartford	Computer-Based Education in the Hartford Public Schools	Robert Parker
Killingly	Computer Education Plan	Jerre Fillmore
Manchester	Microcomputer Course Grades 8-9	James P. Kennedy
Monroe	Computer Literacy Committee Report	Daniel Ryan
New Britain	Computer Education	Edward Murratti
New London	Microcomputer Report	Diane Klotz
Ridgefield	Computers in the Ridgefield Public Schools Computer Arts Curriculum East Ridge Junior High School	John Halapin
Simsbury	Computer Literacy 5, 6	David H. Mattson, Jr
South Windsor	Computer Advisory Committee Final Report	Catherine Sampson
Stamford	Computer Literacy Curriculum Guide 5th and 6th Curriculum Guide 7th and 8th	Philip Baker

(continued)

Appendix A (continued)

	Document	Contact
Stonington	Elementary Computer Education Goals and Objectives Course Outline Advanced Computer Programming Course Outline Computer Basic	Andrew Rines
Vernon	Computer Curriculum Plan K-3 (Pilot Program)	Jon-Paul Roden
Wallingford	Computer Curriculum Plan	Frank Soldan
West Hartford	Procedures for Acquiring Hardware and Software Secondary Computer Task Force Report	Barbara Peck
Westport	Computer Education Scope and Sequence	Mort Sherman
Wilton	Computer Education	F. William Davis
Windsor	Computers in the Windsor Public Schools Computer Literacy Scope and Sequence	Warren Logee
Windham	Computer Curriculum Guidelines Grades K-6 Computer Education Plan	Jeff Ostroff
Regional School District No. 8	Computer Education Action Plan	John Senteio

Appendix B Needs Assessment

Samples

Community Survey

1 Do you have a computer in your home? ☐ Yes ☐ No

2. Is there a computer in your place of business? ☐ Yes ☐ No

3. In your occupation, are you directly or indirectly involved with a computer? ☐ Yes ☐ No

4 Do you feel the ability to use computers is important to your future? ☐ Yes ☐ No

5 Are you comfortable with your knowledge and understanding of computers? ☐ Yes ☐ No

6 Do you feel it is important for the students in our school district to learn about computers? ☐ Yes ☐ No

7. Do you feel the ability to use computers is important to the future job opportunities of students in our school district? ☐ Yes ☐ No

8 Do you feel that we should have a computer education program in our school district? ☐ Yes ☐ No

9 Add any comments here ______________________________

____

____

(continued)

Appendix B (continued)

Staff Survey

1. Do you have any computer experience? ☐ Yes ☐ No

   If yes, please describe ______________________________

   ____

   ____

2. Do you feel comfortable with your knowledge and understanding of computers? ☐ Yes ☐ No

3. Would you like to learn more about computers? ☐ Yes ☐ No

4. Would you attend computer in-service training (or a computer workshop)? ☐ Yes ☐ No

5. Do you feel it is important for the students in our school to learn about computers? ☐ Yes ☐ No

6. Would you like to be involved in teaching students about computers? ☐ Yes ☐ No

7. Do you feel that our school district needs an organized computer education program? ☐ Yes ☐ No

8. Would you like to be involved in the planning and development of an organized computer education program? ☐ Yes ☐ No

9. Comments. ______________________________

   ____

   ____

Student Survey

1. Do you or your parents own a computer? ☐ Yes ☐ No

2. Have you had hands-on experience with a computer? ☐ Yes ☐ No

3 Do you have an understanding of BASIC or some other computer language? ☐ Yes ☐ No

4 Would you like to know more about computers? ☐ Yes ☐ No

5 Would you like to have computers integrated into your regular class instruction? ☐ Yes ☐ No

6 Would you be interested in taking a class on computers? ☐ Yes ☐ No

7. Are you comfortable with your knowledge and understanding of computers? ☐ Yes ☐ No

8. Do you feel the ability to use computers is important to your future? ☐ Yes ☐ No

9. Do you feel that the ability to use computers is important to your future job opportunities? ☐ Yes ☐ No

10 Add any comments here ______________________________

____

____

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Appendix C
Advanced Placement Computer Science

