High Tech/High Touch: A Computer Education Leadership Development Workshop

David Moursund

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Some of Dr. Moursund's major accomplishments include:

- Author or co-author of more than twenty books and numerous articles.
- Chairman of the Department of Computer Science, University of Oregon, 1969-1975.
- Chairman of the Association for Computing Machinery's Elementary and Secondary School Subcommittee, 1978-1982.
- Founder, International Council for Computers in Education (ICCE), 1979.
- Chief Executive Officer, ICCE, 1979-1988.
- Executive Officer, ISTE, 1989- present.

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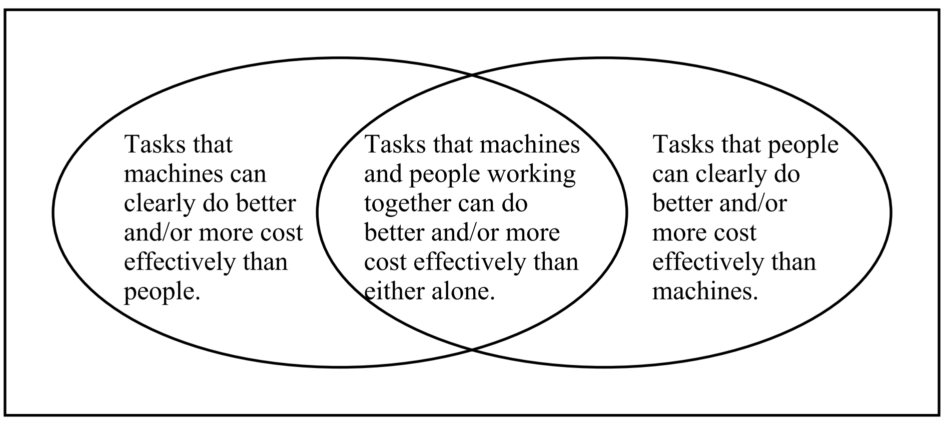
Preface to the 2004 Reprint

This workshop is representative of a "personal growth movement" phase of my life. I first encountered the idea of high tech/high touch in *The Third Wave* by Alvin Toffler (1980). Heidi Toffler, although not listed as an author, contributed significantly to the book. I am truly impressed by the futuristic insight that Alvin and his wife Heidi showed when they were writing this book 25 years ago!

I find it interesting to look at current aspects of Information and Communication Technology (ICT) in education from the point of view of high tech/high touch. The capabilities of ICT systems have grown by a factor of perhaps 10,000 or more since the Tofflers wrote *The Third Wave.* ICT has been a major change factor in our society and in the world. A gradual pattern of "tech" versus "touch" has emerged. ICT (the "tech") has speeded up and/or facilitated increased automation of many tasks and problem-solving activities. People often draw an analogy with how the machines of the industrial revolution changed the nature of physical work. The machines of the ICT revolution are changing the nature of mental work. In combination, the industrial revolution and the ICT revolution are significantly changing the nature of the work that people do. And, of course, they are changing the standard of living, formal and informal education, and many other aspects of our lives.

The diagram given below raises critical questions about machines versus people.



Here is an over simplification of what I gain through the analysis of this diagram. Think of the left side of the Venn diagram as high tech, and think of the right side of the Venn diagram as high touch. The left side and middle sections of this diagram are growing in size, while the right side is shrinking. However, the right side is still very large.

From my point of view, we need a PreK-12 educational system that carefully takes this diagram into consideration. Our children are growing up in a world in which the combination of the industrial and ICT revolution will continue to expand the left side of the Venn diagram. In my opinion, this means that our educational system needs to prepare students to live in such a world.

Each of us has our own ideas on what constitutes a good education for life in the future. My personal opinion is that our schools should spend less time helping students learn to do (by hand, or with very simple tools such as pencil and paper) tasks that machines can clearly do much better than people. This will free up time so that more emphasis can be placed on the high touch and middle categories of the Venn diagram.

I have held this opinion for many years, and the strength of this opinion grows as the capabilities of ICT continue to grow. Here is a short story that helps to illustrate the magnitude of the change going on in ICT.

Recently I replaced a 450 Megahertz computer on my desk at work with a 1.6 Gigahertz machine. My "new" machine wasn't actually new—it was a hand-me-down from a grant that I had been running. I decided to upgrade the primary memory of this machine by adding a gigabyte of memory. The cost was $210. This memory upgrade contains somewhat over 8-billion transistors as well as a number of other electronic components. This means that the transistors cost less than 1/400,000 of a cent apiece.

I mentally contrast this with the cost of vacuum tubes (at perhaps a dollar apiece) when I was first getting into the computer field. Put a different way, I added the equivalent of $8-billion worth of value to my computer, in terms of what such capability would have cost when I was first getting into the computer field. Of course, such comparisons make little sense, since it was not possible to have an 8-billion vacuum tube machine in those days. Still, it makes me feel good to think that in some sense I am a multi-billionaire. I routinely use a tool that a multi-billionaire could not have acquired at the time I first started using a computer.

Finally, you may note that there are two sets of references at the end of the book. The first is from the original book, and it contains only references to books and dissertations. The second is the collection of all of the references given at the ends of the chapters; this comprehensive list was not included in the original book.

The Web had not yet been invented when I was writing this book. Then, and now, I read extensively. I subscribed to a number of periodicals and I bought lots of books. What has changed in my reading habits is the amount of time that I now spend browsing the "global library" that most people call the Web. In the books I have written during the past few years, I have consciously tried to provide references that my readers can find on the Web. Having a world-class library at my fingertips has become on of the great pleasures in my life.

David Moursund

December 2004

Preface (Original)

This book contains materials for the Leadership Development Workshops I have created and facilitated over the past few years. As the book title suggests, I have drawn heavily from the human potential movement. Many of the ideas I use in my workshops are similar to those one is apt to encounter in workshops designed to help participants “grow."

The materials are divided into SESSIONS. In a workshop, each SESSION is 1-3 hours in length, depending on the interests of the workshop participants and the overall length of the workshop. In total, this book contains enough materials for a five day workshop.

Some of the SESSION materials given in this publication are very detailed—nearly at the transcript level. Others are merely the typical types of notes that might be given to workshop participants to be used during a workshop.

Workshop participants and other readers of these materials are encouraged to make use of the ideas and exercises. However, please be aware that the materials are copyrighted. If you want to make arrangements to purchase additional copies or reproduce certain parts of these materials, please contact me.

The January 1989 edition of this book contains two major pieces that were written by students who were using this book as a required text in a graduate course at the University of Oregon. Students in the course were given the assignment of writing materials that would be suitable for inclusion in this text and that were suitable for use in a graduate course in the field of computers in education. I want to extend my appreciation to Sharon Yoder, the course instructor, and to the two students, Shane Goodwin and Cynthia Landeen. Their contributions may be found in Session 12 and Session 2 respectively.

Dave Moursund

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(September 1988) and more

additions (January 1989).

Workshop History and Overview

During the academic year 1976-77 I participated in a group that studied and practiced ideas typically associated with the human potential movement. In the summer of 1977 I participated in an intensive five-day workshop (such workshops are often called encounter groups) and experienced substantial personal growth.

The evening of the day the five-day encounter group ended, I presented a discussion on calculators and computers in education to a group of mathematics educators. I began that presentation with a guided fantasy—an imaginary trip into a world of the future where calculators and computers were readily available to all students. That guided fantasy was my first attempt at combining high touch with the usual high tech ideas I present in workshops.

During the late 1970s and early 1980s I made presentations at a large number of computer education conferences. Gradually I became aware that most of these conferences offered little for the conference speakers and workshop leaders. Usually these people managed to find each other and to cluster together in small group discussions. It slowly dawned on me that conferences should include sessions specifically designed for leaders.

My experiments in combining high touch with high tech were sporadic until about 1983. Then I began a serious effort in my workshops to draw upon the communication ideas and other high touch ideas generally associated with the human potential movement and/or psychotherapy. The goal was to appropriately combine high touch with high tech in a "Leadership Development Workshop." Through considerable experimentation, these workshops have gradually evolved into their present form.

The Leadership Development Workshops are intended for instructional computer coordinators, computer education teachers, workshop leaders, teachers of teachers, and other people who play a leadership role in instructional uses of computers at the precollege level. The overall goal of a workshop is to make a significant and lasting contribution to education. During the workshop, participants are repeatedly asked to think about the question, "What will you do differently next week (as a consequence of participating in this workshop) that will help to improve education?"

This emphasis on change is threatening and/or stressful to many people. The computer is a powerful change agent—but what if a person doesn't want to change or is unable to change? That situation is quite familiar to the psychotherapist. The field of psychotherapy offers many high touch tools and techniques that can help to facilitate change.

The leadership development workshops involve a mixture of small group and large group interaction, combined with formal presentations to the whole group. A key part of the workshop format is small group discussions, sharing and practicing ideas related to the large group presentations. Here we draw on some of the recent progress that is occurring in Cooperative Learning. Many of the workshop activities and discussion topics focus on improving communication and interpersonal skills. Longer workshops seek to capture the flavor and spirit of "retreats," or personal growth group marathon sessions.

Each workshop is built around a general analysis of precollege instructional uses of computers, along with the computer-oriented preservice education and inservice education of educators. This analysis leads to the identification of a number of needed computer-education leadership traits. Additional leadership traits, commonly found in successful leaders, are also examined. Many leadership traits are independent of the academic discipline in which they are to be applied. Also, most of the key leadership traits are people-oriented; thus, the longer workshops place considerable emphasis on examining and developing people-oriented skills for use in a high-tech environment.

It is important to note that these are not “hands-on-computers” workshops. The assumption is that workshop participants have had substantial hands-on experience and can easily gain more such experience if it suits their needs. Occasionally a piece of software will be examined and/or discussed to illustrate a particular point. Always, however, the assumption is that workshop participants are quite capable of examining software without being in this workshop.

Each workshop draws from the topics listed below. Not every topic is covered in every workshop; longer workshops have greater depth and breadth.

1. An overview of problem solving, with an emphasis on the role of computers in problem solving versus the role of people in problem solving. Educational implications of the concept of a computerizable effective procedure. Problem solving is a central and unifying theme because computers are such a powerful aid to problem solving. Computers bring unique new dimensions to problem solving, and thus are quite important to the education of our students.
2. Lower-order skills versus higher-order skills, and how each are affected by computers. A discussion on recent trends in our educational system toward increased emphasis on higher-order skills. If a computer can solve a particular type of problem, can we still claim that solving that type of problem is an example of using higher-order skills?
3. Technical ideas from computer and information science and from computer science education. This includes an examination of goals for precollege instructional uses of computers and for computer-oriented teacher education. This examination is based on a foundation of one's own overall educational philosophy and goals for education.
4. Interpersonal ("people") skills, including active listening, and the giving and receiving of positive strokes. The role of interpersonal skills in a high touch/high tech society. We repeatedly observe that the interpersonal and communication skills of people far exceed those of computers.
5. Written and oral communication skills, including an examination of the “I can't write” syndrome. How process writing in a word processing environment might help cure the “I can't write” syndrome.
6. Computers in mathematics, including an examination of the “I can't do mathematics” syndrome. A comparison of math anxiety and computer anxiety. Ideas from psychotherapy that relate to math and computer anxiety.
7. Computer-Based Information Systems and their impact on social studies education. Roles of Computer-Based Information Systems in problem solving.
8. An examination of responsibilities of computer coordinators at the school building and district levels. Preparation to be a computer coordinator.

9. Evaluation of instructional computer use in a school or school district. A school or district plan for instructional use of computers should have a formative evaluation component.
10. Skills in teaching adults—especially those needed to teach educators. Improving the effectiveness of communication through the use of group facilitation skills.
11. Overall knowledge of precollege curriculum, the educational system and change processes in education. This includes an examination of curriculum development and implementation ideas, as well as a discussion of how to design and carry out effective inservice activities.
12. Stress and burnout—how to recognize them and what to do about them. Examination of the computer coordinator position as a particularly high stress job. Various stress reduction exercises will be illustrated and practiced.
13. Personal growth, and a personal plan for keeping up in computer science education. The idea of a "half-life" of one's formal education. An examination of the long term future of computer education and one's own role in this future.

The workshop facility needs movable armchairs, or small tables to seat three people per table. The workshop room should have good acoustics, so that a number of small group conversations can occur simultaneously. It should have a microphone (not necessary in very small workshops) and two overhead projectors with screens (if necessary, one projector and screen will suffice). One overhead is needed to present items under discussion and a second to record participant input or to display materials presented earlier in the discussion. Coffee, tea, fruit juices, and soda pop should be provided for morning and afternoon breaks. These should be available in the workshop room. Workshops that are one or more days long meet about seven to eight hours per day, roughly evenly divided between morning and afternoon. However, workshops that are two days or more in length may also have evening sessions. In the evening sessions, workshop participants may wish to demonstrate various pieces of software or share materials they have developed. Such longer workshops are best held in a "retreat" setting, away from phones, television and other interruptions.

As mentioned previously, the workshop is not a "hands-on" workshop, involving the study of specific pieces of hardware or software. It is assumed that all participants have had substantial hands-on experience and have easy access to appropriate hardware and software in their job and home environment. Instead, the workshop is an experiential, personal growth workshop. All participants are expected to actively involve themselves in all aspects of the workshop. Close and lasting friendships often result from this type of interaction.

Abridged Resume of David Moursund

Current Titles

Professor, Division of Teacher Education, College of Education, University of Oregon.

Editor-in-Chief and Executive Officer, International Society for Technology in Education.

Education

Ph.D., University of Wisconsin, Madison, 1963.

M.S., University of Wisconsin, Madison, 1960.

B.A., University of Oregon, 1958.

Professional Experience

Professor of Education, University of Oregon, 1982-present.

Professor of Computer & Information Science, University of Oregon, 1976-1986.

Editor-in-Chief, International Council for Computers in Education (name changed to the International Society for Technology in Education in 1989), 1979-present.

Chairman, Department of Computer & Information Science, University of Oregon, 1969-1975.

Associate Professor, Department of Mathematics, University of Oregon, 1967-1969.

Assistant Professor (1963-66), Associate Professor (1966-1967), Dept. of Mathematics, Michigan State University.

Instructor, Department of Mathematics, University of Wisconsin (Madison), 1963.

Selected Publications (Books)

(With Karen Billings) Problem Solving with Calculators. Dilithium Press, 1979.

Calculators in the Classroom: With Applications for Elementary and Middle School Teachers. John Wiley & Sons, 1981.

Introduction to Computers in Education for Elementary and Middle School Teachers. International Council for Computers in Education, 1981.

Parent's Guide to Computers in Education. International Council for Computers in Education, 1983.

The Computer Coordinator. International Council for Computers in Education, February 1985.

Collected Editorials. International Council for Computers in Education, June 1985.

(With Dick Ricketts) Long-Range Planning for Computers in Schools. Information Age Education, 1987. Revised edition published in November 1988.

Computers and Problem Solving: A Workshop for Educators. International Council for Computers in Education, August 1988.

David Moursund, project director. Computer-Integrated Instruction Inservice Notebook: Secondary School Mathematics, International Council for Computers in Education, 1988.

David Moursund, project director. Computer-Integrated Instruction Inservice Notebook: Elementary School, International Council for Computers in Education, 1989.

Effective Inservice for Integrating Computer-as-Tool into the Curriculum, International Council for Computers in Education, 1989.

Brief Summary of Major Accomplishments

I first became involved in computer education during a summer 1963 program for high school students that I helped teach. At Michigan State University during 1963-67 I established a doctoral program in numerical analysis and was the major professor for the first three students to complete the program. In the summer of 1965 I taught my first course for inservice teachers—a numerical analysis course for participants in a National Science Foundation summer institute in mathematics. In the summer of 1966 I directed and taught in such a summer institute.

At the University of Oregon I help establish the Computer Science Department and served as its first Chairperson during 1969-1975. I established a master's degree program in computer science education in 1970. I helped establish a doctorate program in computer science education in 1971. Both of these programs are still continuing, and they have graduated a number of excellent students. More than 40 students have completed the doctorate program.

I was one of the founding members of the Oregon Council for Computer Education in 1971. I established its journal, the *Oregon Computing Teacher*, in 1974. This journal became *The Computing Teacher* when I founded the International Council for Computers in Education in 1979.

I like to write. I am author or coauthor of more than a dozen books, several booklets, and a large number of articles and reports. I regularly contribute to *The Computing Teacher*, especially through my editorial messages.

Areas of Interest and Expertise

I am interested in all aspects of computer use in precollege education. Other interests include mathematics education, problem solving, and the human potential movement. I direct both a master's degree program and a doctorate program in computer science education. I run Leadership Development Workshops for computer education, and I am particularly interested in blending high touch with high tech in these workshops. Other current interests include Staff Development and the topic Computers, Brains, and Problem Solving.

Session 1: Introduction and Active Listening

Goals

1. To explore several methods for beginning a computers-in-education workshop.
2. To participate in an "experiential" exercise designed to make use of ideas of "touch" in the continuum of high tech—high touch.
3. To learn the rudiments of active listening and apply them to a computers-in-education workshop setting.

Preparation

Preparation for a workshop begins many weeks before the workshop. Here I am assuming that all of the preliminary work and site preparation has been done. Participants arrive, are registered, are given large, easily readable nametags, and are provided with appropriate handout materials. One major handout is a comprehensive outline of the entire workshop. It contains a general framework for whatever notes a participant will want to take. As a rough guideline, the handout might contain two to four typed pages of material for each hour of the workshop. These are not resource papers; rather, they are outlines of materials to be presented during each workshop session, detailed directions on what to do in small group interactions, and so on. Participants will likely read most of this material during the workshop, but only short segments at any one time. The handout notes may also be read after the workshop is over in order to provide a comprehensive review of the workshop.

Additional handouts, constituting major resource papers, may also be included. These may be materials that are provided to participants several weeks before the workshop begins, with the expectation that they will study them in preparation for the workshop. Articles from some of the International Council for Computers in Education publications and other select journals might be appropriate.

The first hour or two of a workshop is crucial. (I find that it generally takes about two hours to cover the materials given here for Session 1.) It sets an atmosphere for the entire workshop. Participants are coming into what they may perceive to be a threatening environment. Most feel uneasy, apprehensive. (This will be especially true if the workshop is properly advertised, with clear emphasis upon personal growth, experiential activities, small group interactions, etc.) Many participants will not know very many others in the workshop. The first hour of the workshop is designed to overcome the apprehensions and to begin to build a spirit of group cohesiveness. This is absolutely essential for longer workshops.

An Icebreaker

As mentioned above, workshop participants will need name tags. I have found the name tag format given below to be quite effective in a variety of workshops.

________________________________ ______________________

Name (Last, First) Nickname or first name (Print in large letters)

Indicate one best answer for each question

Years teaching experience.	0-5	6-15	More
Years computer experience.	0-2	3-5	More
I mainly work in grades:	0-6	7-12	Other
Computer Ed. background.	Low	Med.	High
My interpersonal skills.	Low	Med.	High

This name tag format is printed on 3" by 5" cards or on pieces of paper. As workshop participants arrive they are asked to fill out the name tag. They are then asked to find two other people who are "as nearly like them as possible." This causes mingling and discussion! In addition, the groups of three that result are the initial seating triads discussed in the next section.

Notice also that participants are creating a database containing certain information about themselves. The total database has one record for each workshop participant. The process of finding people who are nearly like themselves is an information retrieval task. Thus, this initial exercise combines high touch with high tech!

Getting Started

Get people seated in triads (groups of three). In a small workshop (perhaps up to 20 or 25 participants) it is possible to have each participant provide a brief self-introduction to the whole group. This definitely should be done in workshops of one-day or more in length. In half-day workshops the time might better be spent covering the actual content material of the workshop. In larger workshops the initial introductions will be among people in a triad. But one can do group activities such as asking for a show of hands on the following types of questions.

1. How many of you are or have been elementary school teachers?
2. How many of you are or have been secondary school teachers?
3. How many of you are or have been school or district administrators?
4. How many of you currently hold the title and/or perform the duties of a district level computer coordinator?
5. Who came from outside of this (state, province, country) to participate in this workshop?
6. Who has heard me make a presentation sometime in the past?
7. How many of you thought the name tag exercise was effective?

It may be possible to provide a "participants list" as a handout to all participants. Indeed, it might even be possible to include in the participants list a short (one paragraph) resume of each participant. The feasibility and desirability of this will depend on the circumstances of a particular workshop. If adequate computer facilities are available, participants can enter such data into a computer as part of the process of registering or "signing in" when they arrive at the workshop.

Another excellent "getting started" activity is to ask for a volunteer to come to the front of the room to talk to the workshop facilitator. Carry on a conversation with this person. After getting a little information such as name, where from, computer education and other interests, ask the person about what they expect to get out of being in the workshop. This might be done by use of the question, "What are some of the major problems you face as a computer education leader, and how do you expect this workshop to help you?" Then use active listening techniques as you facilitate a reasonably lengthy response. (Later in this first session we present instruction on active listening. Here we are role modeling use of active listening.) Debrief this activity by making comments about some of the active listening techniques that were illustrated. Place particular emphasis on non-verbal communication, such as body language.

If time permits you will want to have two or three volunteers share their computer education leadership problems and their expectations for the workshop. This provides you with some sense of the makeup and expectations of the workshop participants. It allows the workshop participants to see the diverse nature of the participants and their expectations. In debriefing this exercise with the whole workshop group, point out that you have been using active listening techniques and that instruction and practice in active listening constitutes one major aspect of the workshop.

The results of this initial demonstration of active listening may surprise you and the workshop participants. Generally there will be little agreement among various participants as to what they expect to get out of the workshop. Also, there may be little agreement between you (the workshop leader) and any one of your participants. This lack of agreement is a suitable topic for a light-hearted group discussion; it can be a good ice breaker.

Another way to get people started is to have each participant write a couple of questions on a card. These are to be questions that the participant expects to have answered as a result of being in the workshop. These questions can first be shared in triad group discussions and then turned in to the workshop leader. The workshop leader can study the cards during break times and in the evenings of multi-day workshops. The cards may help the workshop leader reorient some parts of the workshop and they can serve as a basis for the closing session of a workshop. There one wants to make sure that all major questions have been covered and/or that appropriate sources of answers have been provided.

Ultimate responsibility for what a participant gets out of a workshop rests with the participant. A workshop leader can help to create an environment that is conducive to learning and personal growth. But the workshop leader cannot make anything happen for a particular individual. Educators should have no trouble understanding this, since they have considerable experience in "teaching" versus "learning."

The first major exercise or activity of the workshop is the Clear A Space activity given below. Before doing this exercise, stress that this is a computer education leadership development workshop. The goal is to make a significant improvement in education, especially in and/or through computer education. But many of the exercises are personal growth, experiential exercises. These are designed to improve self-knowledge and promote personal growth. Their underlying purpose is to help the participants to become more effective learners and educational leaders. They are a critical aspect of the high touch flavor of the workshop.

Clear A Space

Generally some people will arrive late, so the above activities are partially designed to make sure that most participants have arrived and settled into place. The Clear A Space exercise given in this section is somewhat related to the first step in a psychotherapy technique called "focusing." The reference on that psychotherapy topic is *Focusing* by Eugene Gendlin, published by Everest House Publishers, New York. (Note that some references for this workshop are given at the very end of this book.) Dr. Gendlin is a professor at the University of Chicago. The specific content/process of an exercise such as this is highly dependent upon the workshop facilitator. The following example is designed to give to flavor of the exercise. It is presented in a slow tempo, with frequent pauses to allow the participants time to follow the instructions.

> Please make yourself comfortable; relax, and begin to pay attention to your breathing. Begin to take deeper, slower breaths. Be aware of the contact of your feet with the floor. Be aware of how you are holding your hands and their contact with other parts of your body. Now you may want to close your eyes, as you continue to breath deeply and slowly. You may notice the sounds of other people breathing.
>
> We are going to do an exercise that will help you to participate fully and comfortably in today's workshop. It is an exercise designed to clear a space in your mind, to make room for today's new ideas and experiences.
>
> Imagine your mind as a warehouse, stacked full of boxes, crates and piles of stuff. Each box, or crate, or pile of stuff represents a demand upon you. It is a problem you face—a task demanding your attention. Visualize your warehouse and how full it is. It is full of demands from home, work, and your social life.
>
> I know that many of you had to rush to get here. You have problems waiting at home and at work that need your attention. Your mental warehouse is full of tasks demanding your attention. There is not enough time to do everything that needs to be done. But there is time to continue to breath fully and comfortably.
>
> Now I want you to take some time now to consider some the boxes in your mental warehouse. What box, what problem is foremost in your mind? Consider it for a few moments—understand why it is so big and so important. Maybe it is a problem that you have had for months—maybe it is a new one, that just recently arrived on the scene. Think about wrapping this box in pretty paper with a lovely bow. Acknowledge the problem as you set it aside for awhile—as you begin to clear a space in your mental warehouse. The problem will take care of itself for today, while you take care of yourself at this workshop.
>
> Now select another box, a problem that is hanging over you and preventing you from devoting your full attention to this workshop. Examine the problem, seeing why it is so big, so important. Then wrap it up and set it aside for today. Continue to clear a space. Select a box. Acknowledge that it is important and deserving of attention. Set it aside, as you continue to clear a space in your mental warehouse.
>
> As you continue to breath slowly and deeply, I want you to be aware that your body and mind are preparing themselves to participate fully in today's workshop. Your mental warehouse now has a space cleared; your problems at home and work have been moved back so that you can be fully here today. Be aware that these problems will try to intrude during the workshop. From time to time your mind will wander, and a problem-box will move into your current awareness. When this happens, acknowledge the problem-box and then return it to its warehouse spot.
>
> This workshop will present you with a number of important ideas. There will be so many important ideas that your conscious mind may be overwhelmed. But be aware that your subconscious mind is fully alert, receiving, cataloging, and digesting. Many days from now, when this workshop is long past, you will be pleasantly surprised as your subconscious mind continues to bring to your conscious attention important ideas from this workshop.

> And now, as you continue to breath slowly and deeply, open your eyes and return to this room. Your mind and body are relaxed and alert. You are ready to spend the day being with us in this workshop.

Communication

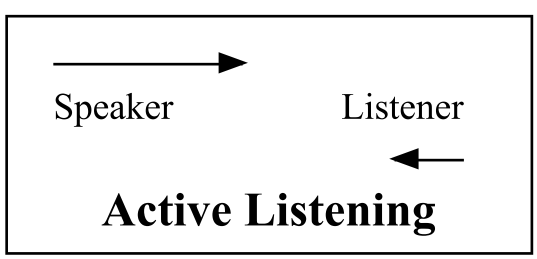
This is a workshop for computer education leaders. It has substantial computer-oriented content. However, it also has considerable content that is independent of any particular discipline, and thus applicable to all teachers. Many of the characteristics and qualities of a good leader are independent of the field in which the leader is working.

One characteristic of all good leaders is well developed communication skills. All successful teachers have good communication skills, both as a sender and receiver. But all of us have room for improvement as communicators. The Clear A Space exercise is sometimes used by psychotherapists to begin leadership development workshops for psychotherapists. For many people it is a quite effective exercise. It is sometimes used by elementary school teachers to get their students settled down at the beginning of a session. How many of you feel that it helped you? (Ask for a show of hands. Generally more than half of the group will raise their hands. There may be hesitation, for fear that they will be called upon to share the details of their experiences. If so, reassure the group that what is in their mental warehouse is their own private business.) Be aware that everybody reacts differently to such an exercise. There is no one “right” way to react. Learn from your reactions, and from the reactions of others.

In recent years I have spent considerable time reading a variety of books written by psychotherapists and receiving other training in this field. I have come to appreciate that the stock and trade of a good psychotherapist is being a good communicator. Many of the ideas in this workshop are drawn from the field of psychotherapy. My favorite authors are Richard Bandler and John Grinder. I recommend a variety of their books, such as Frogs into Princes, Trance-Formations, Reframing, The Structure of Magic I & II, and Using Your Brain—for a CHANGE. Bandler and Grinder developed neuro-linguistic programming (NLP), which tends to provide a unifying model for all psychotherapy-oriented communication. NLP has its roots in computational linguistics and the work of Noam Chomsky. Bandler and Grinder stress throughout their books that a successful psychotherapist must be a master communicator and that their books are designed to improve communication skills. It is interesting to note that Bandler's undergraduate studies were in computer science and mathematics.

Active Listening

Active Listening is a communication skill that is useful to everybody, not just to leaders. However, it is also a skill in which many people, especially leaders, need instruction and practice. The essence of Active Listening is to listen, working hard to understand, and to sense/receive the underlying feelings and meaning inherent to the communication. Note that most of the “action” is Speaker ---> Listener



Guideline to Active Listening

1. Pay attention to the speaker. Maintain eye contact and observe body posture, gestures, breathing, tone of voice, and skin color. Be especially aware of changes and relate them (in your mind) to what is being communicated at the time.
2. Provide feedback to show that you are listening and understand. This feedback might include things such as:
    a. Continuing to do 1. above.
    b. Nodding one's head appropriately, while murmuring encouraging sounds such as yes, okay, I understand, go on, etc.
    c. Paraphrasing and/or restating brief summaries. It can be quite effective to make use of appropriate words from the speaker's vocabulary when providing these summaries. However, extensive paraphrasing or other types of repetition of the speaker's message tends to be distracting and inappropriate.
3. Ask questions only when you do not understand what the speaker means. By and large do not ask leading questions; questions asked should be open ended, providing the speaker with options to proceed in a direction s/he selects. Active Listening is not a courtroom interrogation.
4. Seek the underlying meanings and underlying feelings being communicated. Feedback should reflect that you are receiving the underlying meaning and feelings. This is hard work, requiring full use of one's senses. The ability to be a good active listener improves with practice.
5. Provide positive strokes to the speaker. Your listening and paying active attention is a positive stroke. Understanding the communication is a positive stroke. The final comment “Thank you for sharing.” is a positive stroke.

Have workshop participants read the major ideas of active listening listed above. Pay particular attention to the positive strokes part. Most people don't get enough positive strokes. Workshop participants can be encouraged to give each other lots of positive strokes. This will turn out to be an important part of the workshop.

WHOLE GROUP ACTIVITY: 15 minutes. Divide into triads (groups of three). Designate one person to be speaker, one to be listener, one to be observer. Speaker is to spend about 1-2 minutes on “What I expect to get out of being here today.” A slightly different topic is “What I need in order to be a more effective computer education leader.” Either topic is appropriate, as are other similar topics. Listener uses active listening techniques. Observer observes and acts as time keeper. After 1-2 minutes the observer provides feedback to the other pair, for 1-2 minutes. Then switch roles; everybody should practice all three roles.

DEBRIEF: 5 to 10 minutes. The whole group debriefing time periods allow for a sharing across different triads. They also allow the facilitator to provide additional comments. In the debrief, emphasize that the type of sharing being done in the triads is relatively rare in professional, academic circles. We tend not to know what our colleagues are feeling and thinking. The observer has the opportunity to learn what seems to work and what seems not to work in active listening. For all concerned, it is a useful learning experience.

Make sure that the debriefing includes an emphasis on body language. Some people are highly skilled at "reading" body language. Some writers estimate that as much as 70 percent of one-on-one communication is nonverbal. This is a very important concept. Compare it with communication with a computer or communication via an electronic teleconferencing system. Once again we see the high touch and high tech ideas and how they relate.

The purpose of the first session in the workshop is to introduce the workshop, distribute handouts, discuss the overall schedule, and set an atmosphere of easy interaction with the facilitator and between group members. The instruction and practice in active listening allows all workshop participants to participate; it facilitates communication between participants in the workshop and with the workshop leader.

In a workshop, people should form new triads after the lunch break. In a two-day workshop people should eventually be in four different triads; in a three-day workshop everyone will participate in six different triads, and so on. The purpose of this is to develop closer contacts with a number of people. One can do this through the intimacy of sharing ideas in a triad.

End of Session

Each session should have a clear and distinct ending. It might consist of a brief summary of the key points and a "Are there any more questions?" Another idea is to have participants do a brief, silent introspection. Have them think back over the session and fix firmly in mind the idea(s) that seemed most important to them. How will they make use of the idea(s) when they return to work? What will they continue to do as they have been doing, and what new ideas will they try? This type of closing of a session emphasizes that the ideas in the workshop are useful and are intended to be used—they will make a difference to the participants.

Appendix to Session 1: A Bit of (1985) Computer History

Forty years ago the main group of people interested in computers were the researchers who were designing and building such machines. The first electronic digital computer produced in the United States became operational late in 1945.

Thirty years ago a typical computer system cost more than a million dollars. Computer use was restricted mainly to the military, large governmental organizations, some large research projects, and some large businesses. The first magnetic disk storage device had just been developed.

Twenty years ago "third generation" computers (such as the IBM 360 series) and minicomputers were available. The price of computer hardware had dropped markedly, and the capabilities of computers had increased even faster. Computers were commonplace in government, business, and higher education. Timeshared computing was bring computer availability to increasing numbers of people and even into some precollege educational settings.

Ten years ago microcomputers began to appear. These represented another marked decrease in price. School use of computers was poised to begin rapid growth. Microcomputers made it possible for people to think about having a home computer. We were well into the information age.

Today millions of people have computers at home. Schools have computers (but not nearly as many as are found in homes). Computer use by secondary school students at school and at home is discussed in the recent Ph.D. dissertation by Regan Carey (1985). In Eugene, Oregon, where this study was done, about half of the high school students report they are making regular use of computers.

Computer circuitry is built into all kinds of instrumentation and consumer items, such as digital watches, cars, microwave ovens, and television tuners. Computers have become an everyday tool of many millions of students and workers. Computers are no longer a novelty.

Moreover, developments are continuing without pause. The cover of a recent issue of Business Week magazine features computer chips. The lead article is about ultra large scale integrated circuitry and how it is affecting the computer field (Wilson and Ticer, 1985). The article asserts: "As early as the mid 1990s, a single integrated circuit will pack more raw computing power than a dozen of today's $4 million supercomputers. And it will probably sell initially for just a few hundred dollars." The article goes on to point out how such chips decrease rapidly in price as they are mass produced in a competitive market place. One can speculate that by the year 2000 such a chip may sell for $10 or so.

In mid 1985 IBM announced initial success in fabricating ultra large scale integrated circuitry at the half-micron level. That is, the chip circuitry is made of pathways a half-micron in width. A micron is a millionth of a meter, so there are 10,000 microns in one centimeter. At the half-micron level a single memory chip will store 16 megabits (two megabytes). Recently, several companies announced they were now selling second generation 32-bit single-chip microprocessors. (That is, the first such microprocessors came out in 1981. New, improved models are now available.) Finally, over the past year several computer news articles have discussed new chips that are ten times (or more) faster than those currently on the market.

Note: An August 1988 magazine article indicated that IBM had recently succeeded in developing some parts of a piece of circuitry at the .25 micron level. They expect to use such technology to produce a 64 million bit memory chip by the mid 1990s. If this project is successful than we will eventually be mass producing eight megabyte memory chips! When that occurs, we can expect that the mass produced, modestly priced microcomputer will be quite powerful relative to today's $100,000 to $500,000 computer systems.

References for the Appendix

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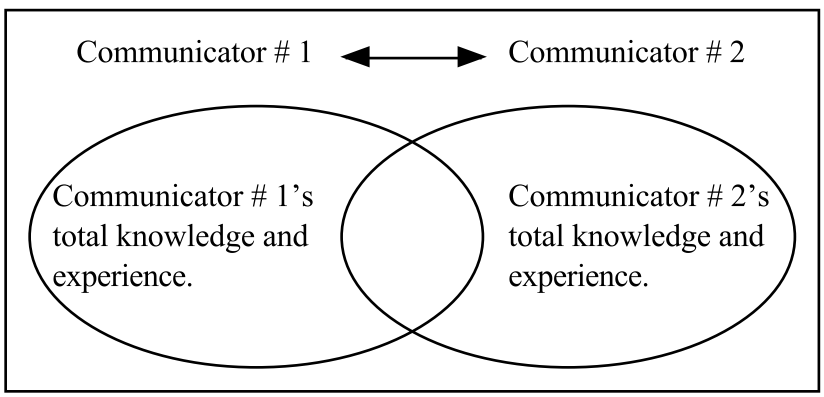
Session 2: Overview of Computers in Instruction

Goals

1. To provide an overview of computers in education that can serve a basis for communication and for further learning.
2. To explore the idea of "shared reality" as it relates to effective communication.
3. To explore the concept called computer literacy, and to see how it has changed over time.

Effective Communication

Effective communication requires that the sender and receiver have agreed upon a common meaning to the symbols being transmitted. I can send you a message in a code that I have made up. If you don't know the code, effective communication does not occur. I can speak to you in Russian. If you don't know Russian, effective communication does not occur. A simple model for this idea is as follows:



Note that a good way to represent this is via a Venn diagram, one piece for each of the two communicators. The extent to which the two pieces of the diagram overlap represents the extent of the shared knowledge and experience of the two communicators.

Psychotherapists talk about "shared reality." A mentally ill person's "reality" might be quite different from that of other people, making communication difficult. A computer educator's reality might be quite different than an artist's reality.

The use of the somewhat vague terminology "COMMUNICATOR" was deliberate. While our first thought might be that the two communicators are people, we might have one or both be machines. When one of the communicators is a computer, we are clearly aware of the limitations in language. A computer language has carefully defined syntax (rules of grammar) and semantics (meaning). If a computer system is set up to communicate in the BASIC programming language, sending it messages written in Logo or Pascal will merely produce a number of error codes or messages in response.

The field of artificial intelligence has as one of its major goals the improvement of the capability of a computer as a communicator. This turns out to be a very difficult task. One can see the difficulty by studying progress in the computerized translation of natural languages over the past twenty-five years. In the early 1960s, it appeared as though substantial progress was occurring. The Central Intelligence Agency of the US government was heavily funding research and development in computerized language translation. But very little worthwhile success was realized. While it was possible to computerize a dictionary and to do rapid lookup of words, that proved to be only a small part of the task.

Computer scientists and linguists eventually understood that the problem was very difficult. Language translation is not a word-for-word translation; it is an idea-for-idea translation. The work of Noam Chomsky on computational linguistics has helped in the development of a theoretical foundation upon which progress in language translation could occur. Many researchers in artificial intelligence have added significant pieces to the puzzle.

Substantial progress has occurred in recent years. We now have commercially available software that is a major aid in language translation. A human translator, skilled in using this software, may be two to three times as fast in doing translation work as a person not aided by the computer. But acceptable quality translation purely by computer is still not yet possible. One of the goals of the Fifth Generation Project in Japan is to produce good language translation systems. Currently (1988) it is not at all evident that this aspect of the Fifth Generation Project will be successful.

Voice input to a computer is related to the language translation problem. As I am talking I use the word “to.” How can a voice input unit know whether I have said to, too, two, or the first part of tooth? It takes considerable understanding of what is being said to figure this out. Note also the problem in voice input of taking connected speech (the way we usually talk) and dividing it into individual words. This has proven to be a very difficult problem. However, significant progress is occurring. In 1988 work at Carnegie Mellon University, making use of neural nets, gave indication that neural net computer systems may be quite successful in solving this problem. Commercially available voice input systems, making use of more traditional computer systems, are just beginning to gain acceptance in the market place.

The simple model for communication in the above diagram can be used to discuss the concept of a programming language and some of the difficulties in communicating with a computer. It can also be used to explain the importance of language arts instruction in a country's school system. It is very helpful to national unity if there can be easy effective communication among the people in a country. One aid to effective communication is a commonality of language. The people attempting to communicate need to have common vocabulary, and they need to attach the same meanings to the words. But words carry meaning partly based upon the cultural experiences of the people involved. Words have emotional content. The tone of voice and body language of a speaker add to the meaning. All of these things lend insight into the difficulty of the problem of computer processing of natural language.

Computer Literacy

It is easy to fall into a communications trap, in which one assumes that both parties attempting to communicate not only share the same vocabulary but also attach the same meaning to the vocabulary. In the early 1970s Art Luehrmann used the phrase “computer literacy” in his writings. In April 1972 the Conference Board of the Mathematical Sciences Committee on Computer Education published Recommendations Regarding Computers in High School Education. Pages 3 and 4 of this report contain the following:

2. A Universal Computer-Literacy Course

Computers now impinge in a very direct way on the lives of practically every citizen of this country. Computers compute gas bills, phone bills, and bank balances. Computers check income tax returns. Computers process the data from the decennial census. Computers predict who will be elected. Computers print out monthly welfare checks.

Of course, computers do many other important things in our society. They are used to operate factories and oil refineries. They are used by businessmen to plan and supervise their business operations. They are used to keep track of the need for food, supplies, etc., of our armed forces. Without computers our moon landings would have been impossible. But the examples in the preceding paragraph indicate that computers have very direct impact on the average U.S. citizen.

The average U.S. citizen hasn't the foggiest idea of how computers work and how pervasive their influence actually is. Consequently, he has no idea of what to do when a computer system makes a mistake; he has no idea of now to vote on local, state, or national issues involving computers (e.g., the establishment of a national data bank); he is, in short, culturally disadvantaged.

It is therefore essential that our educational system be modified in such a way that every student (i.e., every perspective citizen) become acquainted with the nature of computers and the current and potential roles which they play in our society. It is probably too late to do much about adults, but it would be disastrous to neglect the next generations.

We therefore recommend that the National Science Foundation encourage and provide financial support for the preparation and periodic revision of at least one secondary school course in “computer literacy."

At a minimum, this course should:

a. Give the student enough understanding about the way the computer works to allow him to understand what computers can and cannot do. Wherever possible, this should involve at least a minimum of direct interaction with a computer, primarily (at this level) through the use of appropriately pre-programmed application packages.

b. Include a wide sampling of the ways in which computers are used in our society, with non-numeric as well as numeric applications. The impact of these various uses on the individual should be made clear.

c. Introduce the notion of an algorithm, and its representation by flow charts; where time allows and as equipment becomes available, discuss the manner in which algorithms are represented by programs and the way in which programs are executed by machines.

Since the course is intended for all students, the course materials may have to be prepared in two different formats: one for above-average students and the other for below-average students. The latter should contain more illustrative examples, and the former should penetrate more deeply into at least some of the topics.

We suggest that the course be designed for junior high school students. This is about as late as the requirement of specific courses can be insisted on by local school systems. Also, by grade eight, students will have been exposed to enough mathematics so that a reasonable variety of computer activities can be discussed meaningfully.

A course meeting two periods a week throughout the year or four periods a week for one semester should be sufficient to accomplish the purposes mentioned above.

In essence, the above quote provides a 1972 definition of computer literacy. Federal funding for the development of a junior high school computer literacy course was not forthcoming, but substantial progress toward universal computer literacy requirements has occurred during the past decade. By 1985 a number of states had established requirements of passing a computer literacy course or passing a computer literacy test for all secondary school students. For example, in the fall of 1986 the state of Texas began requiring that all students entering the ninth grade either have had a half-year computer literacy course while in the previous two grades or have passed a computer literacy test.

TRIAD GROUP EXERCISE: 10-15 minutes. In triads, discuss the current meaning of "computer literacy." Is the term well defined (that is, is there relatively universal agreement on its meaning)? Has the definition changed since 1972? Will the definition change in the next decade?

DEBRIEF: 5-10 minutes. Lead a whole group discussion sharing ideas that came out in the small group discussions. Ask for a show of hands on how many groups reached consensus on the current meaning of computer literacy. If only a small number indicate "yes," then have one of the groups provide a definition. By a show of hands, see how many people agree with the definition.

The lack of a universal definition of computer literacy is particularly troublesome as governmental agencies establish requirements for computer literacy. The usual answer is to require a course and to specify its length. Sometimes a few of the major goals of the course are specified.

Such an approach tends to make it difficult for schools to implement computer literacy through integration of appropriate computer use and ideas into a variety of courses and parts of the curriculum. Moreover, there are a growing of computer scientists and computer educators who argue against having any sort of computer literacy requirement. Dan McCracken, noted author, lecturer, and educator, has written and spoken out against required computer literacy in recent years. (For example, see his paper in the Proceedings of the August 1985 conference "Extensions of the Human Mind" sponsored by the University of Oregon.)

TRIAD GROUP EXERCISE: 10 minutes. What are some good arguments against requiring students to take a computer literacy course or to pass a comparable computer literacy test? Do the same arguments hold against expecting that all students will participate in courses that make regular use of computers and are designed to impart a certain type of computer literacy? (A math course requiring use of a sophisticated calculator is an example of the type of course we are talking about. A writing course requiring use of a word processor is another example.)

WHOLE GROUP DEBRIEF: Ask workshop participants to share some of their best arguments against requiring a computer literacy course. Ask for a show of hands on how many are against requiring a computer literacy course at the precollege level. The discussion might also focus on whether participants will have the same opinions five to ten years from now. Perhaps the need for required computer literacy courses is decreasing at the same time that more students are being required to take such courses.

It is now suggested by many computer education leaders that students can gain the desired levels of computer literacy through learning to use computer-as-tool in a variety of courses and through routine use of computer-assisted instruction to help learn a variety of subjects. Such leaders suggest that the need for computer literacy courses will soon disappear.

Language and Vocabulary

The above computer literacy exercises provide a convincing illustration of the difficulties of communication in the computer education field. The field is still so young that a standard vocabulary has not yet developed. Important terms, such as computer literacy, still have considerably different meanings to different people. Different people see the computer education field in substantially different ways.

Most people don't give much thought to the need for precise vocabulary. But the essence of science is precise vocabulary and notation, to allow accurate communication over both distance and time. In math, for example, the theorems of Euclid, proved 2000 years ago, are still valid. People sometimes speak of algebra as mainly being a language—a notational system. Most college courses have a substantial vocabulary content. I once estimated that one was expected to learn about a hundred new words per college course. I don't know how accurate that estimate is, but it is suggestive that every discipline has a specialized vocabulary and learning the vocabulary is an important part of learning a discipline.

Recently I looked at several first year high school algebra texts. Most appeared to have glossaries of about 200 terms. Suppose that one concludes that the main purpose of a first year high school algebra course is to learn some notation and vocabulary. Then the availability of computer-assisted graphing and equation-solving systems makes no appreciable difference in such a course. Having computer programs that can automatically solve the types of problems being studied (which are often mainly symbol manipulation tasks) may actually distract from the repeated and mundane usage of the vocabulary and notation needed to integrate it into one's active language system. This type of analysis might help to explain why computers have had so little effect in such courses.