A. Programming Methodology
  1. Specification
    a. Problem definition and requirements
    b Functional specifications for programs
  2 Design
    a. Modularization
    b. Top-down versus bottom-up methodologies
    c. Stepwise refinement of modules and data structures
  3. Coding
    a Structure
    b. Style, clarity of expression
  4 Program correctness
    a Testing
      i. Relation to design and coding
      ii Generation of test data
      iii. Top-down versus bottom-up testing of modules
    b. Verification
      i. Assertions and invariants
      ii. Reasoning about programs
    c. Debugging
  5 Documentation

B. Features of Programming Languages
  1. Types and declarations
    a Block structure
    b. Scope of identifiers
      i. Local identifiers
      ii. Global identifiers
  2. Data
    a Constants
    b. Variables
  3 Expressions and assignment
    a. Operators and operator precedence
    b. Standard functions
    c. Assignment statements
  4. Control structures
    a. Sequential execution
    b. Conditional execution
    c. Iteration (loops or repetitive execution)
  5. Input and output
    a. Terminal input and output
    b. File input and output
  6 Subprograms
    a. Procedures and functions
    b. Parameters
      i. Actual and formal parameters
      ii. Value and reference parameters
    c. Recursion
  7. Program annotation
    a. Comments
    b. Indentation and formatting

C. Data Types and Structures
  1. Primitive data types
    a. Numeric data
      i. Floating-point real numbers
      ii. Integers
    b. Character (symbolic) data
    c. Logical (Boolean) data
  2 Linear data structures
    a. Arrays
    b Strings

c. Linked lists
d. Stacks
e. Queues
3 Tree structures
a Terminology
i. Nodes: root, leaf, parent, child, sibling
ii. Branches and subtrees
iii. Ordered and unordered trees
b. Binary trees
c. General tree structure (optional)
4 Representation of data structures
a Sequential representation of linear structures
b Pointers and linked data structures

D Algorithms
1 Classes of algorithms
a Sequential algorithms
b Iterative or enumerative algorithms
c. Recursive algorithms
2 Searching
a Sequential (linear) search
b Binary search
c. Hash-coded search
d. Searching an ordered binary tree
e. Linear versus logarithmic searching times
3 Sorting
a. [illegible] ort
b Insertion sort
c Exchange or bubble sort
d. Merge sort
e Sorting using an ordered binary tree
f. Quicksort (optional)
g Radix sort (optional)
h. Quadratic versus n*log(n) sorting times
4 Numerical algorithms
a. Approximations
i. Zeroes of functions by bisection
ii Monte-Carlo techniques
iii. Area under a curve (optional)
b. Statistical algorithms
i. Measures of central tendency
ii Measures of dispersion
c. Numerical accuracy
i. Round-off effects
ii. Precision of approximations
5 Manipulation of data structures
a. String processing
i. Concatenation
ii. Substring extraction
iii. Matching
b. Insertion and deletion in linear structures. trees
c. Tree traversals

E. Applications of Computing
1. Text processing
a. Editors
b. Text formatters
2. Simulation and modeling
a. Continuous simulation of physical processes
b. Discrete simulation of probabilistic events
3. Data analysis
a. Statistical packages
b. Graphical display of data
4. Data management
a. Information storage and retrieval
b. Typical business systems
5. System software
a. File management routines (e.g., mail systems)
b. Syntax analysis routines
i. Command scanners
ii. Evaluation of arithmetic expressions
6. Games
a Simple puzzles (e.g., Tower of Hanoi)
b. Simple games (e.g., tic-tac-toe)
c. Searching game trees (optional)
7. Graphics

F. Computer Systems
1. Major hardware components
a. Primary and secondary memory
b. Processors
c. Peripherals
2. System software
a. Language processors
b. Operating systems
c. Graphical output facilities
3. System configuration
a. Microprocessor systems
b. Time-sharing and batch processing systems
c. Networks

G. Social Implications
1 Responsible use of computer systems
2 Social ramifications of computer applications
a. Privacy
b. Values implicit in the construction of systems
c. Reliability of systems

Endnotes

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