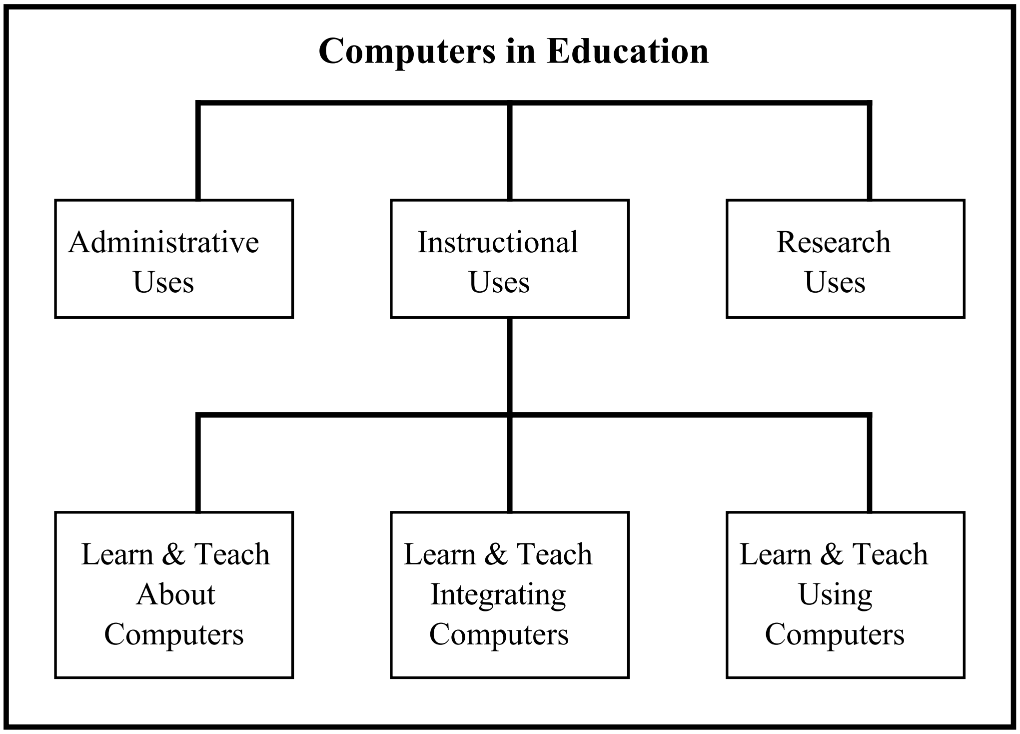
This analysis also suggests a possible change in mathematics education. Rarely do math classes have students talk to each other about mathematics. Students get little chance to use their verbal skills as they learn the language of mathematics. One can make similar arguments about written communication in mathematics. Students do routine symbol manipulation, but rarely are they expected to write about mathematics or to communicate mathematical ideas in writing. One (now, classical) argument for having students in math classes write computer programs is the conjecture that this form of written communication helps one to learn the mathematics under consideration.

The previous paragraph suggests that Cooperative Learning might be quite successful in mathematics instruction. There is a slowly growing body of research literature that supports this position.

Instructional Uses of Computers

To facilitate our workshop discussions on instructional uses of computers, we are going to examine a particular model. In this model the instructional uses of computers are divided into three major categories. The categories are labeled learning/teaching about computers, learning/teaching using computers, and learning/teaching integrating computers.

A “model” of educational uses of computers focusing on instructional uses. Note that it contains both the student orientation (learning) and the teacher orientation (teaching).



Learning/teaching about computers considers the discipline of computer and information science (indeed, the still larger discipline which includes data processing and computer engineering) and asks what parts of that discipline should be taught at the precollege level. We do this with every discipline. Some disciplines, such as reading, writing, and arithmetic are deemed to be "core," essential to the education of all students. Other disciplines, such as nuclear engineering, genetic engineering and Greek receive little attention in our current precollege curriculum.

Computer science is now a well established discipline at the college and university level. The Association for Computing Machinery's "Curriculum 68" helped to define the undergraduate computer science curriculum nearly twenty years ago. "Curriculum 78," published about ten years later, suggested major changes and that the discipline was beginning to show some signs of maturity. The preliminary version of "Curriculum 88" which was released during 1988 suggests some major changes to the college computer curriculum. The Advanced Placement (Pascal) exam which has now been in use for several years helps to define a solid introductory computer science course for secondary schools as well as higher education.

It is important to understand why the three Rs are considered part of the "Basics" of education, to be required of all students starting in the first grade or earlier. Reading, writing, and arithmetic (mathematics) are each important disciplines in their own rights. One can specialize in any one of them in college, eventually getting a graduate degree in any of these areas. But each of the three Rs is also a tool, applicable in the study of other disciplines. Reading gives access to the accumulated knowledge of the human race. Writing provides a method of communication and is also an aid to organizing one's thoughts while attempting to solve problems. Arithmetic (more generally, mathematics) provides a new language and the ability to represent and manipulate numbers and other mathematical entities. It is essential to understanding and doing science, and it is an important aid in solving a wide range of problems..

OPTIONAL TRIAD GROUP EXERCISE: 10 minutes. In triads, discuss the question of whether the field of computer and information science is sufficiently important (in the sense that the three Rs are) so one can argue that substantial instruction in computer and information science should be integrated into the K-12 scope and sequence.

DEBRIEF OF OPTIONAL EXERCISE (5 minutes). Ask for a show of hands of how many triads reached consensus on the yes or no side of this topic. Ask for a sharing of a few key arguments in each direction. Be especially alert for suggestions that one learns transferable skills and techniques for problem solving by studying computer and information science. The research literature provides little evidence to back such suggestions.

One purpose of this exercise is to get workshop participants to discover for themselves certain aspects of the remaining two major categories of instructional use of computers. Computer-assisted learning is potentially quite important to all students. But maybe one doesn't need substantial knowledge of computer and information science in order to learn to make effective use of CAL. Similarly, the idea of computer-integrated instruction (CII) is quite important. But perhaps it can be effectively implemented without spending much time in direct study of computer and information science.

For me, probably the single most important idea from computer and information science is that of a (computerizable) effective procedure. Perhaps one can only come to fully appreciate and understand the concept of a computerizable effective procedure through a study of computer science. One might build a case for instruction in computer programming based upon the importance of effective procedures. The topic of (computerizable) effective procedure is discussed in more detail in the Problem Solving session of these materials.

Learning/teaching using computers is often called computer-assisted learning (CAL). In this workshop the term CAL refers to all aspects of using computers in the instructional delivery system, to aid either the student or the teacher. CAL can be divided into two (somewhat overlapping) subcategories. One major category is computer-managed instruction, with both diagnosis and prescription. An example is use of computers to generate and implement Individual Educational Plans (IEPs), for example as used in special education. A second category, often called computer-assisted instruction, includes drill and practice, tutorials and simulations.

As an aside, we have some evidence that supports the contention that IEPs are a good idea. If they are, then why not have them for all students? Substantial progress has occurred in the development of software that is useful in producing (and implementing) IEPs. Perhaps someday we will extend the idea of an IEP to all students.

The more general topic of the role of computers in individualized instruction is covered in Computers and Individualized Learning written by Richard Robbat and published by ICCE in 1986. He suggests that computers can contribute significantly to the individualization of instruction. However, there are many strong factors working against individualization of instruction.

Note that one cannot easily draw a fine line between the first two categories of instructional uses of computers. Seymour Papert speaks of microworlds, and he suggests that immersing a student in a Logo environment will contribute substantially to the student's educational growth.

Perhaps such a student studies and uses Logo as an aid to learning about angles and shapes in geometry. The specific study of problem solving in a Logo environment, and the study of programming in Logo, would probably be considered to be part of learning/teaching about computers. But the use of this Logo and computer science knowledge would probably be considered to be part of CAL.

Computer-integrated instruction is concerned with integration of computers both as a tool and as a source of problems in the overall curriculum. The computer makes available tools such as word processing, graphics packages, spreadsheets, filers, database systems, statistical packages, and so on. A simple-minded example is provided by handheld calculators. For many years most leading mathematics educators have been recommending a substantial decrease in the teaching of paper and pencil computational skills and a substantial increase in teaching of higher level cognitive processes. The calculator tool makes possible a substantial change in the mathematics curriculum. Similarly, large changes might be possible if a word processor with spelling checker, grammar checker and various aids to organizing one's ideas were an everyday tool of all students.

There are a number of teacher productivity tools that might be classified under computer-integrated instruction. A teacher might use a computerized gradebook, a word processor to develop and store lesson plans and handouts, computer graphics to make visuals, a test generation program, etc.

New tools are coming. The availability of voice input would further complicate the issue of what we want students to learn about writing. Voice input is close to becoming a reality. It is, of course, one of the objectives of the Fifth Generation Project in Japan. Raymond Kurzweil brought a voice input system to market during 1988. IBM and several other companies are making good progress in this same field. Sooner or later we indeed will have such computer systems. By twenty years from now we may find such systems routinely used with students who are just beginning to learn to read and write.

This “about, using, integrating” model is certainly not the only model. How is it similar to and different from the “tutor, tool, tutee” model of Robert Taylor discussed in his book The Computer in the School: Tutor, Tool, Tutee published by Teachers College Press in 1980? The following discussion question assumes that a reasonable number of the participants have read Taylor's book. It is useful to the workshop facilitator to know how many participants have read Taylor's book. Many people who have seriously studied the computer education field have done so. It provides a good historical perspective of the early work done by five of the pioneers of computer education (Alfred Bork, Thomas Dwyer, Arthur Luehrmann, Seymour Papert, and Patrick Suppes). It comes as a surprise to many people that these pioneers were so insightful. The fact that all four of these people are still active scholars (Thomas Dwyer recently retired) is evidence of the youth of the field of computer education.

WHOLE GROUP DISCUSSION: What are similarities and differences between the two models of instructional use of computers? What ideas that are currently considered to be important in computer education are not included in the writings contained in Taylor's book? (That is, have there been really solid advances in computers-in-education that were not foreseen by these pioneers?)

The “about, using, integrating” model is somewhat more comprehensive and far-reaching than Taylor's model. It suggests possible substantial change in the content of curriculum—what it means to "know" a certain subject. There is quite a difference between tutor and learning/teaching about computers. Tutor mode is essentially restricted to computer programming, and there is much more to computer and information science than just computer programming.

When one puts forth a model such as either of the above, it is important that there not be major gaps. What is missing? It is almost always easier to see what is there rather than to see what is missing. A leader must have the deeper understanding, because most of the people being led will accept on faith the general models put forth by the leader.

OPTIONAL TRIAD EXERCISE: 5-10 minutes. In triads, discuss what is missing in the "about, using, integrating" model. That is, think of the various aspects of instructional uses of computers. See whether each is present in the model and how comfortably it seems to fit into the model.

DEBRIEF OF OPTIONAL EXERCISE: 5-10 minutes. Have people share the ideas discussed in triads. The intent is to clarify the model, to provide a more solid foundation for communication in the remainder of the workshop.

Computer Literacy Revisited

We began this session with a discussion of computer literacy. We could end in the same manner. Computer literacy can be defined in terms of the three-part model of instructional uses of computers in education. It is a balance of learning/teaching about, using, and integrating computers. The nature of the balance will be dependent on the particular school system, availability of appropriate hardware, software and support materials, and ability of educators to implement whatever balance is selected.

For example, in the Problem Solving session of this workshop we will argue that the notion of computerizable effective procedure is fundamental to computer and information science and is one of the most important ideas to be developed in the twentieth century. It could well be that the best way to teach the idea of computerizable effective procedure is to have students learn to write computer programs. If so, this constitutes a strong argument for including computer programming in a definition of computer literacy and having all students learn some computer programming. Of course, this also suggests that teachers who are teaching introductory computer programming should thoroughly understand and should emphasize the idea of computerizable effective procedure.

CAL is but one of many current or possible approaches to instruction. However, it seems clear that CAL is of growing importance. One goal of education is to have all students learn to learn. This means that they should experience and learn about a variety of aides to learning. Some use of CAL can be justified by this type of argument even in situations where CAL is not cost effective. One argues that students should have the opportunity to experience use of a broad range of CAL materials in a variety of disciplines and at a variety of grade levels. CAL is discussed more in the session on Analysis of the CAL Goal.

I believe that the majority of computer education leaders now feel that the most important aspect of computer literacy is its computer-integrated instruction component. Many schools and school districts are implementing plans for all students to learn to use a variety of computer tools. Full implementation of these plans will require a massive increase in availability of computer hardware. It also requires considerable teacher training and reconsideration of the overall curriculum.

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Appendix to Session 2:

Gender Equity in Computer Learning

A Review of the Research

by Cynthia Landeen

[Editor's note: This Appendix was written by Cynthia Landeen as part of the work in Sharon Yoder's computers in Education Seminar, University of Oregon, Fall 1988. The High Tech/High Touch book was part of the required readings for the course. All students were given the assignment of writing an addition the text that they felt would be useful to students taking the course. They were told that some of their writings would be added to subsequent editions of the text, to help produce a living, growing text.]

Historically, computing is a relatively new field, a field that is not and never has been the exclusive domain of men. Women have made valuable contributions to the development and application of computers. The world's first computer programmer was August Ada Lovelace, who wrote the instructions for Babbage's computing machine in the 1800's. Adele Goldstein wrote the first programs for the ENIAC, a computer built in the 1940's and operated by 100 female programmers. Grace Hopper was the central figure in the development of the language COBOL and she was also the first person to use the term “bug” to refer to a computer malfunction (after finding a moth in the machine).

It appears, however, that as computers become more a part of our everyday world they are becoming sex-linked. It is as if the computer is yet another machine apparently understood only by the collective male intelligence. A review of the literature on computer use is distressing. Research shows that when it comes to computers, males dominate. Video game arcades are frequented almost exclusively by males (Lockheed, 1985). Voluntary participation with computers through clubs, camps and classes shows males outnumbering females in ratios that vary from 9:1 to 3:1 (Hess & Miura, 1985). School based computer centers also appear to be primarily used by males, with male to female ratios ranging as high as 20:1 (Lockheed et al., 1983).

Computer equity is the process of making computer learning equally available to all students. To the extent that some students are missing opportunities to engage in computer learning, there is inequity. Surveys of school-aged children repeatedly show that the present generation of girls is aware of, and interested in, computer technology. For example, the 1983 Gallup Youth Survey reported that 65% of girls aged 13-19 planned to take computer courses in college, and over half of that group thought it likely they would have a computer related major in college. How is it then, that boys are gaining an edge in the use of computer technology? Research shows that the gender of the computer teacher is not the significant factor (Stasz et al, 1985). Although no research is available, Sanders (1985) has suggested that inequity in computer use is a function of social factors. In this paper I will discuss the research that has been done on the topic of gender inequity in computer use, drawing conclusions from the literature and suggesting possible topics for further study. This examination and analysis of the research can serve as a beginning for the process of determining the factors that explain the male domination of computers.

Research Regarding Boys, Girls, and Computers

Becker and Sterling (1987) conducted two national surveys of schools to obtain detailed data about how computers were being used for instruction. The second survey conducted in the Spring of 1985 employed a stratified probability sampling design to select 2,331 public and non-public elementary and secondary schools nationwide. At each school the primary computer teacher was asked to complete a ten to eighteen page questionnaire about computer use in their school as a whole. In addition, a stratified sample of various types of other teachers were asked to complete one of seven separate fourteen page questionnaires about how they used computers in their own teaching. In this survey Becker and Sterling show that in at least 20 percent of the elementary schools offering computer programming as an elective, no girls participated in it. A great many school reported substantial male dominance, especially in before and after school activities, in game playing in middle and high schools, and in elective programming activities in elementary schools. In contrast, there were almost no areas where even a small fraction of schools reported dominance by female computer users. The only exception is that a clear majority of the word processing users in high school (but not at lower grade levels) were girls. Thus, in a substantial percentage of schools at all levels, boys dominate time on school computers.

In a study done by Wilder, Mackie and Cooper (1985), a developmental survey was conducted among the student body of a suburban school district in New Jersey. All students responded by indicating liking for and perceptions of sex appropriateness of common items and activities, among them computers and video games. There was sufficient evidence to substantiate the hypothesis that males and females view the computers as a male activity. On a scale where 1=mostly for boys, and 9=mostly for girls, responses were slightly, but consistently and statistically significantly, on the masculine side of the midpoint. The overall mean for students in grades K-12 was 4.59. The pattern was consistent for students of both genders. Boys perceived the computer as slightly (but statistically significantly) more appropriate to males than did girls Mean = 4.40, as did girls (Mean = 4.74). The data collected in this study suggest that children begin school with a belief in the neutrality of computers. Overtime, however, there is an apparent tendency for children to see computer use as a more masculine than feminine endeavor. The extent to which computers were sex typed shifted slightly from grade to grade, but it was present throughout the school years. Females consistently saw computers as less male appropriate than did males, but both sexes saw computers in the male domain.

In a related study, Eastman and Krendl (1987) hypothesized that experience with computers might alter sex-related attitudes toward computers. Computer searches on an electronic encyclopedia were used for the students' computer experience, thinking that this application might be seen as more related to writing than to mathematics. Twenty-six eighth graders (11 female, 15 male) were studied while they used TRS-80 computers to access an electronic encyclopedia (Academic American). This computer class was compared to another class of 31 students (17 female, 14 male) that used only print materials in the school library and a control group of 23 students (10 female, 13 male) that did not do a research assignment. To assess achievement on the computers, seven measures were examined. To assess attitudes before and after computer use, responses to 22 items on a questionnaire were evaluated.

Results from the Eastman and Krendl (1987) study indicated girls had significantly higher scores for organization ($F(2.55)=7.05$, $p<.01$), presentation ($F(2.55)=5.90$, $p<.01$), and referencing ability ($F(2.55)=3.92$, $p<.05$), than did boys. Somewhat surprisingly, results from the comparison of the computer achievement measures showed little difference between boys and girls' performance on any of the seven measures. However, the comparison of pretest means by gender for the 80 students did show a significant difference for attitudes toward computer-and-gender-roles ($F(6.73)=6.42$, $p<.01$). On the computers-and-gender-role items, boys held more stereotypical views than girls ($F(6.73)=6.10$, $p<.05$). For example, girls were less likely to expect that their abilities would differ from boys, and girls were less likely to think that mathematics skills were related to learning to use computers. The pattern of interest here is that based on the analysis of responses to the test items assessing attitudes toward computers-and-gender-role, significant sex-related differences found on the pretest disappeared on the posttest.

The study by Eastman and Krendl (1987) suggests several positive approaches to computers for schools. It suggests that the middle-school/junior high grades are developmentally suitable for introducing computers as research tools for the classroom in a way that positively effects some social attitudes held by the students. It also suggests that motivation to use and achieve on computers is not tied to gender. Furthermore, it suggests that computers are appropriate teaching tools for traditional learning as well as for learning new skills.

The study by Wilder et al (1985) shows that the differences between the sexes in attitudes toward the computer are statistically significant, but quite small in an absolute sense. Similarly while boys and girls tend to view the computer as a more masculine than feminine activity, the ratings of both sexes are closer to the neutral point on the scale than they are to the extreme masculine end of the range. One possibility for this is that the differences in behavior are related to something other than students' attitudes. For example, what attracts males and fails to attract females to the computer may be the fact that much of the software has largely employed the metaphors of war and sports, traditional areas of male interest. This is evidence that student achievement on computers may be more related to the kind of activity for which computers are used than any inherent sex related differences.

The Teacher's Role

Education is an area in which women comprise a majority of computer users. Using data from a national survey of schools Becker (1985) found that women comprise 67% of the most knowledgeable computer using teachers in elementary grades and 44% of the most knowledgeable computer using teachers in the secondary schools.

Where does the educator fit in among the questions surrounding computer equity? Does the gender of the teacher influence the computer use by the student? Even apart from specific pedagogical techniques, the gender of the teacher can be influential. While it is often assumed that girls need to see women in roles normally identified as male however Stasz, Shavelson and Stasz (1985) found that male and female teachers present equally viable role models in the areas of computer based math and science education.

Becker (1985) surveyed a stratified sample of 2,265 elementary and secondary schools. The primary computer teacher, as designated by the school principal, responded to an eighteen-page questionnaire. These teachers provided data about thirteen ways of using microcomputers in their classes. Becker (1985) found that computer-using teachers use microcomputers in the same way regardless of gender. In elementary schools, both groups of teachers use microcomputers mainly as a part of math instruction, and secondarily as part of English instruction and to teach students about computers, independent of their role as tools that provide practice in math or English. Among secondary school teachers, most used computers as an object of instruction, and it's use as a tool in math instruction fell to second place. The findings of Stasz, Shavelson and Stasz (1985) strongly support Becker's conclusions. Their study indicated that district and school characteristics as well as classroom organization and composition did not differ between male and female teachers. Furthermore, gender was unrelated to teachers' subject matter and computer knowledge, patterns of microcomputer-based instruction, and instructional decisions and practices. They found no correlations between gender and microcomputer use.

In attitude, Becker (1985) found that women computer-using elementary school teachers had much more positive attitudes about microcomputers than men in every area of the curriculum. Becker (1985) also found women to appear to be more flexible and innovative. The overall results for elementary schools suggest that women acting in the role of the computer using teacher have been at least as successful as the men, and by some measures females have been more successful than their male counterparts.

Significant differences were found by Becker (1985) as a function of the primary computer teacher's gender. Male teachers as a group had more involvement with microcomputers and their schools' use of microcomputers was substantially more intensive than in schools where women were the primary computer teachers (15.9 vs. 14.7 hours per week). Secondary schools with male microcomputer teachers seemed to have stronger programs noted by 86 minutes/week vs. 65 minutes/week ($p<.01$) spent by the average student on the computer. Finally schools with men as primary computer teachers reported more learning by average and above average students. 73% of the men reported that the above average student learned “much more” as a result of the computers, while only 15% of the women teachers gave this answer. (At the elementary level, the figures were 11% and 31%.) Using regression analysis the reason for the gender difference seemed to be that the men had a greater personal involvement as computer enthusiasts. In regression analysis of other outcomes, gender of the computer teacher was a significant factor.

While there have been no published studies of how secondary school girls respond to a computer teacher of either gender in the classroom, the presence of a woman computer teacher at the secondary level does seem to influence girls in social activities regarding computers. With a woman teacher, membership in computer clubs was more likely to include a balanced proportion of boys and girls. In 81% of the computer clubs at secondary schools with a male computer teacher 60% or more members were boys. This is still true for 51% of the clubs with a female teacher. But the 30% difference is substantial and statistically significant, ($p<.001$).

What Causes Gender Inequities

Using computers in schools is a fairly new development, and the research described in this article is representative of what is currently known. The studies document the existence of the sex discrepancy in computer use.

Sanders (1985) has suggested some of the probable causes for inequity in computer use. A major reason for the sex discrepancy which increases in the middle grades can be attributed to social factors. Average teenage girls are highly social and enjoy being with their friends. Results from questionnaires given to 250 middle school girls in New Jersey, Oregon and Wisconsin found that the most powerful factor discouraging girls from using computers was “the absence of friends” (Sanders, 1985). Girls apparently prefer to participate in activities with social contact. Computer use, on the other hand, is frequently a solitary activity and the contact is with a machine. The location and arrangement of computers may also reinforce the lack of social communication. Since computers are usually arranged in rows with one student per machine, computer use tends to be a very individual activity.

Traditionally, computers have been regarded as a solitary male activity with a strong emphasis on mathematics and competition. Trying to compete with boys is considered unfeminine. In fact, socially approved helplessness is at its strongest at puberty, and therefore it is acceptable for girls at the middle school ages to give up in the face of difficulty. Therefore when the number of computers is limited, and they are used on a first come, first served basis, boys tend to be more aggressive and the girls back away (Sanders, 1985).

Computers are used mainly for mathematics and business education. Often the computers are located in math rooms and the courses are taught by male teachers. Mathematics has a strong male connotation, and programming classes that stress BASIC and Pascal place greater emphasis on mathematics and problem solving than does Logo for instance (Fisher, 1984).

Software also stresses competition and games. Many programs promote conflict and violence in win or lose situations. In a software survey (Sanders, 1984) of 157 middle school students and 30 adults enrolled in computer classes, 40% of the software appealed predominantly to only males, 15% to only females and the rest to both. Both video games and educational software stress violent action, aggressiveness, sports and space wars. Girls however prefer fantasy, simulations, artistic and word oriented rewards (Fisher, 1984).

Why Does the Sex Discrepancy Matter

Sex discrepancy in computer use matters because it may lead into an occupational and economic discrepancy when today's children grow up into tomorrow’s adults. It is possible that in our lifetime, computer literacy will become as necessary as a high school diploma. The U.S. Department of Labor estimates that by the time our children enter the job market, 50-75% of the jobs will involve computers in some way: operation, repair, hardware and software design, sales, programming and service delivery among them. Many jobs will require the ability to use the computer in ways that range from limited button pushing to sophisticated programming. Those among us who are not computer literate enough to fill the requirements of such jobs will indeed be disadvantaged in the job market

Women are already disadvantaged in the job market. They continue, year after year, to earn about 59% of what men earn. Put another way, the average female college graduate earns about the same income as the average male high school dropout, about $12,000. A major reason for the salary discrepancy is occupational segregation, or the tendency of men and women to cluster in “single-sex” jobs. Women constitute 80% of all clerical workers, but only 6% of all craft workers. The average female clerical worker earns $11,400 per year; the average male craft worker earns $18,720 per year. In the computer field, more women are computer operators at $12,065 a year (63%) than systems analysts at $26,728 a year (25%). As a very reliable rule of thumb, the more male the occupation, the higher the salary.

Although these figures are well documented, there is a human reality of artificially constricted careers and limited job satisfaction and achievement. The greater human tragedy is of adults who, despite their best efforts, cannot support themselves and their children decently because their jobs pay less than a decent salary. Lack of computer skills is likely to relegate future workers to low-skill, low-pay jobs.

Many junior high school teachers point out that the typical fourteen year old girl is barely aware she will grow up, let alone that she will work for a living. Nevertheless, she needs to know that when she does grow up, she can expect to spend about 28 years of her adult life working for pay. We'd better make sure she's as prepared to do so as her male classmates.

Recommendations

The issue of access has been and continues to be explored. Lack of access means less experience, and therefore less knowledge. Unfortunately, research on the educational consequences of school computers is fragmentary, and mostly dated. We need better studies to measure the consequences of the particular ways that schools use computers. For example,

- Researchers need to construct a knowledge base that describes the impact of the resources currently being used in the schools and designed to offset inequitable behaviors;
- Research needs to be done regarding different, more androgynous forms of software, to find how we can encourage children of both genders toward computer use;
- Classrooms can be arranged to encourage cooperative learning, in circles or in clusters;
- Women need to be encouraged to teach in the traditional fields of math and science as a means of encouraging girls toward non-traditional fields;
- More information needs to be gathered from girls regarding social needs and how these can be applied to computer learning situations.

This is only a partial list, but it offers many opportunities for research into practical applications of computer learning.

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Session 3: Leadership Traits

Goals

1. To create and study a list of leadership characteristics.
2. To explore the concept “You are enough."
3. To increase understanding of leadership roles in a high tech/high touch society.

Communication Skills

Probably the most important trait of a majority of successful leaders is good communication skills. Thus, we begin this session with a discussion of some modes of communication.

Active Listening is essentially a one-on-one mode of facilitating effective communication. It is a skill that many people pick up on their own. It is a skill that most of us get a chance to practice on a daily basis. Conscious practice can improve one's Active Listening skills. The few minutes in Session 1 that were spent on this topic can provide a useful introduction to those who have never encountered it before. But some colleges offer full courses on active listening and related skills, so there is much more to learn than covered in the short exercise we did earlier in the workshop.

We are all used to the idea of a one-on-many communication, such as in talking to a group. As educators, we often get an opportunity to practice our one-on-many oral presentation skills, in talking to a class of students or to a collection of educators.

Perhaps the biggest difference between one-on-one and one-on-many oral communication is the difficulty in receiving feedback from one's audience. In a one-on-one conversation much of the communication may be via body language. The raising of a eyebrow or a slight wrinkling of the forehead may carry as much information as dozens of words. Such nonverbal communication provides needed feedback to the speaker. It supplements and often even replaces verbal feedback.

A person speaking before an audience also needs feedback. Feedback is needed to check if effective communication is occurring and so one can personalize the communication to fit the specific needs of the audience. It is more difficult to obtain feedback from a large audience than it is from a single individual. But a skilled speaker is able to “read” the audience, to sense their moods and how well they are understanding the presentation. Also, the opportunity exists to ask for a show of hands, to ask for questions, and to use other interactive techniques.

You may have noticed that many of the situation comedies on television are “video taped before a studio audience.” Most performers perform better if there is some form of feedback from a live audience. Performers learn to develop a rapport with the audience; this performer-to-audience rapport helps to improve the quality of the communication. And notice the combination of high touch with high tech. Both performers and producers must have appropriate balances between their “tech” and their “touch” skills.

Likely you remember the first time you had to speak before a large group of adults. Many teachers still fear doing such presentations, even though they are quite experienced in working with a classroom full of students. Perhaps the major difference is experience. With practice one learns to communicate with a group, obtaining feedback as needed. But most teachers don't get such practice.

Writing is another form of one-on-many communication. Writing is clearly a different skill than oral presentation. Most computer education leaders (such as participants in my High Tech/High Touch workshops) are comfortable with their oral presentation skills. But at the same time, many of these educators display the “I can't write” syndrome. Certainly I have found this to be the case as I work to find teachers who will write articles for The Computing Teacher that are representative of what they are doing with their students in the classroom. Many teachers are doing really excellent things with their students, but are unable or unwilling to share their knowledge via writing. (Many of these teachers are willing to present workshops or give talks at conferences.) A later Session of this workshop addresses the “I can't write.” syndrome.

The “touch” idea in our high tech/high touch model may help explain some educators' writing difficulties. One might argue that writing is lower “touch” than is talking or giving oral presentations. This might help explain why a high-touch teacher would rather talk than write.

In any event, consider the problem faced by people trying to develop good interactive computer-assisted learning (CAL) materials. The medium may be a computer with appropriate computer graphics and sound, or it may be a videodisc system. The medium is high tech, and people trying to develop CAL materials generally have had relatively modest experience with the medium. Moreover, the medium is quite a bit different from the more traditional educational-communication media. It is difficult to obtain high quality training and experience in developing CAL materials.

Based on this type of analysis, it is not surprising that the quality of much CAL material leaves something to be desired. Eventually we will have many developers of CAL materials who grew up in a CAL environment and who have developed substantial skills in communicating via this medium. The past few years have seen considerable progress, as CAL developers slowly master this new educational-communication medium.

This analysis can also serve as background for a major discussion about what human teachers can do that computers can't, and vice versa. If workshop time permits, this is an excellent discussion topic.

Growth Groups

Many psychotherapists consider themselves to be master communicators. That is, part of the stock and trade of a psychotherapist is communication skills. Many psychotherapists work with groups. They develop considerable at facilitating group processes. This Leadership Development Workshop makes use of a number of techniques that are used in encounter group, growth group, and group therapy settings.

One of the early books in the personal growth field was written by Carl Rogers. Carl Rogers on Encounter Groups was published in 1970 by Harper & Row. This is a good book for people who want to understand the nature and process of encounter groups and to improve their group facilitation skills.

John Naisbitt, in Megatrends: Ten New Directions Transforming Our Lives (Warner Books, 1982), emphasizes that high tech and high touch go hand in hand. He points out that the rapid movement toward high tech evident in the 1960s was accompanied by rapid growth in the personal growth movement, encounter groups, and so on. Note that Carl Rogers' book was published in 1970, after the movement was well started. Naisbitt points out that much of both the early high tech and the early high touch occurred in California. He uses this as one argument that high tech and high touch are somehow related.

Ask for a show of hands as to who has read Naisbitt's book. In a typical workshop about one-third to one-half of the participants have read the book. To me this suggests that the workshop participants have considerable interest in where our society and educational system are headed. They are open to change.

Ask for a show of hands as to who has participated in and/or led growth groups. The discussion might be directed toward the question of whether such group processes are relevant to educational change. That is, if education is to change, educators will have to change. Might this change be facilitated to some extent by making use of growth group ideas?

A Guided Fantasy

Both writers and speakers can gain considerable skill in one-on-many communication. Part of the way they do this is to know their intended audience. Part of the way is to be good at painting a general picture and letting the audience fill in the details—to personalize what is being presented. The "Clear A Space" exercise used Session 1 is a good example. What does it mean to clear a space in one's mind? The warehouse metaphor, with boxes representing problems, is assigned meaning by each person receiving the communication. But each assigns meaning based upon personal knowledge, characteristics, worldview, previous experience in applying the metaphor, etc.

This view is consistent with the "constructivist" model of learning that is now receiving considerable support from educational researchers and leaders. In essence, each person constructs their own knowledge. In a workshop, each person is exposed to a common set of ideas. But each person interprets these ideas in light of their previous knowledge and experience. Thus, each person comes up with a unique interpretation. That is, each person constructs the new knowledge they will gain based on their previous knowledge and experience.

Effective oral and written communication skills are very useful to anybody, but especially to a person in a leadership position. There are a number of other traits, characteristics, and skills useful to leaders. During this session we will make a list of these characteristics and discuss them. We will use a guided fantasy to help us approach this task.

The idea of a guided fantasy, or a fantasy trip, is an attempt to personalize a one-on-many communication. A guided fantasy is essentially a guided daydream. It can be a very effective mode of communication. It is often used in encounter groups, personal growth groups, human potential movement groups, and in other settings where people are trying to expand their knowledge-of-self.

In a typical workshop, one can expect that several participants have had formal experience with guided fantasy. Ask for a show of hands on who has had guided fantasy training/experience. Ask one or two to share their understanding of guided fantasy. The purpose is to reassure the group that there is nothing to fear. Guided fantasy is merely a mode of one-on-many communication that they may not previously have encountered.

GUIDED FANTASY EXERCISE (10 minutes to present; 10 minutes to debrief in triads; 5 minutes to debrief whole group). Guided fantasies are presented at a slow pace, with frequent pauses to allow participants time to carry out the instructions. Soft background music can be quite helpful but is not required.

> Get yourself into a comfortable position. You may want to set your notebooks and pencils down. Begin to focus on your breathing. Notice how deeply you are breathing, and feel the flow of air into and out of your lungs. Take a deep breath, hold it, and slowly let it out. Feel the air flowing through your lungs. Feel tension flow out as you exhale.
>
> Now you may want to close your eyes. Take another deep breath, hold it, and slowly let it out. With each deep breath you may find that your body will relax a little more. Now take a medium deep breath, hold it for a medium period of time, and slowly exhale. As your body begins to relax, your mind will also begin to relax. Take a medium deep breath, hold it, and slowly let it out. Perhaps your mind is beginning to float. Continue to breath comfortably and fully.
>
> Now I want you to imagine that you are going to visit a school district to observe an educational leader who has a very good reputation. You have heard about this leader from friends who have also visited the school district. They say it was a great experience. Let come into your mind what you might expect during this visit.
>
> As you travel to the school district your mind begins to think about what characteristics this educational leader might have. Why are your friends so positive about this leader? What can this leader possibly do that you don't do? Make a mental list of some characteristics you expect to find.
>
> Now you are at the school district and you are being introduced to the educational leader. Is the leader a man or a woman—old or young? Are you surprised? You notice the way the educational leader greets you, the nature of the first interaction. The two of you chat for a brief time. Imagine what you talk about. How is the educational leader dressed?
>
> Now the leader has an important meeting dealing with educational affairs. You are invited to attend, to sit quietly in the back of the room. You are an observer, watching the educational leader in action. What is the nature of that meeting—the topic to be discussed? Who is at the meeting? Is it just a couple of people, or is it a large meeting?
>
> You continue to observe as the meeting progresses. You see the main issues being brought forth. You see interaction, facilitated by the educational leader. You see leadership skills being demonstrated. Make a mental list of some of these skills.
>
> Now the meeting is ended and you again find yourself in conversation with the educational leader you came to visit. You pay the leader a compliment for handling the difficult meeting so well. You ask the leader to comment on where these leadership skills were developed. How did the leader get to be a leader. Make mental notes on the response.
>
> Now it is time to leave. You say your good-byes, indicating appreciation for the opportunity to visit and to learn. It is time to return to your own job.
>
> Now, as you are ready, I want you to return to this room. You are relaxed and alert. You remember clearly the details of your visit to the school district. Please share your experience with your triad. Take about ten minutes.

TRIAD GROUP DEBRIEF: (Ten minutes) What did you experience? Share it with your triad. One person talks, one person facilitates by active listening, one person observes. Take about two minutes per person.

WHOLE GROUP DEBRIEF: (Ten minutes) What did you experience? Were there any surprises? Was the exercise stressful, or did it seem to reduce your current stress level? (The focus on breathing used at the beginning is a variation on a standard stress-reduction activity called the "Six Breaths" technique. It has two long, deep breaths, two medium breaths, and two regular breaths. More information on stress reduction is given in the Stress and Burnout session.)

What did you learn? Did people in your triad have similar experiences? If discussion lags, bring up the example of the participant in a previous workshop who was unable to visualize a leader—who had no role model. Can one grow in leadership skills without benefit of appropriate role models? Did any participants visualize a COMPUTER EDUCATION leader? There aren't so many role models there.

Was the leader self-made, or a “born leader?” One may believe that leaders are “born leaders,” and thus conclude something about themselves as a potential or actual leader. One's image of a leader may be of a superior being, much different than oneself or ordinary mortals. If so, this can be a serious psychological barrier to becoming a leader.

Were the leaders one pictured women or men? (Have a show of hands. How many women pictured men, and vice versa?) Responses here seem to vary with the part of the world in which the workshop is being held. There are many places where women are still discriminated against. Often the female workshop participants themselves will visualize male leaders. How many people pictured leaders who were older than themselves? How many pictured leaders of their own race?

INDIVIDUAL ACTIVITY: (Five minutes) Make a list of leadership characteristics. Draw on characteristics observed in the fantasy trip as it seems appropriate and useful. Try to write down at least ten important characteristics.

WHOLE GROUP ACTIVITY: (Ten minutes) Make a list of leadership characteristics. Put them on an overhead or chalkboard. Do this by asking one person for one item. Write it down and ask how many had that item. Then ask someone else for another item and repeat the process. Some sample items are given below. These are typical of the types of items that may be mentioned. This is not intended to be a comprehensive list.

1. Pleasant personality; warm and friendly.
2. Good oral communication skills; good active listening skills.
3. Good written communication skills.
4. Skills in facilitating a meeting.
5. Technical knowledge, about the problem at hand.
6. Knowledge of people one works with. Wide range of interests.
7. Knowledge of available resources.
8. Reliable. Punctual. Business-like.
9. Good negotiating skills.
10. Organizational ability. Being a “take charge” person.
11. Sensitive to the needs of others.
12. Goal oriented; keeps people on task and moving toward accomplishing goals.
13. Ability to let others “speak their piece” and to incorporate their ideas into the task at hand.
14. Flexibility; ability to see the big picture and to adjust one's views as circumstances and added information dictate.

15. Sense of humor.
16. Hard working, with a high level of energy.
17. Able to tolerate a high level of stress.
18. Decisiveness, and good change-agent skills.
19. High ideals; honest; good educational values.

DISCUSSION: Note how many of these leadership characteristics are independent of the area in which one is leading. The current president of Apple Computer Company was formerly a marketing manager for Pepsi Cola; clearly he has overall leadership skills that allow him to easily switch from working with people who produce and market soft drinks to working with people who produce and market computers. This raises the issue of technical competence versus general leadership skills. (The technical competence issue comes up again and in more detail in the Computer Coordinators session. Don't emphasize it here if the workshop is to include the session on computer coordinators.) Ask for other general observations from the participants. The participants may observe the number of “people skills.” This is a sign of the importance of high touch.

Also, people may be surprised that nobody has listed characteristics such as “sneaky, politicking, backstabbing, and conniving.” When doing the fantasy trip people tend to visualize a leader with only good characteristics-—perhaps they idealize.

At this point in the debriefing it is appropriate to point out that individually and collectively the workshop participants know what it takes to be a good and successful leader. The workshop participants are aware of their own strengths and weaknesses. They know things they could do to become better leaders. They are confident in their current leadership skills. This is illustrative of the concept “You are enough.” Each workshop participant is a successful educator and leader. Each has the knowledge and potential to become a still better educator and leader. The concept “You are enough.” is illustrated in an exercise given later in this Session.

WHOLE GROUP ACTIVITY: After the list is extensive and if time remains, do the following group activity. Each person is to decide the three most important items on the list. Write their numbers on a piece of paper. Now vote by show of hands, each person getting three votes.
One can pick any item from such a list and discuss its relevance. For example, being a leader is often stressful. If one cannot tolerate high levels of stress, one is apt to find being a leader isn't conducive to having good health.

WHOLE GROUP EXERCISE: YOU ARE ENOUGH. It is easy to be overwhelmed by a long list such as the leadership skills given above. But most workshop participants have most of these skills. The following exercise is designed to emphasize that we have within ourselves the capabilities to be effective leaders. It is a guided imagery exercise.

> Get yourself into a comfortable position. Begin to focus on your breathing. Feel the flow of the air into your lungs. Sense the flow of oxygen throughout your body. Notice the contact of your feet with the floor. Perhaps you can hear the breathing and sense the presence of others in the room.
>
> And now, as you continue to breath comfortably, I will read some of the leadership traits from our list. As your conscious and unconscious mind listen to these traits, they will be aware to what extent you have these traits. Notice how your mind and body react to each item on the list. For

each, be aware that you are enough. Make mental notes of your special strengths. Feel good about your special strengths and talents.

1. Pleasant personality; warm and friendly.

2. Good oral communication skills.

3 Etc. Etc. Etc. (Use the same list as above, shortened if necessary to save time.)

Continue to breath fully and comfortably. Be aware of your strengths and your potentials. Realize that you are enough.

And now, as you are ready, return to this room.

DEBRIEF: Ask workshop participants if they would like to share particular parts of their experience. Is there anybody who didn't learn something through the exercise? (If somebody suggests 'yes' you might point out that they learned that their reaction to the exercise was quite a bit different than the reaction of most workshop participants. If done politely this will produce a good laugh and be a good way to end the session.)

There are a number of good ways to end a workshop session. The facilitator can summarize key points, ask for questions, or ask for a volunteer to summarize key ideas from the session. An activity that I find particularly successful is to ask each participant to get in mind the one or two ideas that were most important to them. Then take about 15-20 seconds per participant to have each person briefly state their one or two key ideas. This exercise strongly supports constructivism. There will usually be a wide range of "most important" ideas. Often these will not be ideas that the workshop facilitator was emphasizing during the session. Note also that this type of closing exercise gives valuable formative and summative evaluation feedback to the facilitator.

References

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Session 4: Higher-Order Skills

Goals

1. To increase understanding of the "back to basics" movement and of the issues involved in lower-order versus higher-order skills.
2. To understand the potential impact of computers on the current balance between lower-order and higher-order skills in our educational system.
3. To examine ways to make use of computers in increasing higher-order skills.

Bloom's Taxonomy

Within each academic discipline there is a continuum of knowledge and skills. This continuum can be viewed or divided in a number of ways. For example, Bloom divides the continuum into (1) knowledge, (2) comprehension, (3) application, (4) analysis, (5) synthesis, and (6) evaluation (Bloom, et al, 1956). Others merely talk about lower-order and higher-order skills. [Note: There is an extensive bibliography at the end of this chapter.]

The "basics" or lower-order end of the knowledge continuum for a particular discipline consists of the facts and skills that serve to define the discipline and allow one to recognize and solve some simple, low level problems of the discipline. In discussing these lower-order facts and skills one might emphasize terms such as recall, training, speed, and accuracy. In mathematics, for example, the one-digit addition "facts" are considered to fall on the lower end of the Bloom's taxonomy scale.

The high-order end of the continuum of knowledge and skills within a discipline is discussed using such terms as analysis, synthesis, interpretation, evaluation, inquiry, reasoning, and problem solving. These are often called "thinking skills." In this Session we will use the terms thinking skills and higher-order skills interchangeably.

WHOLE GROUP EXERCISE: Compile a list of terms used in talking about lower-order skills; compile a second list used in talking about higher-order skills. This can be done by putting the headings Lower-Order Skills and Higher-Order Skills on an overhead projector. Then have workshop participants make contributions to first one list, then the other. The purpose of the exercise is to get participants involved and actively thinking about lower-order versus higher-order skills.

WHOLE GROUP EXERCISE: Have the classroom teachers in the workshop think about how much time they have their students work on lower-order skills, and how much time on higher-order skills. (Participants who are no longer classroom teachers can make estimates based on when they were classroom teachers.) The result is to be expressed as a percentage of time spent on lower-order skills, rounded to the nearest ten percent. Then gather summary statistics from the teachers by asking for data from elementary school teachers, middle school or junior high school teachers, and senior high school teachers.

Lower-Order and Higher-Order Skills

In recent years there have been a number of studies and reports recommending that schools place increased emphasis on higher-order skills. Goodlad, for example, comments on the irony of how much social studies instruction emphasizes lower-order skills when instead it could be developing reasoning skills such as "deriving concepts from related events, testing in a new setting hypotheses derived from another set of circumstances, exploring causal relationships, drawing conclusions from an array of data, …" (Goodlad, 1983).

The Paideia Group analyzes disciplines in terms of (1) acquisition of organized knowledge, (2) development of intellectual skills—skills of learning, and (3) enlarged understanding of ideas and values (Adler, 1982). The third classification emphasizes higher-order skills, and the Paideia Group recommends that this classification receive increased attention.

Summaries of a number of books and reports arguing for increased emphasis on higher-order skills are give in a recent Educational Development Center book (Felt, 1985). Summaries of eleven recent articles on improving students' thinking skills are given in a publication by ERIC (1984). The general flavor of such literature is that leading educators feel our educational system should be placing increased emphasis on problem solving. Most of this literature suggests that we have placed too much emphasis on lower-order skills during the past fifteen years.

WHOLE GROUP EXERCISE: 5 minutes. Pick a discipline you know well. Make a brief list of some of the main lower-order skills in the discipline; make a brief list of some of the higher-order skills. The purpose of this exercise is to help workshop participants to understand whether they can readily differentiate between lower-order and higher-order skills.

DEBRIEF: Ask if anyone had problems differentiating between lower-order and higher-order skills. If so, have them share their examples.

One way to view the lower-order versus high-order issue is that the lower-order facts and skills are the fundamental building blocks one repeatedly uses when carrying out higher-order processes. This type of analysis can be used to lend support to the "back to basics" movement. The argument is that one cannot expect to acquire higher-order skills without having the lower-order skills. "You've got to learn to crawl before you can learn to walk." "You've got to learn to walk before you can learn to fly." Both common sense and substantial research support this position (Fredericksen, 1984).

The back to basics movement received considerable attention and support during the 1970s and early 1980s. National and state assessments indicate that progress actually occurred in improving scores on tests of the basics. That is, overall declines in large-scale assessments represent substantial declines in higher-order skills that were only partially offset by increases in lower-order skills (Felt, 1985, page 27). In essence, as all teachers know, we can "teach to the test." If national assessment is going to emphasize lower-order skills, our school systems will emphasize lower-order skills and test scores in these areas will go up.

During this same time span we have begun to obtain some usable international assessment results. National and international results from mathematics assessment have proven quite discouraging to mathematics educators in the U.S. (Carpenter et al, 1981; Travers and McKnight, 1985). Japan, for example, has a higher high school completion rate than the United States. Although top U.S. students do as well as top Japanese students in math achievement, the mean achievement scores on the entire population strongly favor the Japanese.

WHOLE GROUP EXERCISE: 5 minutes. Pick a discipline you know reasonably well. Make two lists of "basics" or lower-order skills. The first list is to be specific to the discipline you select. The second list is to be skills that are not specific to the discipline, but essential to the discipline. Here we are looking for basic skills with high transfer value. The ability to use a dictionary to check the spelling or definition of a word might fall into this latter category.

GROUP DISCUSSION: Using ideas from workshop participants, create a list of basic skills that are not specific to any particular discipline. For each item on the list, check to see if some people also included it within their specific discipline list. Finally, for each item on the list, discuss whether computers and other related technology are having or will have any effect. Look for general patterns of how computers might make a difference in basic skills. Are the differences that are suggested pedagogy or content?

While the past decade has seen increased emphasis on basics, general educational research as well as progress in technology have been whittling away at this extreme emphasis on lower-order skills. Educational leaders have argued that there is too much emphasis on basics (Sizer, 1984). "In a recent poll of professional educators, nine out of ten respondents said that better instruction in thinking skills should be a priority in educational planning for the coming years," (Beyer, 1984). Moreover, there has been substantial progress in understanding problem solving and how to help students to become better problem solvers. An excellent review of the literature on teaching problem solving is provided by Fredericksen (1984). A key point is that students become better at problem solving in a particular discipline if they are given specific instruction and practice in problem solving in that discipline. As with lower order skills, students learn what is taught.

Transfer of Knowledge and Skills

For simplicity, let's keep in mind a "reading, writing, arithmetic" definition of basics. Then, to a large extent, we see:

1. There is use of these basics in many disciplines.
2. There is transfer of learning of basics.

The latter point is quite important. For example, basic arithmetic skills learned in a math class are apt to be used by students in non-math classes. Basic reading skills obviously transfer to other disciplines, even though there is need for special instruction in how to read technical materials such as math and science.

There is a substantial literature on transfer, and we won't go into it here. Roughly speaking, the literature indicates that the more closely alike two situations are, the more transfer will occur between the two. If one wants to teach for transfer, help the students to create many examples from a wide range of possible applications of the knowledge and skills being studied.

Transfer of learning is one of the most important ideas in education, and it is also a poorly understood idea. It seems desirable to include in our educational system basic knowledge and skills that readily transfer. But many people have a mental image of a mind as a muscle, and that exercising the mind develops its general capabilities. For example, they tend to believe that studying geometry, algebra and higher math makes one into a better thinker and overall problem solver. Earlier generations of educators used the same arguments to support the study of Greek and Latin. There is little evidence to support this position, and it has largely been discarded by educational leaders.

But we now have a new generation of computer educators who feel that the teaching of problem solving in a computer programming environment will make students into better problem solvers. Not surprisingly, research evidence to support this contention is sparse. Indeed, even though mathematics problem solving and problem solving in a computer programming environment seem closely related, relatively few studies have found transfer in the direction of computer programming to math problem solving skills. Note, however, that high scores on mathematics aptitude tests correlate highly with achievement in computer programming and introductory computer science courses.

INDIVIDUAL AND TRIAD GROUP EXERCISE: 10-15 minutes. Each individual is to select a specific discipline and make a brief list of higher-order skills for that discipline (five minutes). Then, working in triads, discuss the lists. Look for examples of higher-order skills specific to one discipline that seem to transfer easily to another discipline. Look for higher-order skills that seem quite specific to a single discipline, with little transfer.

DEBRIEF: Via group sharing, make a list of examples of higher-order skills that transfer. Look for patterns, or for some general theory that would help explain transference or lack thereof. Make sure that the discussion includes an examination of which of these high-transfer, higher-order skills are emphasized in our educational system. Do computer-related examples get mentioned?

The research literature on problem solving strongly suggests that expertise in one field does not readily transfer to another. Thus, being a world class chess player does not automatically make one into a world class problem solver in any other field. A person can be an excellent mathematician and be quite poor at dealing with the problem of helping students to learn mathematics.

Computer Simulations

The debriefing discussion for the previous exercise may move in the direction of simulations or computer simulations. Research into use of educational simulations supports the idea of giving students opportunities to practice the skills they will later be expected to perform. For example, many of the skills required to fly an airplane can be practiced in a flight simulator. Good transfer of learning occurs because the flight simulator is very similar to a real airplane. Similarly, much of modern laboratory science makes use of very sophisticated instrumentation—equipment that is beyond the financial reach of most high schools. But a number of excellent simulations exist that can help students gain a deep understanding of a variety of fundamental experiments. Their use is supported by science educators (Steidley, 1983).

During the past twenty years there has been substantial research on educational simulations covering a broad range of traditional school topics. The computer-based educational simulations developed under a National Science Foundation project directed by Ludwig Braun in the early 1970s provided excellent examples of what could be done with the computer equipment available to schools at that time. Now an increasingly wide range of computer-based educational simulations are becoming available. Two recent Ph.D. dissertations at the University of Oregon contains an excellent survey of the literature and an in-depth study of a simulation designed to help students learn key ideas in personal health (Hollingsworth, 1987; Woodward, 1985). The dissertation study supports the contention that a computer simulation can be used to help students gain applicable skills in the personal health area. In Woodward's study the simulation was used as a supplement to conventional instruction, covering and reinforcing the same materials. This seems to be an effective approach.

WHOLE GROUP DISCUSSION (IF TIME PERMITS): Ask workshop participants to share some of their personal experiences in making use of computer simulations with students. What evidence can the workshop participants provide on the efficacy of using the simulations?

While many computer educators strongly support use of simulations, few can cite relevant literature to support such use. Instead, they have a "gut level" or "intuitive" feeling that it is good to use simulations. In essence, the simulations have face validity.

Three Examples

The issue of what constitutes an appropriate balance between instructional emphasis on lower-order skills and instructional emphasis on higher-order skills is crucial. In this section we provide three examples; in each case we see how technology (especially, computer-based technology) is entering the picture.

GROUP DISCUSSION EXERCISE: The three examples given in the next few pages are:

1. Writing.
2. Mathematics.
3. Information retrieval (databanks).

Divide workshop participants into groups of perhaps ten people each, with each group selecting a specific one of the three examples. Each group is to spend about 30-45 minutes discussing the ideas of the example. Add to and/or expand the ideas. Discuss the likelihood that the changes that are being suggested will occur—and if so, when. What can computer education leaders do to hasten the proposed changes? Should they do this?

One way to debrief this exercise is to have each group make a brief report to the entire group of workshop participants. Each group could provide a brief summary of the key ideas brought up in its discussion, and recommendations for action in schools.

Example 1 (Writing)

The overall process of writing involves some lower-order skills such as spelling, grammar and handwriting. But in total, writing is a high-order process, requiring use of many higher-order skills. Both prewriting and writing involve careful and reasoned analysis, interpretation, and organization of ideas. Good writing involves repeated revision based on feedback provided by oneself and others. If writing is evaluated holistically with emphasis on high-order processes, then a program of study emphasizing spelling, grammar and handwriting does little to improve a student's writing.

Technology has produced the typewriter and the word processor. Technology has produced the computerized spelling checker and computerized grammar checkers that can run on a microcomputer. Research has produced the idea of process writing—for example, as taught through the Bay Area Writing Project. Process writing includes prewriting, composing, revision (using feedback generated by self and others) and presentation of the final product.

Recently, the technology and research in writing have begun to combine. Students are learning to do process writing in a word processing environment. Two doctoral students at the University of Oregon recently completed their dissertations in this area (Boone, 1985; Wetzel, 1985). They have developed a successful model for helping teachers learn to teach process writing in a word processing environment. It seems likely that eventually all students will enter secondary school having grown up in a process writing environment; they will be reasonably skilled at using a word processor. Meanwhile, this is a problem that must be attacked at both the elementary and secondary school levels. For many years to come the majority of secondary school students will lack these word processing and process writing skills.

Please read the last paragraph of the next section, as it is also applicable to this section.

Example 2 (Mathematics)

In mathematics, lower-order facts and skills include vocabulary, notation and computation. The elementary and middle school mathematics curriculum places substantial emphasis on students developing both accuracy and speed in paper-and-pencil computational skills. The core of the grade school mathematics curriculum is built around such computation. Generally, performance in computational tasks is a key determiner as to the mathematics track students follow in junior high and high school. Thus, tremendous amounts of time are spent on computation. Grayson Wheatley, a well known mathematics educator, estimates that the typical U.S. student completing the ninth grade has spent 200 hours studying and practicing paper-and-pencil long division of multi-digit numbers (Wheatley, 1980).

Teaching students to add, subtract, multiply and divide fractions also receives considerable attention in the mathematics curriculum. Wheatley's estimate on time spent on long division may be a good estimate on time spent learning to calculate with fractions. (Note that if one uses a metric system of measure, the need to calculate with non decimal fractions is greatly reduced. A complete switch to metric would allow a substantial decrease in emphasis on calculation with fractions. The analogy with having a written language in which spelling is completely phonetic may be relevant here.)

Now, of course, we have the calculator and the computer. For many years, the National Council of Teacher of Mathematics has recommended increased use of calculators and computers (NCTM, 1980). Recently NCTM has come out with the even stronger recommendation that the entire math K-12 curriculum should incorporate use of and adequately reflect the capabilities of calculators and computers (NCTM, 1985). The recommendation is that much less time be spent on lower-order, paper-and-pencil computational skills, and that more time be spent on higher-order skills. Problem solving is to be emphasized throughout the mathematics curriculum.

These same NCTM reports point to the fact that students do not do well in transferring their mathematical knowledge to other subject areas. For example, many students do not seem to realize that mathematical techniques are important in the social studies. Social studies courses tend to make relatively little use of the graphing, equation-solving, or mathematical modeling techniques students learn in mathematics classes. Sizer also addresses the fact that our secondary school system is quite discipline-oriented, whereas real-world problems tend to be interdisciplinary (Sizer, 1984, page 133).

It seems likely that eventually all secondary school mathematics classes will meet in a computer lab, with perhaps one computer per student. Moreover, eventually students will enter secondary school having had many years of experience in using calculators and computers as aids to learning mathematics and as aids to doing mathematics. If current trends continue, many of these students will have had substantial experience with Logo while in elementary or middle school.

Mathematics is a particularly interesting area for discussing the potential impact of computer-based technology on the lower-order versus higher-order skills area. From the point of view of a fifth grade student or teacher, the long division of multi-digit numbers is a higher-order task. But it takes only a few minutes of instruction in using a calculator for a typical fifth grade student to acquire long division skills exceeding the average paper-and-pencil skills of students who are several years older.

The calculator and long division example are just the tip of an iceberg. In calculus, for example, students learn to differentiate and integrate a wide range of functions. But computer programs (for example, Mu-Math, which runs on a microcomputer) can accomplish such tasks. From the viewpoint of a student just beginning differentiation and integration, these are certainly higher-order skills. But from the viewpoint of an accomplished mathematician they are lower-order skills. The fact that they can be computerized both lends credence to their classification as lower-order skills and allows of a shift of emphasis in this area of mathematics education. Some of the time spent developing speed and accuracy in by-hand differentiation and integration could be spent developing higher-order problem-solving skills.

In both the writing and the math examples, the overall goal is to have students develop improved higher-order skills. In both cases there is research that suggests increased emphasis on lower-order facts and skills does little to improve the higher-order skills. In both cases technology is serving as a change agent or motivation for considering change. In both cases computers can carry out or help carry out some of the key lower-order tasks. In both cases the computer technology is not central to the disciplines—but provides a strong excuse for reconsidering what is currently done in school and is an enabler of significant change. The disciplines of writing and mathematics remain as core disciplines in the curriculum.

Example 3 (Information Storage and Retrieval)

An excellent third example is provided by the general area of information storage and retrieval. Here we deal with the basic idea of learning facts versus learning where and how to retrieve the facts. The memorization of some facts is essential to everyday functioning and to developing higher-order skills in information retrieval. But easy access to large quantities of stored information (such as in a large library) tends to increase the value in having good higher-order skills in retrieving information and using retrieved information. That is, the balance between memorization of facts and acquiring thinking skills that make use of facts is shifted by easy access to information.

This balance underwent a major shift when movable type for the printing press was invented. Books became cheaper and more readily available. The industrial revolution led to a need for having large numbers of workers with rudimentary reading and writing skills. Thus, universal literacy became an educational goal in many countries. Even rudimentary levels of skill in reading and writing provide a significant supplement to memorization and oral communication.

Now we have Computer-Based Information Systems (CBIS). This discipline has made very rapid progress over the past twenty years. Gerald Salton has been a leader in the field during this time. It is interesting to compare his 1968 and 1983 books which contain broad coverage of the field (Salton, 1968; Salton and McGill, 1983). There has been substantial progress both in the underlying theory as well as in hardware and software. CBIS is now a major field in computer science and an important part of modern librarianship studies.

The hardware progress in CBIS is, of course, the driving factor. For example, in 1965 the University of Oregon was quite proud of its newly-installed IBM 360/50 computer that cost about a million dollars. It had two 5-megabyte magnetic disk drives, along with the more common magnetic tape drives. Now many purchasers of microcomputers are including 10-megabyte or 20-megabyte magnetic disk drives. The manufacturer's cost of a 10-megabyte disk drive is about $200! In 1988, a 60-megabyte magnetic disk for a Macintosh computer cost about $800.

IBM is now marketing a magnetic disk storage system that will store five billion characters of information (a gain by a factor of 1,000 over the past twenty years.) Five billion characters is roughly equivalent to the total contents of a typical elementary school library. But the whole storage system is smaller than a typical desk. IBM expects to sell many thousands of these magnetic disk storage systems.

Progress in laser videodisc technology for databases is even more exciting from an educational viewpoint. A laser videodisc is not erasable, but the videodiscs are quite cheap to produce in quantity. [Note: Write-once laser videodisc systems have been on the market for a couple of years. Videodisc systems with erase/write capabilities are just beginning to come to market. Currently they are reasonably expensive and not quite as reliable as one might like.] That is, once a laser videodisc has been produced, additional copies can be made by a stamping process not unlike that used to mass-produce phonograph records. A single videodisc, less than five inches in diameter, can store 500 million characters—that is, the equivalent of 500 long novels. The cost of producing multiple copies is perhaps a dollar or two apiece.

The laser videodisc technology has already entered a mass production stage for the home hi-fi music system market. A medium quality laser videodisc player for digitized music now retails for under $300. Laser discs for storage of computer data use nearly the same technology. While some additional expense is entailed in connecting such a laser videodisc system to a computer in order to access databases stored on videodiscs, it is evident that this technology will provide a major breakthrough in the cost of storing and retrieving large amounts of information. A half dozen manufacturers began marketing microcomputer laser videodisc systems in 1986-87 with prices under $1,000 excluding the computer.

Along with rapid progress in the storage of large databases has come rapid progress in communication to access databases. A combination of space satellites and fiber optics are making it possible to transmit more and more data at lower and lower costs. A March 1986 ad from AT&T indicated that in an experiment they used fiber optics to transmit 20 billion bits of information per second. A pair of these fiber optic “wires” could be used to carry on 300,000 simultaneous telephone conversations. Over the next couple of decades, the copper telephone wires coming into people's houses will gradually be replaced by fiber optic (glass) wires. This will provide greatly increased rates of information flow. For example, interactive television (very high quality picture phones) would be possible.

Artificial Intelligence

As we move out of the industrial revolution age and into the information age, it is evident that things will never be the same again (Toffler, 1980). Automated factories and computerized robots will take over more and more of the manufacturing processes. Computers will become everyday tools of more and more people who work with information.

As pointed out in the third example of the previous section, it is obvious that computer technology can be used to store databases and that this is making an important contribution to the information age. What is less obvious, but perhaps more important, is that a database may consist of computer programs. That is, there is an ever increasing collection of computer programs designed to solve quite complex problems. One can use a computer both to store the programs and to execute the programs.

In the past the programs that could be stored, retrieved, and used were designed to accomplish relatively specific tasks. For example, there are computer programs to draw a graph, solve various types of equations, compute statistical analyses, or project a company's sales based upon previous sales data. But over the past few years, computer science researchers have made substantial progress in artificial intelligence. In particular, they have developed the idea of “knowledge-based expert systems.” These are computer programs that contain and use the knowledge of a human expert or a collection of human experts. The potential of such artificially intelligent computer systems is so immense that it has received international attention. The “fifth generation” project in Japan has led to major responses in both the United states and in Europe (Feigenbaum and McCorduck, 1983).

In the United States there are now a number of companies that produce knowledge-based expert systems. A few of these systems are now routinely used in some hospitals for medical diagnostic work. Others are used to prospect for minerals, aid in drilling oil well, and design advertising campaigns. A 1985 article in “The Wall Street Journal” indicated that about 50 systems were in use and another thousand were at various stages of development (Davis, 1985). A variety of articles in research and trade publications suggest that by 1988 there were about 2,000 such expert systems in routine use in business and industry in the United States.

Progress in artificial intelligence means that more and more higher-order problem solving tasks will be accomplished by merely retrieving an appropriate computer program and feeding data to that program. That is, computers make many higher-order tasks into lower-order tasks. Examination of the potential impact on mathematics education alone, for example, has hardly begun. An excellent summary of some of the key ideas is provided in the recent NSF-supported work of James Fey at the University of Maryland (Fey, 1984). Our educational system has not yet begun to cope with the idea of an “inverted” mathematics curriculum, with students learning to use sophisticated software to accomplish higher-order tasks, and not learning the underlying basic skills or theory.

At the same time we are coming to understand limitations of computers and we know many tasks that people do much better than computers. Writing, speaking, and interacting with people all provide excellent examples. In a one-on-one conversation, for example, non verbal communication skills often are dominant. These are uniquely human skills.

WHOLE GROUP EXERCISE: Make a list of higher-order skills that seem likely to remain in the province of humans (that is, skills in which humans are far superior to computers) for many years to come.

DEBRIEF: This is, of course, a high tech/high touch exercise. We are looking for high-touch examples that take unique advantage of human problem solving skills. While computers have been programmed to produce certain types of art, music, and poetry, in no sense have computers begun to approach human skills in these areas.

Another area of human dominance is interdisciplinary problem solving. Listen to a group of professors discussing research and development to improve education. The discussion may range over many academic disciplines, grade levels, and types of schools. It may cover budgeting, teacher training, parenting, the influence of television, and the role of computers. Such a discussion vividly illustrates higher-order skills. Such skills can be supplemented, but clearly cannot be supplanted, by access to computers.

Summing Up

Our current educational system was, in essence, developed before the information age began. Even now, relatively few schools have as many as one computer workstation per ten students. (That is, relatively few students have access to a half-hour of computer time per day. For the academic year 1988-89 a reasonable estimate for the United States is that there will be about one microcomputer or computer terminal in the schools for each 20 students.) But continued rapid progress in the design and manufacture of computer hardware suggests that computers will eventually be ubiquitous (Wilson and Ticer, 1985). That is, today's first grade students will live their entire adult lives—work, play, and study—with easy access to computers with perhaps a hundred times the capabilities of the microcomputers that are now popular in our schools.

If we assume that eventually computers will be an everyday tool, we must ask where students will learn to make effective use of the tool. For example, the use of computers as a graphics aid might be taught in a mathematics course. But graphics is useful in many disciplines; students should graph data in social studies courses as well as in science courses. Computer graphics is important in graphic arts work and in technical drawing.

The point is that computers are an interdisciplinary tool. While initial instruction in use of a specific piece of software might be relegated to a particular course, students need instruction and practice in using the software in many courses. It cannot be assumed that transfer of learning will automatically occur. This creates an immense teacher inservice problem. Eventually all teachers will need to know how to work with students who have grown up with computers and who use computers as an everyday tool. All teachers will need to know both those aspects of computers that are most relevant to their own academic disciplines, and how to help students use computers as a general-purpose tool in their discipline.

Research is needed on effective inservice for accomplishing this teacher-training task. A start is provided by the research of Ferres (1983). His research provides a model for effective inservice of elementary school teachers who want to use Logo in their classrooms. The Computer-Integrated Instruction Session in this book discusses a National Science Foundation inservice education research project currently being conducted by Dave Moursund. This three-year project is developing models and materials for effective inservice for integration of computers as an everyday tool into the curriculum.

There is much basic research still to be done on lower-order versus higher-order skills. But the much larger research challenge is to gain the knowledge needed to incorporate computers into this whole area. A suggestion for the way technology is leading us is provided by the high tech/high touch ideas of Naisbitt (1982). It seems likely that high tech/high touch-oriented research will discover that increased use of computer-based technology will do two things:

1. Give an increased advantage to a person with high-order interdisciplinary-oriented skills who has been educated to make effective use of the technology.

2. Maintain or increase the importance of "people-oriented" skills.

Research on the role of intra- and inter- personal skills in an increasingly technological society may prove particularly rewarding. For example, the computer equity issue is often studied by looking at numbers of men and women taking various computer science courses or making certain types of uses of computers. The results are often used to argue for increasing the number of women in computer science courses. Suppose, instead, that a combination of computer application and interpersonal skills are much more broadly useful in a highly computerized society. We might then see an inequity running in the opposite direction and people beginning to encourage men to take appropriate coursework to improve their interpersonal skills.

WHOLE GROUP DISCUSSION: Have workshop participants share their ideas and experiences on the topic of the previous paragraph.

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Session 5: Problem Solving

Goals

1. To understand the terms problem and problem situation.
2. To learn to differentiate between relatively formal and relatively informal problems and problem situations.
3. To understand possible roles of computers in problem solving, and to understand the idea of a computerizable effective procedure.
4. To understand how an orientation toward computer-assisted problem solving will change the overall curriculum.
5. To develop some ideas on how to make use of the increased knowledge about problem solving you have gained in this session.

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Note: This Session is divided into two major parts. The first part is foundational material. It is helpful if workshop participants read this material in advance of the workshop. Alternatively, this Session could begin with a relatively formal presentation of the key ideas. The second part of the materials includes activities and group discussions in the usual workshop format. For more information on problem solving using computers see Moursund (1988).

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Part 1: An Overall Task of Education

Academic Disciplines

Human beings are problem solvers. At a conscious and subconscious level we contemplate possible actions and possible outcomes of these actions. We analyze current situations and desired changes to these situations. We take action based on our conscious and unconscious analyses. In doing so we draw upon knowledge stored in our own head (personal knowledge). We also often seek out and make use of some of the accumulated knowledge of the human race that is stored outside our own head.

The totality of human knowledge can be divided into disciplines or problem areas such as anthropology, biology, chemistry, etc. Each discipline has its own specialized vocabulary and notation, techniques of inquiry, methods of training, and accumulated knowledge. The notation of music, for example, is quite different from the notation of mathematics. This means that it takes a reasonable amount of education within a discipline to merely communicate with others within and about the discipline. Our educational system is designed to provide a broad exposure to many different disciplines. Elementary schools tend to use generalists as teachers. Secondary schools tend to have subject matter specialists teaching the various courses. College faculty are subject matter experts. At this level of education there is continuing debate on breadth requirements (a broad liberal arts education) versus depth requirements in one's major field.

Each discipline has its own specialists who work to increase the accumulated knowledge of the discipline. They work to define and solve general categories of problems falling within their discipline. Generally these specialists are very talented within the discipline, have studied and practiced the discipline for many years, and work long hours. It often requires many hundreds of hours of work to make a small, original contribution to a field. A major breakthrough may require years of work, and most researchers never achieve such a level of success.

It is hard to master a discipline to a level where one can be a successful teacher and/or researcher in it. It is not easy to develop new ideas and to expand a well-established field of study. This is especially true in vertically structured disciplines such as mathematics, biology, chemistry, physics and other sciences where the frontiers build upon many years of accumulated research results. In mathematics, for example, some of the important ideas were developed more than two thousand years ago, and mathematicians have made steady progress since then.

The idea that a researcher or teacher might have specialized talent in one particular discipline is important. Each human seems to have a unique set of potentials. Howard Gardner has identified seven distinct types or areas of human intelligence: linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal, and interpersonal (Gardner, 1984). The people who are at the frontiers of each discipline tend to have considerable natural talent within the discipline. This, combined with long and hard work, allows them to master the discipline so they can discover new results and in other ways advance the discipline.

The accumulated knowledge within a single discipline, such as mathematics, may represent the work of tens of thousands of researchers working over many hundreds of years. These researchers have identified key problems within the discipline and have solved many of these problems. They have developed both specific methods for solving specific problems and general methods for attacking problems that have not yet been solved or are not readily identified as falling into the "solved" category.

Sometimes progress within a discipline makes it possible for non-specialists to solve certain types of problems that formerly could only be handled by specialists within the discipline. Consider, for example, the difficulty of doing long division or working with fractions using Roman numerals. The development of the Hindu-Arabic notational system, along with the decimal point and the zero, were all major achievements. These ideas have been combined with the teaching of a variety of paper and pencil computational algorithms so that most students now develop a reasonable level of computational skill. That certainly was not the case just a few hundred years ago.

The handheld calculator is a more recent aid to problem solving in mathematics. A combination of decimal notation and the calculator make it much easier for people to learn to solve calculation problems. (Do you think that when the Hindu-Arabic notational system was first being introduced, people who knew only the Roman notational system thought it was "cheating" to calculate using the new notational system? Do you think it is "cheating" for a sixth grade student to use a calculator in lieu of doing pencil and paper calculations?)

Accumulated Knowledge of the Human Race

The accumulated knowledge of the human race can be roughly divided into three major categories:

1. Personal knowledge. This is the collective knowledge (including all experiences) carried in people's heads and bodies.
2. Published knowledge. This includes books, audio and video tape recordings, films, photographs, data stored on computer-readable media and other materials that can be

accessed by people. Note that it may take considerable education and/or use of appropriate equipment to access the knowledge.

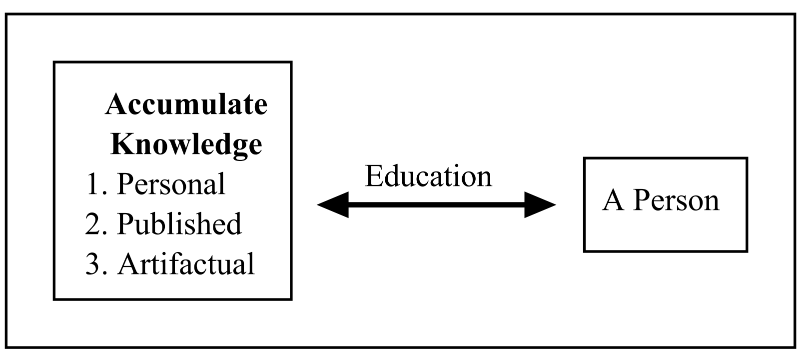
3. Artifacts (artifactual knowledge). Here we use a broad definition of the term artifact. This includes hand and power tools, cars, microscopes, our electrical power grid, buildings, factory equipment, etc. As with published knowledge, it may take considerable formal education to learn to make use of some of these artifacts.

From a high tech/high touch point of view, one might suggest that Category 1 is high touch while Categories 2 and 3 are medium tech or high tech. Once I internalize some knowledge/skill, actually make it part of me, it becomes high touch. It is stored in my mind and body. I use it to talk, listen, read a book, ride a bicycle, or drive a car.

Much of the accumulated knowledge of the human race is the high touch knowledge belonging to individual people and making each person unique. Each person, even an identical twin, has experiences contributing to this uniqueness. One can access some of this knowledge that others have by use of interpersonal communication skills. For example, by talking to a person I can learn part of what they know. If I am good at reading body language, I may learn still more. Some people are much more skilled than others in such interpersonal communication.

Personal knowledge also includes the skill and knowledge of a star athlete. A combination of natural talent with many years of training and coaching are usually needed to produce a star athlete. The role of a coach is both important and interesting. The star athlete outperforms the coach, but the coach makes significant contributions. Experts in effective inservice for teachers suggest that a coaching model is quite effective in working with teachers. (Bruce Joyce and Beverly Showers have written several books and a number of articles on coaching as part of an effective inservice.)

Our informal and formal educational system helps build an interface between the accumulated knowledge of the human race and the general interests, needs, and capabilities of each individual growing up in our society. The diagram given below suggests this interface. Note that the “Person” on the right must have personal knowledge in order to access and make use of the accumulated knowledge. This personal knowledge is part of the collective personal knowledge labeled “1. Personal” in the box on the left.



The education needed for interfacing between the accumulated knowledge of the human race and an individual person can be divided into three major categories.

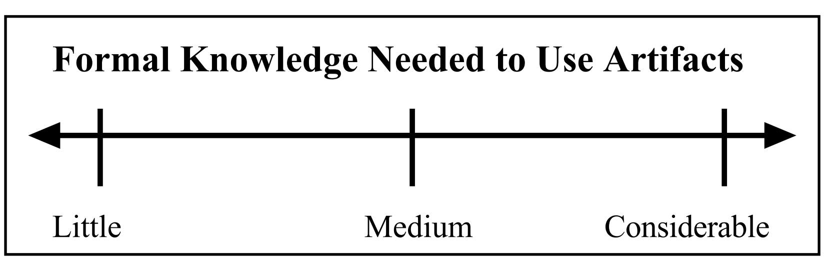
1. General informal education (life experiences) and general formal education (such as the three Rs) which are basic, interdisciplinary, and assumed to be common to the core of many disciplines and human interactions.

   There does not seem to be any particular advantage in drawing a fine line between informal and formal education. Much of the knowledge needed to function successfully in any particular society can be acquired through the informal educational process. However, formal education is now a standard part of our social system. In our formal educational system, one can identify the strands that extend over several years in a school district's curriculum. These are the basics that are considered sufficiently important to be covered in a spiral approach designed to help all students gain a useful level of knowledge and skills. Most published material assumes the reader will have this basic core knowledge.

2. Specialized education at an introductory level in disciplines considered by our society to be particularly important. The typical school curriculum offers a number of specialized courses at the secondary school level. High school courses in chemistry or psychology are representative of the introductory courses in specialized areas. Note that many other topics, perhaps deemed less important or universal, are taught outside the formal school system. Horse riding is a typical example. Also, there are considerable differences in what courses are offered in various schools throughout the country.

   The topic of specialized education suggests that of specialized training. One might begin vocation-oriented specialized training quite early in a student's schooling. In the United States the tendency has been to delay this specialized training until the latter years of high school or even until a post high school program of study. The long-term value of a broad and moderately deep general education is emphasized.

3. Learning to use the artifacts (tools, devices, aids to problem solving) of one's civilization. Very young children know how to flush a toilet, turn on an electric light or a television set, use a telephone, and use clothing made of synthetic materials. They easily learn to make use of these parts of the accumulated knowledge of a variety of disciplines. The artifacts—aids to problem solving—of a civilization can be roughly placed on a continuum based on the amount of formal schooling required. The left-most point on the continuum would be artifacts and aids to problem solving requiring no formal schooling to learn to use. Near the right end of the continuum would be those artifacts and aids to problem solving requiring a great deal of formal schooling to learn to use. For example, it takes only a little training/experience to learn to use a pair of binoculars. More training/experience is required to learn to use a microscope, and still more to learn to use a scanning electron microscope.



I find artifacts and aids to problem solving falling near the left end of the continuum particularly interesting because they do not involve formal schooling. Children learn to accomplish a wide variety of tasks (that is, solve a wide variety of problems) through informal instruction, imitation of peers, or trial and error.

Each artifact or aid to problem solving is associated with some problems that humans know how to solve. A young child learns to flip a light switch in order to solve a darkness problem. This requires much less training and experience than does gathering materials for a fire and starting a fire. The light switch and electrical lighting artifacts have been made so reliable and user friendly that they are safe enough to use and easy enough to learn to use so that a young child can do it.

The amount of training and experience needed to learn to solve a particular category of problems is a key idea. As was illustrated by the Roman numeral versus Hindu-Arabic notation versus handheld calculator discussed earlier in this book, intellectual and technological progress can make a considerable difference in the ease of learning to solve a particular category of problems. We clearly are interested in whether (and if so, how) computers might move some problems from the "requires some or a great deal of formal schooling" category into the "requires little or no formal schooling" category.

Each of the three interface-education categories can be examined in light of progress in computers and related technology over the past forty years. Such an examination suggests that our educational system will need to make major changes as computer technology continues to progress and computers become more and more readily available.

Impact of Computers

One can view the computer as the heart of a new discipline, which is called computer and information science. People acquire informal knowledge of this discipline through ads, television, movies and comic books. Schools need to decide whether this discipline belongs in the multi-year strands that form the core of a general education. Or, should computer and information science be considered as a more specialized discipline, with an introduction being available in high school, and more specialized and deeper courses available only in post secondary education? And, certain aspects of computer and information science lend themselves to a training (as contrasted with an education) approach. A few years ago, quite a few high schools offered training in key punching or some other form of data entry. Now data entry is a declining industry and specialized training in data entry is no longer a guarantee of a job. Ability to use a word processor seems to be following the same pattern.

We have identified an important issue. To what extent do we place computer and information science into Category 1 and to what extent into Category 2? Many school systems are placing this discipline in both categories, with the strands starting as early as kindergarten or the first grade. Essentially all school systems have placed computer and information science into Category 2, with courses starting at the ninth grade or earlier. A number of state legislatures have mandated computer literacy—that is, they have required that students pass a computer literacy course or a comparable exam.

One can also view computers as a new instructional delivery aid. Research suggests this technology can help students learn more, better, faster (Kulik, Bangert, and Williams, 1983). With the help of Computer-Assisted Learning (CAL), a typical student can acquire more personal knowledge in a shorter period of time. That is, some of the formal education goals in Categories 1 and 2 can be accomplished better/faster via CAL.

But most interesting, and most challenging to our formal educational system, is how computers affect the interface between a discipline and students. Artifactual knowledge is not a new thing. But computers are making possible artifacts with more and more intelligence—with the ability to solve more and more complex problems. A young person solves the problem of needing light by learning to turn on an electric light. In essence the flipping of a light switch is “telling” a very sophisticated electrical system to “Give me light."

In that same sense, pushing a sequence of buttons on a calculator is telling the calculator to solve a certain category of computational problem. But this telling requires more formal schooling than that required to learn to flip a light switch. Running a graphics package on a microcomputer and giving it a set of data to graph is telling the computer to solve a particular graphics problem. But this requires more formal schooling than is required to learn to use a calculator. Computers are making it possible for an ever-increasing set of problems to be solved by merely telling the problem to a machine. But the telling process remains quite sophisticated and requires substantial formal education in many instances. It is this fact that ties together the general ideas and activities of this workshop.

The human-machine interface in artifacts can be designed to require little formal education or training. Even if the artifact is a computer, formal instruction can be minimized. The Macintosh computer illustrates a trend that is just beginning. With relatively little formal instruction many people can use a Macintosh to accomplish quite complex tasks. Much of the compute power of a Macintosh is used to make the overall computer system user friendly—easy to learn to use and easy to use.

Part 2: Workshop Activities

Problem Solving in Different Disciplines

I believe all educators list “problem solving” as one of the major goals of education. What is most interesting is to see that each discipline has its own concept of what constitutes a problem and what it means to learn to be a problem solver. Math tends to have the most straightforward definition, and the most writing and research on problem solving has been done in this area. But as we explore problem solving in this session, we will have in mind all disciplines. We are looking for unifying themes in problem solving and how computers affect these themes. Keep in mind that we are not thinking of problem solving as a self-contained discipline. Problem solving is a key component of every discipline, and most real world problems are interdisciplinary.

PROBLEM SOLVING FANTASY TRIP: (Five to ten minutes) Select a discipline that you know well—perhaps one that you teach. We will do a fantasy trip exploring the nature of problem solving within that discipline. (Note: This guided fantasy is to be presented in a slow, calm soothing voice. There can be frequent pauses, especially between paragraphs. Allow time for participants to build the necessary images in their minds.)

> Please get yourself into a comfortable position. You won't need to take notes, and you may want to close your eyes. Begin to pay attention to your breathing. Notice how deeply you are breathing, and feel the flow of the air into and out of your lungs. Sense the presence of others in the room, and hear their breathing. You may find that your body is beginning to relax.

> Now I want you to begin to think about an academic discipline that you know quite well. Think about that discipline and how you developed your competence. See yourself studying and practicing within the discipline. Sense how your body feels when you function well in the discipline. How do you sound when others listen to you teaching or talking about your discipline?
>
> Continue to breath slowly and comfortably. You are a fully competent adult, able to solve the problems of your discipline.
>
> And now let come to your mind a specific example of a problem you have solved within your discipline. Imagine the problem and the situation in detail. What was the source of the problem? What did you do to help you clarify and understand the problem? What steps did you take to solve the problem? Did you draw upon information you had previously memorized? Did you make use of reference materials?
>
> Review the problem solving process in your mind. Did you draw upon your formal academic background? Did you make use of interpersonal skills? Did you work long and hard? Experience once again the satisfaction you felt in solving the problem.
>
> And now, as you continue to breath slowly and comfortably, I want you to return to this workshop room. Your mind and body are relaxed and alert. You are ready to debrief in triads.

DEBRIEF IN TRIADS: Share the particular area and nature of problem solving that you encountered in your fantasy trip. Pay particular attention to whether "problem solving" means the same thing to each member of your triad. To what extent was your problem solving situation high tech; to what extent was it high touch?

DEBRIEF IN WHOLE GROUP: Make a list of the problem areas and/or types people in the workshop discussed in their triads. Does problem solving mean math to most people? Note that many people experience math anxiety (Tobias, 1978). Thus, if such people tend to equate problem solving with math, they likely experience problem-solving anxiety. Get workshop participants from non-math disciplines to give examples of their problems. It is important to stress that every discipline has problems and teaches problem solving.

This might be a good place to probe for math anxiety and anxieties in other disciplines. It may be that a student with high anxiety in a discipline is unable to learn the discipline due to the anxiety. In working with such a student, a high touch approach may prove fruitful.

We have not yet defined the term "problem." This was deliberate, to avoid influencing the types of problems people would pick in the guided fantasy exercise. It should be clear from the above discussions that each person has their own concept of what constitutes a problem, and different disciplines use the word in different manners.

Now we need to talk about problem solving in a more formal manner. We need to agree on the main components of a definition of problem. This facilitates communication among us and allows us to read what other experts have written about problem solving. I define a situation to be a problem for me if it satisfies all three conditions given below.

1. The situation under consideration is reasonably well defined. This means that I can understand both the given (initial) situation and the goal (desired end) situation.
2. I am able to take various actions that I perceive may contribute to moving from the given to the goal state.
3. I have involvement with or ownership of the situation, so that I desire to take actions that may lead to reaching the goal.

The latter characteristic, ownership, is often ignored when people talk about problems. However, lack of ownership helps explain why so many students are turned off by the types of school book problems presented to them in school. The first two characteristics are often stated more formally. For the remainder of this workshop session we define a "formal problem" to be one which includes (Polya, 1957):

1. Given initial situation. What is known? What is the current situation?
2. Goal(s). What is the desired final situation? How can one tell if the goal is achieved?
3. Guidelines, restrictions, allowable operations. What are the rules of the "game?" What types of activities are allowed as one works to move from the given initial situation to the desired goal state?

The overriding key characteristic of a formal problem is that the Givens, Guidelines, and Goals—and a solution procedure, if one is known—can be communicated over time and distance. This might be done strictly within one's own mind. I recognize a situation as being like a problem that I have successfully dealt with in the past. I analyze the situation to make sure the Givens, Guidelines, and Goals match the former situation. If they do, I apply the solution procedure I previously used, knowing that this will solve the problem.

But I don't need to memorize everything. Suppose that I recognize the situation under consideration is somewhat familiar and that likely others have dealt with it sometime in the past. I can go into an information retrieval mode. I can talk to friends or use reference materials. My goal is to retrieve information from sources outside my own head on what steps to take to solve the problem.

WHOLE GROUP EXERCISE: What are the most important ideas in problem solving? Imagine that you could help all of your students to learn a couple of key ideas about problem solving. What ideas would you have them learn? (The workshop facilitator accepts suggestions from participants and lists them on an overhead.)

I enjoy leading this exercise in a workshop. I generally get a long list of responses, such as the following:

1. Stick to it—keep trying.
2. Think of different approaches.
3. Draw a picture.
4. Think of resources available to you, such as a library.
5. Draw upon your background knowledge.
6. Break the problem into smaller components.
7. Understand the problem.
8. Build upon previous work of yourself and others.

The latter two are the responses that I think are best. If you can't understand a problem (Givens, Guidelines, Goals) then you won't be able to tell if you have solved the problem even if you do succeed in solving it. If you don't build upon previous work of yourself and others, than every problem is a "start from scratch, reinvent the wheel" situation.

But building upon the previous work of yourself and others requires retrieving information. Thus, information retrieval is a key concept in problem solving. Also, information retrieval provides a solid link between problem solving and the computer field, since computers are quite useful for the storage and retrieval of information. I can improve my ability to solve problems by improving my ability to retrieve information about how others have dealt with the same or somewhat similar situations.

TRIAD GROUP ACTIVITY: To what extent is problem solving merely an information retrieval activity? Why can't all problems be solved merely by information retrieval? (If they could, an educational system stressing memorization and use of libraries would improve students' problem solving abilities.) Triad group members are to share personal examples of problems that require more than just retrieving information.

WHOLE GROUP DISCUSSION: Many problems we encounter in our everyday lives are unique to ourselves. They involve personal knowledge. Moreover, even if they are not unique, we have no easy way to retrieve information about how others have dealt with the problems. Perhaps the knowledge exists, but is merely part of the collected pool of personal knowledge that people carry in their heads. For example, perhaps you are having troubles with one of your own children or a student in your class. It could well be that this identical problem occurred and was successfully solved sixty years ago in a remote village in India. But that doesn't help you cope with the problem.

The discussion might lead to issues such as creativity or solving problems that no one has previously encountered. In any event, we are often faced by problem solving situations that are different from what we have previously encountered and for which we are not able to make use of external sources of information.

The need for creativity in problem solving is well illustrated by this exercise. Each of us, everyday, encounters problems that are unique to ourselves. We must creatively cope with these problems.

The debriefing discussion on the exercise may also lead to examples of situations that are often called problems, but lack one or more of the three characteristics to be a formal problem. If the situation one is dealing with appears to have only some of these characteristics, we call it a problem situation. Most real-world “problems” are actually problem situations.

TRIAD GROUP EXERCISE: Select either the software piracy “problem” (lots of pirated software is used by students and teachers) or the equity “problem” (certain groups of students are underrepresented in terms of computer access, enrollment in computer-related courses, etc.) of computers-in-education. Clearly state the Givens, Guidelines, and Goals. (You might also want to discuss the issue of ownership.) Which of the three Gs seems to give your triad the most trouble?

WHOLE GROUP DEBRIEF: For software piracy and computer equity, it is not too hard to state the given initial situation. In equity, for example, we know that some kids have much better access to computers than do other kids. In both cases one can state goals. However, this is fairly hard. For example, is the goal in software piracy to ensure that absolutely no unauthorized copies are made of software? But the biggest difficulty is the guidelines—the allowable types of steps that one might take to move from the givens to the goal.

Interestingly, each of these problem situations allows one to build upon previous work of others. Get workshop participants to share some of the things they have done to deal with piracy and inequity.

Often it is difficult to make use of the accumulated knowledge of the human race in dealing with problem situations. Suppose that one does not have access to a group of bright, knowledgeable people who have thought about the problem situation (such as in the workshop sharing of ideas on piracy and equity). One approach is to work to transform the problem situation into a formal problem. That is, one first formulates as a formal problem the task of transforming the problem situation into a formal problem. The first problem one attempts to solve is to transform the original problem situation into a formal problem. Such meta-problem solving activities are generally considered to fall on the high end of Bloom's taxonomy.

Progress in formally defining the equity problem allows people to share ideas on how they attack and perhaps solve the problem. There is now a substantial literature on computer equity. Some pieces of the problem have been carefully defined. One can read articles on how to achieve equal male/female enrollment patterns in high school computer courses.

Similarly, the software piracy problem situation is being attacked by individuals and companies throughout the country. Many schools are doing a good job in this area.

Formal problems are nice in that one can study them in detail and one can do research to see if others have encountered and solved the same problem. Note the value of people learning the vocabulary of various problem areas so they can communicate, make use of reference books and periodicals, and build upon the work of others. And keep in mind that merely because a problem is formally and carefully stated does not mean that people know how to solve it or even that it is solvable. For math-oriented people, the problem of trisecting an angle provides an excellent example. The problem is to use only a compass, straight edge, and pencil to trisect any given angle. Mathematicians have proven that this problem cannot be solved. Of course, if one allows a protractor to be used, the problem is easily solved.

Obviously some problem areas are more formal or well defined or science-like than others; that is, they lend themselves to the type of study and communication described in the previous paragraph. Indeed, my brief definition of science is, “Science is description and prediction.” In a science it is possible to communicate one's ideas and work over time and distance. It is possible to build upon the work of others—to have cumulative progress over time, with contributions by widely separated individuals. Computers are an aid in developing the science of problem solving, or in making more disciplines or academic areas to be more science-like.

WHOLE GROUP EXERCISE: Consider a 10-point scale, with a 1 being disciplines with the smallest percentage of formal problems and a 10 being disciplines with the highest percentage of formal problems. Label your end points using disciplines that you understand reasonably well. Now, where does the discipline of education fall on your scale? Next, where do you think education will be in twenty years?

WHOLE GROUP DEBRIEF: Collect data from all workshop participants and record it using the overhead projector. The discussion might move in the direction of how computer-assisted learning can be viewed as an attempt to make education into a more formal problem. Learning theory and teaching theory each contribute to making education more science-like. Many educators believe that special education has made considerable progress in becoming science-like.

I have used this exercise in a number of workshops. Disciplines used to label the 1 point include writing, poetry, music, art, and history. (Note that there tends to be little agreement here, but one can detect patterns in the responses. The high touch disciplines tend to be listed.) The 10 point on the scale is usually mathematics. Education is then given a rating in the 3-5 range, with a few people rating it lower and a few higher. If time permits in a workshop, it is interesting to have a discussion among those who rate education well outside the 3-5 range.

Generally, people's ratings for twenty years from now are higher than their current ratings. That is not surprising. Both learning theory and teaching theory are making progress. We are gradually isolating specific educational problems that can and are being solved. Methods for solving these problems are communicated over time and distance. They are built into our preservice and inservice teacher training programs. They are built into our books and other instructional materials.

TRIAD GROUP EXERCISE: Give examples of specific educational problems that are relatively formal and which we know how to solve. Share examples from your school or school district where such solutions have been implemented.

WHOLE GROUP DISCUSSION: Have triad groups share what they learned. If discussion lags, bring up the idea of an Individual Educational Plan (IEP) used in special education. Special education has made significant progress toward identifying and solving a number of specific problems of special needs students. In some states computerized databanks are being developed which contain detailed descriptions of special education problems and ways to attack these problems.

One might ask why we don't have IEPs for all students. The idea of individualizing instruction for all students is quite appealing to many educators. Computers could help us move in this direction.

Effective Procedure

Let's look at a simple math problem to help increase our understanding of formal problem solving.

> I go into a store and see an item that I have come to buy. I note that it costs $13.25. I give the clerk a $20 bill. How much change will I receive?

Even here it is not clear that this situation actually satisfies the three-part definition to be a formal problem. There may be missing information—such as the fact that there is a six percent sales tax. Is the $20 a Canadian bill, while the price is in US dollars? Am I allowed to ask another student the answer? Or, can I use a calculator?

For the moment let's suppose that this is indeed a formal problem, that there is no trickiness and that the problem is to be solved using mental operations along with pencil and paper. With minimal mental effort I translate the problem into a paper and pencil computation and carry out the computation.

```
  20.00
 -13.25
---------
   6.75
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I then translate the 6.75 back into $6.75, note that this amount seems to make sense, and I am done.

Many real-world problem solving situations are handled by following the steps just illustrated. The steps are:

1. Understand the real-world problem, determining the givens, guidelines and goals.
2. Translate the real-world problem into a formal problem of a type one has previously studied and knows how to solve (in this case, a pure arithmetic computational problem).
3. Solve the formal problem if possible (being aware that not all formal problems are solvable). This might be done using a solution procedure retrieved from one's head, or a solution procedure stored elsewhere.
4. Translate the results back into a solution to the real-world problem, checking to make sure that the answer makes sense.

Here and earlier we used the expression *solution procedure.* Computer scientists often use the expression *effective procedure.* Consider the following definition of effective procedure.

> An **effective procedure** is a detailed step-by-step set of directions that can be mechanically interpreted and carried out by a specified agent, and that has been designed to solve a certain category of problem.

It is not inherent to the definition of effective procedure that it actually succeed in solving the problem. Students write computer programs that are designed to solve certain problems. The programs can be mechanically interpreted and carried out by a computer. But the programs may contain syntax and logic errors.

We are particularly interested in formal problems that have effective procedures that have been proven to solve the problems. For the remainder of this session, we define a formal, solvable problem to be one for which we have an effective procedure that has been proven to solve the problem.

Each discipline has its own types of *agents* for carrying out the steps in effective procedures for formal, solvable problems. Our overriding concern here is the computer as an agent. When we think of computer as agent, we include robots and other computerized machinery. The computer is an interdisciplinary aid to problem solving—that is, it is a useful agent in many disciplines.

A computer science researcher tends to be concerned with whether a problem can be solved by a “theoretical computer” (such as a Turing machine) and is not concerned with whether it might take millions of years for a “real” computer to accomplish the task. Reality dictates that people be concerned with getting problems solved in a reasonable amount of time using machines currently available to them. To simplify the discussion in the remainder of this session let's agree to use the following definition.

A problem is said to be a **pure solvable computer problem** (PSCP) if it satisfies all of the following conditions:

1. It is a formal problem.
2. An effective procedure is known for solving the problem.
3. The effective procedure can be carried out by a computer (or by computerized equipment, such as a robot).
4. The effective procedure can be carried out in a "reasonable" time and at "reasonable" expense using hardware and software currently available.

The class of PSCPs continues to grow through the development of better hardware and software, through research into various problems in every discipline, and through research in computer science.

Now we are at the core of where we are headed in this Session. Computer-assisted problem solving is important because problem solving is important and because computers can help solve a wide variety of problems. Think about the following general steps in solving a problem. This set of steps is applicable only to certain types of problems, those that can be transformed into PSCPs.

1. Understand the problem. This means understand the givens, guidelines, and goals. It often requires both a broad general education and specific knowledge about the problem area.
2. Recognize or come to realize through working on the problem that it can be translated into a pure computer problem for which a (computerized) effective procedure exists and is available to you.
3. Translate the original problem into a pure solvable computer problem meeting the criteria/model of the effective procedure available to you.
4. Have the computer carry out the effective procedure.
5. Translate the results back into the vocabulary and situation of the given problem.
6. As best as possible, check to see if the original problem is now solved.

EXERCISE FOR INDIVIDUALS: Each person is to select a solvable type of problem within their own discipline—a problem in which a computer can aid in the solution process. Make sure that it satisfies the three-part definition of having well defined givens, guidelines, and goals. Now mentally work your way through the six-step process, thinking about each step. What type of education is needed to prepare one to be able to carry out the steps?

DEBRIEF IN TRIADS: Share what you have learned with members of your triad. It is most instructive if different disciplines are represented in this small group discussion.

This exercise should also be debriefed in a whole group setting. My experience is that many workshop participants are not able to think of good examples. Their training and experience have not emphasized this problem solving way of viewing the world. It takes considerable education and experience to develop this way of viewing various disciplines. As a consequence of being in the workshop, it is expected that some people will make progress in incorporating the idea of PSCPs as part of the way they view each discipline.

For me, the above analysis and discussion suggests that within each discipline we should study:

1. The general types of problem situations with which the subject is concerned. This requires acquiring a basic talking and reading level of knowledge about the subject. The vocabulary may be more or less formal. However, we are looking for overview knowledge, knowledge that a person is apt to internalize and not quickly forget. This is part of what we called Category 2 knowledge earlier in this Session.
2. The retrieval of information (from the accumulated knowledge of the human race) for this discipline. Note that sometimes the information one retrieves will be a computer program to solve a particular type of problem. If a computer is used to retrieve this information, the same computer may be used to carry out the effective procedure represented by the program.
3. The types of steps one can take to solve problems within the discipline. (What are typical guidelines in formal problems within the discipline?) In music, for example, one can play certain types of chords on different types of instruments, transpose to a different key, or sight read. In art, one makes use of certain media, shows perspective by size and placement, and represents emotions by appropriate use of colors. In math, one can draw a graph, carry out computations, and solve equations. In social studies, one can arrange data into a database and then represent it in a graph, in order to support the argument one is writing in an essay. In chemistry, one can carry out laboratory experiments, and formulate and test hypotheses. Each discipline has its own unique types of allowable operations and also draws upon more universal types of operations.
4. What constitutes a formal problem within the discipline? Examples of formal problems that can be solved. Examples of formal problems that have not been solved or that are not solvable. Insight into what makes a formal problem easy or difficult to solve.
5. A definition of "solvable formal problem" specific to the discipline, as well as the notion of a computerizable effective procedure. That is, study solvable formal problems within the discipline both of non-computerizable and computerizable types.
6. Study of some by-hand, book-assisted, computer-assisted and other methods that exist for executing the steps of effective procedures within the discipline. The goal is a thorough understanding of effective procedure and some understanding of various agents involved in effective procedures.
7. Lots of practice in translating problem situations (especially real-world problem situations) into formal problems (and, where possible, into solvable formal problems).
8. Study of what to do when a problem is not within one's repertoire of solvable problems. (I don't have access to an effective procedure that can solve it. I don't know if a procedure exists. I am unable to carry out the steps of the effective procedure I have access to.) This is particularly important in the social sciences and

humanities since most so-called problems in those areas do not satisfy our definition of formal problem. Computers are of more limited use in such areas.

It must be recognized that most real-world problems are interdisciplinary. Thus, an educational system should provide lots of practice in applying the above ideas to interdisciplinary problem solving situations.

Out of this type of analysis we begin to see how computer-as-tool affects the teaching of various disciplines. The basic nature of each discipline remains unchanged. But in every discipline, computerized information retrieval is of growing importance. In some disciplines there are relatively few formal solvable problems, still fewer PSCPs, and the PSCP approach is of relatively little value. In other disciplines this approach may cover a significant portion of the discipline. The basic curriculum of these disciplines may eventually undergo substantial change due to computers.

Another way to discuss the above ideas is to talk about metaknowledge. While I have a Ph.D. in mathematics, over the years I have forgotten many of the details of how to solve various categories of problems. I still have knowledge of what categories of problems are solvable and I have knowledge of general categories of methods used to solve these problems. I call this metaknowledge. Might part of our formal school time be spent specifically in developing metaknowledge in a wide variety of disciplines?

TRIAD GROUP EXERCISE: Working individually, make a list of five major disciplines and/or curriculum areas that you feel you know quite a bit about. Each discipline/curriculum area should be limited to your own academic level of interest or expertise. Thus, one might pick math in grades 6-8 or graphic arts in grades 10-12. Then order them on the basis of what part of the discipline/curriculum area consists of PSCPs. After your list is complete, share it within your triad. If time permits, debrief in the whole workshop group.

TRIAD GROUP EXERCISE: Select one PSCP from a discipline and curriculum area that you teach or have taught. Describe it in detail. Share it with members of your triad.

DEBRIEF: The concepts of formal solvable problem and PSCP seem to be hard for teachers to grasp. Not all pure problems are solvable, and not all solvable problems can be solved by computer. It is desirable that each workshop participant get firmly in mind one example of a formal solvable problem that can be solved by computer. This is most meaningful if the example is within a discipline the person knows well.

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Session 6: Goals of Computer Education

Goals

1. To create and examine a list of overall purposes or major objectives of education; to discuss this list in light of computers and related technology.
2. To examine a typical list of goals for instructional use of computers in precollege education; to understand strengths and weaknesses of these goals.
3. To understand instructional computing goals from a problem solving point of view.

History of Precollege Instructional Computing

The history of instructional use of computers in precollege education dates back to 1960 and before. The programming language FORTRAN was developed during 1954-1957. While this language was designed mainly to fit the needs of people who had at least a bachelors degree in mathematics, engineering, or a science, there were some quite early efforts to teach computer programming in FORTRAN to high school students. Richard Andree of the University of Oklahoma began working with high school students in the late 1950s. It was soon discovered that high school students with a good background in mathematics could learn to program in this language. However, few schools set as a goal that their math-oriented students should learn FORTRAN. Batch processed FORTRAN, making use of punched cards, was both inconvenient and beyond the financial resources of most high schools.

In the 1960s computer-assisted learning (CAL) research at the precollege level received considerable federal funding. The work of Pat Suppes from Stanford showed that computers could be an effective aid to students. He used a format of ten minutes a day of computerized drill and practice to supplement traditional instruction. However, few schools set as a goal that their students should make daily use of CAL. Such CAL was not cost effective for most elementary school settings.

In the mid 1960s BASIC became available, and timeshared terminals were installed in some schools. It became evident that BASIC was better suited than FORTRAN to the needs of high school students. However, timeshared computing was beyond the financial resources of most high schools.

In 1972 the Conference Board of the Mathematical Sciences recommended that all junior high school students should take a course designed to make them computer literate. Two courses were recommended, one assuming a higher level of math interest and ability than the other. However, few schools set as a goal that all students should become computer literate. Relatively few precollege educators understood the idea of computer literacy; there were few instructional materials or appropriately trained teachers to support a rapid implementation of computer literacy courses.

During the 1970s timeshared minicomputers began to provide relatively inexpensive computing to many schools. It became possible to teach BASIC programming or to have students make extensive use of databases of relevant information such as career information systems. In Oregon, for example, the computerized Career Information System developed at the University of Oregon did much to hasten the acceptance of computers into schools.

The lack of support for schools adopting specific goals for instructional use of computers rapidly faded as microcomputers began to proliferate in the late 1970s. The inexpensive microcomputer made it possible for schools to have enough computer equipment to support a variety of computer goals. During the early 1980s many schools and school districts set specific goals for computer education and began serious efforts to implement these goals. Now having such goals and implementation efforts is the norm rather than the exception.

The number of microcomputers and computers in schools has grown rapidly during the past ten years. For the academic year 1988-89 there will likely be approximately one microcomputer or computer terminal available for instructional uses for every 20 students. Some of these microcomputers will be quite powerful. Indeed, some will be more powerful than mainframe computers that served the needs of entire colleges or universities about 25 years ago. However, a ratio of one "keyboard" per 20 students is woefully inadequate if we want computers to have a significant impact on the precollege curriculum.

There is an added difficulty that many of the microcomputers in schools are now so old that they are wearing out and/or hopelessly out of date. Most school systems have financed their computers using non-reoccurring funds. Thus, they have not made provisions to replace computers that wear out or become hopelessly out of date. These and other factors are combining to slow the rate of growth of computers in schools.

Goals for Education

It seems reasonable to assume that goals for computers in education should take into consideration and/or be rooted in the higher-level objectives/purposes of an educational system. Unfortunately, that has not usually been the case. We begin with an exercise designed to get workshop participants thinking about the relationship between the highest level goals of education and goals for computer education.

INDIVIDUAL EXERCISE: Spend about three minutes making a brief list of what you consider to be the major purposes and/or objectives of education. These should be broad, philosophical statements such as "To help each individual to achieve their full potential." or "To support the religious views of the community and country."

DEBRIEF IN TRIADS (Five minutes): To what extent do your lists agree? What are the sources of your disagreements? Are both high touch and high tech well represented in the lists your triad has created?

WHOLE GROUP DISCUSSION: Make a master list of overall objectives/purposes. Do this by having people give examples of goals that were agreed upon within their triads. For each major objective/purpose, get a show of hands as to how many people listed this item. List those that seem to have broad support.

Be aware that different groups in a country may set different objectives. The preservation of the historical roots of a community may end up balanced against the objectives of having citizens who can serve in a highly technical military force or help a country compete in international business.

The following list can be used for discussion purposes. It is a composite from several workshops.

1. To help each student to achieve his or her full potential.
2. To have all students learn the basics—reading, writing, arithmetic, speaking and listening.
3. To have all students learn to solve problems.
4. To preserve the community's (or the country's) cultural and historical heritage.
5. To support the national goals and objectives of the country (for example, from an economic or military point of view).
6. To have all students become life long learners.
7. To have all students become responsible, moral individuals.
8. To have all students develop good interpersonal skills.
9. To have all students become good citizens. For example, this might include developing knowledge to be a responsible voter, and developing knowledge and skills to hold a job.

While this list could be extended, it contains enough items to allow us to proceed to the next part of this workshop session. Each item on the list can be examined in light of computer and other technology. Suppose, for example, that a community has a school system that lists as one of its major objectives the preservation of the values and ways of doing things that parents and grandparents have (that is, a variation of 4. above). How would this fit with teaching all students to use calculators and changing the math curriculum so that long division of multi-digit numbers becomes a calculator topic rather than a paper and pencil topic?

INDIVIDUAL AND TRIAD GROUP EXERCISE: Pick one of the major objectives listed above. Think about how it might be affected by computers and related technology. Then share your observations with the members of your triad. The purpose is to practice analyzing overall goals of education in light of how they may be affected by computers.

Discussion of possible computer-related impacts on overall education goals can serve to introduce the topic of a specific list of goals for computers in education. However, before examining such a list one might first want to examine to what extent our educational system and goals are rooted in the past. Consider the four "ages" given below:

1. Hunter-gatherer.
2. Agricultural.
3. Industrial.
4. Information.

Until about 12,000 years ago, all people on earth were living in hunter-gather societies. Them large parts of the world began to enter the agricultural age. The industrial revolution began in Europe during the 1700s. The information age began in the United States in the mid 1950s. Currently there are many countries that have agricultural-age societies, many with industrial age societies, and an increasing number with information-age societies.

Currently in the United States about 3% of the work force works on farms, a little less than 20% in industrial-type jobs, and about 75% in the information-age jobs (a combination of service jobs and high tech jobs). While the latter category clearly dominates, it is a mixed category. It includes computer scientists, teachers, and clerks in fast food stores. A more accurate description of the Information Age might be the “Information and Service Age.” Far more people hold service types of jobs, such as being a clerk in a store, than hold high tech, information processing jobs.

TRIAD GROUP EXERCISE: Identify major components of our current educational system that seem rooted in or designed to fit the needs of the various ages listed above. What would constitute major changes to fit the Information Age? Give specific examples.

WHOLE GROUP DEBRIEF: This is a fun exercise. It seems clear that the design of our educational system is rooted in a combination of the agricultural and industrial ages. There is little to suggest that we are changing to fit the information age. Indeed, it isn't clear to most educators and educational leaders what types of changes are needed to accommodate the information age. If time permits, direct the discussion toward types of changes that would be appropriate for an information age.

For example, an industrial age requires workers who follow directions, don't question authority too much, are punctual, and who are willing to do repetitive, routine tasks. A modest level of skill in reading and writing is quite desirable, but most such jobs do not require much critical thinking, problem solving, and other higher-order cognitive skills. This list of requirements fits well with the basic nature of many of our school systems. It might be contrasted with individualization of instruction, emphasis on independent thinking and higher-order processes, setting one's own goals, and so on.

It is interesting to view the trend from hunter-gatherer to agricultural to industrial ages as being a movement from high touch towards high tech. And the information age is fueled by still more technology, with the computer being at the heart of information storage, processing, transmission, and retrieval. To the extent that people require a balance between tech and touch to be comfortable and happy, we can see that this trend is producing an imbalance. What are balancing factors as we move increasingly into an information age? What role might schools play in contributing to this balance?

Goals for Computers in Education

My first involvement in writing goals for computer education was during a 1972-73 graduate seminar I was teaching. In the spring term, I wrote up a set of goals and the class spent considerable time discussing and refining them. These goals were later published in the first issue (May 1974) of the Oregon Computing Teacher. These goals recommended that all students should become computer literate, that computer-assisted learning and computer-integrated instruction should be used when they are educationally and economically sound, and that students desiring more advanced computer educational training should have such opportunities.

WHOLE GROUP ACTIVITY: By a show of hands, find out how many schools and/or school districts represented by the workshop participants have adopted a set of goals for computer education.

A surprisingly large number of schools and school districts are moving rapidly in the computer education field without having carefully stated goals. Explore this further. How many school districts have a detailed scope and sequence that implements some or all of their major goals? Is it desirable to have such a scope and sequence? Once implemented, is such a scope and sequence easily modified to reflect changes in computer technology or overall ideas of appropriate use of computers in education?

The first four goals listed below reflect a slight refinement of the 1972-73 goals published in the May 1974 issue of the Oregon Computing Teacher. The fifth goal was added more recently, both to promote discussion and to help tie this session in with the session on Problem Solving.

1. All students shall become functionally computer literate.
2. Computer assisted learning shall be used when it is educationally and economically sound.
3. Computer-integrated instruction (CII) shall occur when it is educationally (and economically?) sound.
4. All students shall have reasonable opportunity to take elective computer-related courses designed to:
    a. Help contribute to their college-prep program of study.
    b. Help prepare them for a job upon leaving school.
    c. Help prepare them to be a homemaker.
5. All educators should strive to make our educational system more effective through appropriate use of computer technology.

In a workshop, each of the five goals should be discussed briefly to help clarify its meaning. For example, the first goal specifies that all students should become computer literate. Does this goal mean the same thing now as it meant in 1972 when the Conference Board of the Mathematical Sciences recommended it? What will its meaning be ten years from now? Is it reasonable to set educational goals whose meaning change rapidly over time?

What does it mean for CAL or CII to be educationally and economically sound? Educational soundness is perhaps best assessed by comparison with standard educational practices currently in effect. That is, we know the overall goals of education and how our educational system is designed to achieve the goals. We don't want to damage our educational system by inappropriate use of CAL and CII.

Economic soundness may be more difficult. But suppose that a particular educational objective could be obtained by use of CAL or by non-computer methods. Suppose that the CAL approach cost twice as much. We would then say that the CAL approach was not economically sound. If the CAL approach cost only half as much as other modes of instruction that achieved similar results, we would say the CAL was economically sound.

The question mark on economical soundness for CII is because we don't have a good basis for comparison. Suppose that we decide it is important for students to learn to do process writing in a word processing environment. This requires use of computers. One can teach process writing without computers, but one cannot effectively teach computer-based process writing without use of computers. Similarly, suppose we decide it is educationally sound to have all students learn to make routine use of a computer graphics package in high school science and mathematics courses. The issue of economical soundness might better be stated as an issue of whether we can afford it and are there better uses of the money.

The fourth goal suggests that schools might offer a range of more advanced computer education opportunities for select groups of students. Here one must examine if the appropriate hardware, software, instructional support materials and teacher are available. It is better to not offer such courses than to offer poor quality courses.

The fifth goal is intended to be somewhat nebulous. One way to view effectiveness of an educational system is to consider the **problem** (Is it a formal problem or just a problem situation?) of achieving the overall objectives of education. In the session on Problem Solving we did an exercise placing "education" on a ten-point scale, with the left end being the disciplines with the least formal problems and the right end being disciplines with the most formal problems. We also did an exercise that suggests that most educators think education over the next twenty years will move toward the right end of the scale. The fifth goal relates to this.

In analyzing the goals, look not only for what is there, but also for what is missing. Perhaps there are quite important goals missing.

WHOLE GROUP EXERCISE: Have each person spend a couple of minutes thinking about major goals that might be missing from the list. Note that many of the workshop participant suggestions are likely to be included in the present list, but not in an obvious manner. This exercise should help lead to a better understanding of what the various goals include or mean. If major new goals are suggested, add them to the list.

It is important for computer education leaders to understand the purpose of each goal for computers in education. Why is it included on the list? How do the computer education goals relate to or support the overall objectives of education? What educational problems does each computer education goal address? Are there other ways to address the same educational problems?

One very important idea in working to solve real-world problems is that the process of solving a problem may create new problems. For example, we build a factory to mass-produce goods that people want to buy cheaply. But the factory causes air pollution. As we identify problems that might be solved by accomplishing the goals for computers in education, we must be on the lookout for new problems that might be created.

For example, suppose that a school system implements a required computer literacy course for eighth grade students. This course displaces some other course or electives that the students take. Does this improve the overall quality of education the students receive?

TRIAD GROUP ACTIVITY: (Fifteen minutes) Work in triads and use active listening. The "talker" is to select one of the five goals for computers in education. Talk about what educational problems it addresses. Talk about the strengths and weaknesses of the goal. Will accomplishment of the goal solve the educational problems, and will it create additional problems?

WHOLE GROUP DEBRIEF: Carry out a general discussion and make lists of the strengths and weaknesses of these goals; get varying viewpoints on the problems they are designed to address. Make lists by getting contributions from workshop participants. If two overhead projectors are available, put strengths on one and weaknesses on the other. Collect the lists with a minimum of comments. The discussion comes later.

A major purpose of this exercise is to encourage looking beyond the superficial. There should be quite a list of weaknesses. For example, suppose that eventually computer-assisted learning is both economically and educationally sound for each individual topic in the curriculum. What would it do to schools if the entire curriculum were handled via computer-assisted learning? (There might not need to be any teachers involved. Perhaps aides or parent volunteers could provide the necessary level of supervision.) Here we have a clear high tech/high touch issue. If we move toward replacing some of the high touch in our educational system by high tech, what will be lost? Can we measure these loses? The potential measurable gain is for increased scores on standardized tests. How can one compare the potential loses and gains?

The computer education leader should be able to cope with these weaknesses and discuss such problems from a reasoned and intellectually defensible position. The goals may be a useful starting point, but that is all they are. It requires knowledge of computers (technical knowledge), students, educators, school systems, and our society to adequately cope with such a crude statement of goals. This type of analysis suggests that computer education leaders need to be broadly educated.

Many school districts have not only adopted a set of computer-in-education goals, they have also specified a detailed scope and sequence for accomplishing the goals. Such a scope and sequence tends to be “cast in stone.” Do we know enough about computers in education to develop and implement scope and sequence materials that will be valid five years from now? Will the list of computer-in-education goals listed and discussed above still be valid five or ten years from now?

TRIAD GROUP EXERCISE: (Twenty minutes) The short article given below is Dave Moursund's November 1988 editorial in The Computing Teacher. Read it, and then carry on a small group discussion on the controversy that it discusses. Attempt to reach group consensus on how to resolve this controversy.

Standardized Testing and Computer Assisted Instruction

There is one sure way to get a rise out of the students in my graduate computer education courses. Just mention standardized testing and the increasing role it seems to be playing in education. Most of my students become quite agitated in thinking about this, and some become downright hostile towards the school systems where they work.

Students face a barrage of standardized tests, beginning in grade school and often continuing on into graduate school. Moreover, some teachers are now being evaluated by how well their students do on standardized tests. Increasingly, teachers themselves are being required to take standardized tests, either to obtain a teaching certificate or to maintain their teaching certificate.

The educators I work with give a variety of reasons why they are troubled by the major emphasis on standardized testing. Reasons given include that such testing is a waste of time, irrelevant to the curriculum, focuses too much on lower-order skills, and is a major force moving education in an inappropriate direction. The tests seem to be driving the curriculum—teachers are teaching to the tests and students are studying methods specifically designed to raise their test scores.

Interestingly, I pick up nearly similar feelings of disquiet and fear when my students discuss computer-assisted instruction. Much of the CAI material is rather superficial, focusing mainly on lower-order skills. Deeper aspects of the human elements of teaching remain elusive to most CAI developers. There is a distinct possibility that eventually the content of CAI-based courses will become the curriculum.

Standardized Testing

Generally I maintain a neutral stance in discussing standardized testing. I have some understanding of the processes that have been followed in developing and evaluating the test items. I know a little about validity and reliability. And, of course, I understand some of the roles that computers now play in the overall process of developing standardized tests.

In recent years computers have played an ever-increasing role in standardized testing. Two trends are evident. First, there are large databanks of possible test questions, along with item analysis and other statistical data that have been gathered through use of the test items. Thus, it is growing easier to create standardized tests or other tests with specified characteristics. Second, an increasing amount of testing is now being done online. In one type of online testing, called adaptive testing, the computer system adjusts the selection of questions to the particular person being tested, making changes based on performance during the test.

Adaptive testing has many characteristics of computer-assisted instruction. Indeed, much of the CAI that is currently available can be considered as tests, with some feedback and perhaps some remedial instruction being provided while the test is being taken.

Perhaps it is the close similarity between objective testing and routine drill and practice CAI that agitates so many of my students? In both cases, a large part of education seems to be reduced to a lower-order skills, multiple choice or short answer format. The multidimensional aspects of a good student/teacher rapport are missing, along with much of the richness of a good classroom environment. Many educators find this objectionable. They know education has many important dimensions that cannot be measured through such a testing format.

Coachability of Objective Tests

Recently I read *None of the Above: Behind the Myth of Scholastic Aptitude* written by David Owen. In large, it is an attack on the Educational Testing Service and their widely used test, the Scholastic Aptitude Test (S.A.T.). But at a deeper level it questions all standardized tests. It is a powerful book, and I strongly recommend it to all educators.

There are a number of important points discussed in Owen's book. One is the nature of the standardized test questions themselves, and the fact that many questions are subject to multiple interpretations. Thus, one has to have or to develop a mindset somewhat similar to those who create the questions in order to interpret the questions in a manner leading to “the correct” answer.

But a deeper problem that Owen raises is the “coachability” of standardized tests. It is possible to teach to the test or to coach students so that they will do well on a particular test. A number of companies publish books that are designed to help students improve their test taking ability, and many of these books are geared toward a particular test such as the S.A.T. Indeed, there are now a number of pieces of software designed for the same purpose. Some companies advertise the purchase price will be returned if the user doesn't make a certain specified gain in their S.A.T. test score.

Owen discusses several companies that run short courses specifically designed to help students learn to make higher scores on specified standardized tests. In these courses, students learn a wide range of tricks, almost none related to increasing their understanding of the material being tested. It turns out that because of the way standardized tests are created and the way that the test constructors think, it is possible to correctly guess answers to many questions without even reading the questions!

Earlier in this editorial I suggested that the feelings my students have about standardized testing and about CAI seem to be similar. Owen's has increased my understanding of this issue. The real world does not consist of a sequence of objective questions, where success is measured by one's ability to select the one correct answer from a short list of choices. But both standardized testing and most of the currently available CAI view the world in exactly this manner. Thus, both foster teaching to the test, teaching objective test taking skills, and rewarding students for developing a good objective test mentality.

A Confrontation?

The problem of an objective text approach to education is not easily solved. Objective testing has become institutionalized, and it is now a driving force in our educational system. Moreover, most currently available CAI seems designed to contribute to this approach to education.

I suspect that eventually there will be a major confrontation between the forces that support standardized testing, objective testing, and objective oriented CAI, and those who feel that this represents a major threat to education. Currently I side with the latter group.

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Session 7: Analysis of the Computer-Assisted Learning GoalSession 7: Analysis of the Computer-Assisted Learning Goal” “”

Goals

1. To increase your understanding of the meaning and implications of the CAL goal discussed in the previous session.
2. To increase your understanding of the current state of CAL and its future potential.
3. To help you understand obstacles that tend to inhibit CAL from realizing its potential and roles computer education leaders can play in overcoming these obstacles.
4. To examine some arguments that might support increased use of CAL.

The CAL Goal

The second major goal we listed for instructional use of computers in the previous session is:

> 2. Computer-assisted learning shall be used when it is educationally and economically sound.

The CAL goal is unique in that it is a process goal (as contrasted with a content goal), indicating that computers might be applicable to the pedagogy of education in all disciplines and at all levels. It does not address a specific educational problem. Rather, it essentially indicates that CAL is an instructional medium and that its use should be based upon its cost-effectiveness in any particular teaching/learning situation.

But there have been surprisingly few studies on the cost effectiveness of CAL. David Hawley (1985) completed such a study for his Ph.D. dissertation at the University of Oregon. In this study Hawley analyzed use of drill and practice materials in the third and fifth grades. His study demonstrated cost effectiveness over a four-month period. He included the costs of hardware, software, site preparation, teacher training, and so on. Effectiveness was measured by gain scores on a standardized test. The control group used equal amounts of time to use non-computer aids to learning.

Many people argue that CAL will add to the individualization of instruction; they suggest this is a strong argument for use of CAL. However, Richard Robbat (1986) wrote a booklet for ERIC that examines the issue of computers and individualized instruction. At the time he was writing this book, Robbat was a secondary school history teacher and a strong supporter of individualization of instruction. However, he was not able find good evidence that computers are making a major contribution in this area. He suggests that the nature of our educational system and preparation of teachers makes adoption of individualized instruction quite difficult.

Background Information

The term CAL covers a range of materials and ideas. Many writers suggest that CAL materials generally fall into one of three categories:

1. Drill and practice.

2. Tutorial (instruction).

3. Simulations and micro-worlds.

In some sense these three categories form a continuum from relatively simple to relatively complex. The greatest amount of CAL material falls in the first category, and the greatest amount of research on CAL has been on drill and practice materials (Kulik et al, 1983). See also (Forman, 1982). People often use such terms as computer-assisted instruction (CAI), computer-based instruction (CBI) or computer-based learning (CBL) synonymously with CAL.

Most CAL systems include some sort of management or record keeping system, and all produce some sort of report for the student and/or teacher. The term computer-managed instruction (CMI) usually refers to a system that does diagnostic testing and prescription, along with appropriate record keeping. Some CAL systems have such CMI features.

In addition, a CAL system may be more or less intelligent. ICAI (Intelligent Computer-Assisted Instruction) is an important aspect of CAL. This "intelligence" may be used in diagnosing and remediating student problems, tracking a student's progress, individualizing, and helping to teach higher-order cognitive processes. It may be used to process student responses in a more intelligent fashion.

CAL has a long history—dating back nearly to the first general purpose electronic digital computers. Substantial work on CAL languages and authoring systems was done during the 1950s, and the Plato project began late in that decade. CAL has been studied in numerous research projects. In recent years meta-studies (studies of studies) have attested to the effectiveness of CAL. The greatest amount of research has been done on drill and practice. The evidence for the educational effectiveness of computerized drill and practice seems quite convincing. Students (on average) learn perhaps twenty to thirty percent (or, even more) faster in such CAL settings.

There has been less research on the more sophisticated forms of CAL, and much of this research has been done by the United States military or through military-funded projects. A number of exciting projects have demonstrated the potential of these forms of CAL. However, there is relatively little solid research literature on the effectiveness of using computer simulations in precollege education. The Ph.D. dissertation work of Woodward in 1985 and Hollingsworth in 1987 at the University of Oregon suggest the effectiveness of one particular health simulation with mentally retarded secondary school students.

Beginning in the early 1980s, a number of videodisc-based projects have explored use of this new medium in CAL. Gradually such CAL has come into use in medical school education, in certain employee training in business and industry, in military education, etc. The acceptance by public schools has been rather slow.

Educationally Sound

The CAL goal listed above uses the term "educationally sound" but doesn't define the term. Presumably a definition would have to include some sort of comparison with other materials or modes of instruction designed to accomplish the same task. Thus, we can compare CAL with conventional education in terms of the affective domain, how fast students learn, how well they retain what they learn, etc.

The suggestion that we should not use CAL materials which are not educationally sound has caused many educators to raise a similar issue about non-CAL instructional materials. Many educators argue that we don't pay much attention to the educationally sound issue for the conventional educational materials. For example, research going back to the early 1900s attacks the value of basal spelling texts and suggests better ways for students to learn spelling. EPIE (the Educational Products Information Exchange, New York) has long held the position that print materials used in schools are not adequately tested.

WHOLE GROUP EXERCISE: Select some instructional materials that you have used extensively in your teaching. Cite evidence that these materials are educationally sound. If possible, cite evidence that these materials are more educationally sound than other materials that are used or might be used for the particular educational task.

DEBRIEF IN TRIADS AND WHOLE GROUP: The work of Ken Komoski at EPIE should come up. He indicates that most (over 90-percent of) curriculum content is textbook based, and that textbooks are rarely evaluated for their educational effectiveness.

The discussion might also focus on the overall textbook writing, publishing, and adoption process. Major textbook publishing companies tend to pay careful attention to ensuring that their books will meet adoption requirements of states that prepare a statewide adoption list. Considerable effort goes into ensuring that books are attractive and have characteristics that might increase their likelihood of being selected by school districts and teachers. Relatively little of this overall effort goes into classroom testing. Educators such as Ken Komoski argue that this overall process tends to result in relatively educationally ineffective books.

In 1985 the state of Texas went through a textbook adoption process for textbooks to be used to teach a junior high school computer literacy course. Texas is a very large market, so getting on this adoption list is important to publishers. There were thirteen books submitted, each with a 1985 or 1986 copyright. Many had been rushed to completion to meet the Texas deadline. Many had been carefully modified to meet the guidelines established by Texas. These guidelines, for example, indicate that a book should not encourage children to eat "junk" foods. Blueberry muffins would be considered to be junk food, so should not be used in examples of items to be purchased or consumed. One can argue that such guidelines contribute little to educational effectiveness of the materials.

Perhaps the most important long-term impact of CAL will be its contribution toward making the teaching/learning process into more of a science. Educational researchers are beginning to feel that the science of teaching/learning is sufficiently developed and sufficiently powerful so that it can make a significant contribution to education. Many such people feel that CAL provides a vehicle that is powerful enough to implement their findings. (Ask for a show of hands for who has had a course or extensive workshop on Theory of Teaching. While many teachers have had some Learning Theory, courses in Teaching Theory are not so well established in our teacher education programs.)

The concept that teaching/learning can be made into a science is particularly supported by advocates of direct instruction. The work of Engelmann, Becker, and Carnine at the University of Oregon has shown considerable promise. They are now working to computerize some of their materials using videodisc technology. Their theory of instruction is described in Engelmann and Carnine (1982). Carnine, Engelmann and others are now involved in a multi-million dollar videodisc project to develop a variety of instructional materials. Three discs (six sides) covering fractions were published in late 1985. It was reported in 1988 that this set of materials was currently the best seller of precollege videodisc educational materials.

GOOD SOFTWARE EXERCISE FOR INDIVIDUALS: A few years ago it was common to hear "Ninety-five percent of the software that is out there is no good." Now the figure one often hears quoted as not good is eighty percent; moreover, there is now much more educational software available. T.E.S.S. (The Educational Software Selector) published by EPIE now lists about 8,000 educational software items.

Make an estimate of the number of different pieces of educational software available in your school or school district. Make an estimate of what percentage of this software you would consider to be "good." (In doing this, make up your own definition of "good." Be prepared to share your definition.) Then share your results in your triad.

WHOLE GROUP DISCUSSION: The evaluation of software is very difficult. EPIE, MicroSIFT (a federally funded project which was run through the Northwest Regional Educational Lab located in Portland, Oregon) and others have made massive efforts that are only partially successful. The MicroSIFT evaluation form has been widely distributed and widely used (Evaluator's Guide, 1986).

The difficulty is the issue of educational soundness or educational effectiveness, relative to other instructional aids. In essence, educational soundness/effectiveness is determined by a careful control group/experimental group type of research. This is expensive and takes a lot of time. Almost none of the software on the market has been so tested. In that sense, we are running into the same problems we have with textbooks. Indeed, it is an interesting exercise to explore the analogy of textbooks versus software. What makes us think that these two educational industries will not end up controlled by the same companies and run in the same manner?

If time permits, this would be a good place to delve more deeply into the software evaluation issue. There seems to be an unending call for more and more evaluation of software. However, our educational system tends to not be willing to pay for it. A number of software review publications or services have gone out of business. EPIE seems perpetually to be having financial difficulties, and the MicroSIFT software evaluation project has ended. Why is this?

As indicated above, evaluation is, in essence, research. Educational research is expensive and time consuming. The market for educational software is still quite limited. This means that it could well cost more to adequately evaluate a piece of software than one might hope to recoup by sales.

There are other difficulties. It is relatively easy to change (and hopefully, improve) a piece of software. Suppose that one does extensive classroom testing of a piece of software, and then makes changes based both on the testing and new ideas that occur to the program developers. One then needs to begin again in the evaluation process. The videodisc materials being developed by Carnine, Engelmann, et al are undergoing extensive formative evaluation. Typically each set of materials is redone three or more times. This is very expensive and takes a long time. But the result is educational materials that are much more educationally sound than most existing materials.

Still another difficulty is the ease of copying good ideas. A company may develop educational software that uniquely and effectively uses color, sound, windows, or some other computer features. Such basic ideas are quickly adopted by other companies. Thus, little profit or other advantage is gained by the company doing the initial work. Still less is gained if there is a long evaluation process before the software is distributed. An unscrupulous competitor might have a near-imitation product on the market even before the originator succeeds in doing so.

Economically Sound

TRIAD GROUP EXERCISE: (Ten minutes) Consider the idea of your school or school district making a massive commitment to CAL during the next five years. This commitment would be at the level of five percent of the entire school budget each year for the next five years. If you don't know what the average per pupil expenditure is in your school district, use the figure $4,500 which is about the United States 1988-89 average yearly expenditure. Pick one side—either being for this idea or against this idea. Spend a minute formulating your position and arguments to support your position. Now share your ideas and feelings in your triad. Practice your strongest arguments for or against increased use of CAL. One person talks at a time, for a minute or two, while the other two in the triad serve as active listeners.

ALTERNATE SMALL GROUP ACTIVITY: Each person is to (mentally) select one very good piece of CAL courseware that they know quite well. In triads, have one person at a time describe a piece of courseware, sharing what is good and not so good about the courseware. How would increased student use of this software improve education? The goal is to share knowledge and insights into the CAL field. This type of small group discussion also allows the participants to compare their knowledge and insights with others. Are you familiar with the software others list? Do you have the same opinions? Can you articulate your opinions as well as others?

WHOLE GROUP DISCUSSION: (Ten to twenty minutes) How many people selected the "in favor of" side, and how many the other side? (Show of hands.) Use the overhead projector to make lists of the best pro and con arguments.

Relatively few people in a computer education leadership development workshop will select the argument that there are much better ways to use the money. The money could be used for books, teacher training, remodeling the school building, drug education, etc. One could put together quite good arguments that there are many non-computer uses of the money that would improve education more than the proposed CAL usage. That is, one can argue that CAL is not economically sound relative to other quite different uses of the funds. Since, in essence we are comparing unlike objects, this type of argument is difficult to deal with.

Cost/effectiveness has two factors—cost and effectiveness. One way to measure educational effectiveness is by gain scores on standardized tests. One can measure the cost of CAL. The issue is, what are the costs of achieving certain educational objectives by use of CAL versus achieving them by other methods. David Hawley's study (1985) cited earlier in this session looked at gain scores on a variety of tests. He figured the cost of such gains via conventional instruction and via a combination of conventional and CAL instruction. In his study, students made relatively large gains on the test scores. Thus, although CAL increased the cost of the instruction, it proved to be quite cost effective. Students learned substantially faster at only a small increase in cost.

But Hawley's study was based on the assumption that gain scores on a standardized test are a good and appropriate measure of what we are trying to accomplish in school. Owen (1985) argues that standardized tests are a poor measure of what it is we want students to learn in schools. (See also the Moursund editorial at the end of the previous chapter.)

It is interesting to consider the argument that a student's time is worth money. This is another way to analyze cost/effectiveness data. The argument is as follows. The average cost in the United States for keeping a student in school for one hour is a little over $4.00. This figure comes from assuming a school day of six hours, a school year of 180 days, and an annual school budget of about $4,500 per student. CAL may help a student to learn faster. The time saved can be equated to money, using the figure of $4.00 per hour.

For example, if a student learns twenty percent faster while using CAL, then an hour of CAL need cost only .2 times $4.00 = $.80 or less to be cost effective. Note that this argument is especially powerful in situations where education is particularly expensive (costing several times the $4.00 per hour, for example). Special education provides good examples. Medical schools now make extensive use of CAL. The cost of medical school instruction is about ten times the cost of public school instruction in the United States. Military education is making increased use of CAL. Simulations (for example, flight simulators) are especially cost effective for the areas in which they need to train personnel.

Now consider purchasing a relatively good microcomputer, a printer, and some CAL software. Assume that $2,500 is spent for this computer system and to maintain it over a period of five years. If the system is used about six hours a day during the school year, it will be used about 5,000 hours during these five years. This is a cost of just $.50 per hour. Thus, it is highly cost effective according to the above criteria!

WHOLE GROUP DISCUSSION: What are the good and bad features of the above argument? Why isn't CAL being used extensively in almost all schools in the United States?

TRIAD WHOLE GROUP EXERCISE: The analogy with educational TV is often raised. It is argued that educational TV has had little affect, and that CAL will run into the same problems. Why hasn't educational TV had a larger positive impact, and why do we expect CAL to be different?

WHOLE GROUP DEBRIEF: It turns out that we know relatively little about the overall impact television has had on education. Remember, much education is informal, taking place outside of schools. It is indeed true that within formal educational settings, the impact of television has not been very strong.

One standard argument concerning television versus CAL is the nature of the interaction. Television is passive, while CAL is active. Students remain on task for a higher percentage of the time when engaged in CAL. Indeed, perhaps much of the success of CAL can be attributed to increased time on task. Note, however, recent work by Carnine, Engelmann, et al. In testing some of their videodisc materials they set up a situation in which students in a conventional educational setting had a very high percentage of time on task. Even then the videodisc experimental group learned more than the control group in an equal amount of time. This attests to the value of the underlying teaching and learning theory that is incorporated in these videodisc materials.

The Future of CAL

If all computers currently available in precollege education were used only for CAL, the average student would receive perhaps 15-20 minutes of CAL per day. Even this little bit of CAL usage would be enough to begin to make a significant difference in a student's education. Studies (such as the work of Suppes, going back to the 1960s) have shown that ten minutes of computerized drill and practice a day in a topic such as elementary school mathematics can make a significant difference. Hawley's (1985) study used this format for third and fifth grade arithmetic.

It seems obvious that there will be increasing amounts of CAL software and increasing evidence on its effectiveness. It seems inevitable that eventually CAL will play a major role in our educational delivery system.

It also seems evident that the amount of computer equipment available in precollege education will continue to grow. One can find a number of schools having five to ten times as much hardware as the average for the whole country. If having such computer access gives students an educational advantage, there will be strong pressure for other schools to have similar amounts of computer access.

Alfred Bork puts forth another, very strong, argument for increased use of CAL. For many years his CAL materials were used in a first year college-level physics course at the University of California, Irving. Extensive research verified the quality and effectiveness of this course relative to the conventional (teacher taught) course covering the same materials at the University of California, Irving. Bork notes that the majority of United States high schools do not offer a physics course. (Most of the schools that don't offer the course are small. Thus, the majority of students actually attend high schools offering such a course.) It would cost perhaps $5 to $10 million to develop a very high quality CAL physics course for use in high schools. This is a small cost relative to the number of students who currently have no access to a physics course while in high school.

But if such a course were available, it would undoubtedly prove to be better than a number of the physics courses currently being taught. Moreover, it would be more conveniently available to a number of students. This is because many schools offer only one or two sections of the physics course. Some students can't take physics because it conflicts with other courses they have to take or want to take. Thus, there would be competition between the conventional physics course and the CAL course.

The same argument can be made for a number of other courses. Eventually a federal or large state educational agency will begin to fund the development of such courses. This will introduce an element of competition into our educational system. Such competition might well have a major impact on the educational system.

Currently CAL is mostly an add-on expense in precollege education. Only rarely can one find situations in precollege education in which that is not the case. If CAL is to be widely used and not be an add-on expense, there will eventually be a restructuring of teacher duties and the nature of teacher pay. Perhaps there will be master teachers who receive higher pay, or large classes with substantial computer usage and lower paid aides.

There is beginning to be some competition from “storefront” or drop-in” schools making use of CAL materials. In California, for example, if a student drops in to such a storefront operation and uses CAL materials for a prescribed amount of time, the storefront “school” receives a day's ADM payment from the state.

TRIAD GROUP EXERCISE (15 minutes): Spend a minute or two thinking about what you feel the 10-15 year future of CAL will be, and the longer term future. For example, by then we could have a substantial number of entire courses available in computerized videodisc format.

How will this change the teaching/learning environment? What can a human teacher do that a CAL system cannot do? Share your ideas in your triad. Active listening techniques are to be used, with one designated speaker at a time.

WHOLE GROUP DISCUSSION: Individuals are to share their most important ideas with the whole group. Out of this may come notes of caution. We may see that the very long-term picture for CAL is bright, but that it faces a rocky future during the next 10-15 years or more. The discussion could focus on what computer education leaders can do to help achieve the desired goals. One of my scenarios of the future of computer education is that CAL will be widely adopted, and that eventually the good CAL will become more and more tool-like. That is, CAL and computer-integrated instruction will tend to merge with time.

Widespread adoption of CAL runs into the high tech/high touch issue. It seems evident that most CAL is intended to be used individually, with a student concentrating on display screen and keyboard. That is, it is a high-tech, low-touch environment. Consequently, it may be rejected. Indeed, we might expect that eventually there will be carefully done research studies exploring whether extensive use of CAL is detrimental to the overall educational/social/"whole person" development of a student.

WHOLE GROUP DISCUSSION: What can be done to make CAL more high touch? As CAL becomes more widely used, what roles can teachers play to ensure that schools continue to have a major high-touch component?

The following section is the October 1988 editorial for The Computing Teacher which I wrote. It reflects my current thinking on working to achieve an appropriate balance between teacher-taught education and CAI.

CAI or Teachers? Not Either/Or — But Both!

At the spring 1988 annual conference of the Northwest Council for Computer Education the keynote presentation was a panel discussion by Karen Billings, Sylvia Charp, David Thornberg, Tom Snyder and myself. LeRoy Finkel was the moderator, and the central focus was the future of computers in education.

The initial part of the discussion was a brief presentation by each panel member. The various points of view were mostly upbeat and can be summarized by:

1. Computers in education are a good idea and progress is continuing.
2. Computer-as-tool is great. (This was the main point I made, and it was reinforced by other speakers.)
3. Routine CAI drill and practice has proven quite useful.
4. Empowering the teacher, and focusing on how to make effective use of one computer per classroom, is a great idea.
5. Teachers are wonderful. The human-to-human interaction of teacher with student is at the core of quality education.

A variety of questions from the audience focused on the same issues. Each comment about maintaining the current central role of teachers brought cheers from the audience.

As the discussion progressed, I found myself growing more and more frustrated. Two major themes had been ignored in the initial presentations and were being ignored in the discussion. One was the issue of whether students in the future will be learning any solid computer science and computer programming. Surprisingly, no panelist made a prediction in this area and no member of the audience raised the question. But that contributed only modestly to my feeling of frustration.

The second major theme that nobody seemed willing to raise was that of computer assisted instruction as a vehicle for presenting curriculum units or entire courses. Sylvia Charp, who is a strong proponent of CAI, had focused on supplemental drill and practice in her presentation. At an opportune time, I mentioned the topic and suggested that it will gradually produce a massive change in education. Sylvia Charp cheered, several other panel members immediately jumped into attack mode, and many of my former and current graduate students blanched. I was pleased that my statement had brought increased life to the panel presentation.

As the discussion continued it became clear that many people view CAI in an either/or mode. That is, they think of CAI and our traditional educational practices that make little use of CAI as being in direct competition. Either we maintain our current system or we have CAI. They do not acknowledge the fact that we already have both in many schools.

Those who oppose CAI then go on to paint a frightening picture of children spending all day chained to a soulless, inhumane machine that assumes full responsibility for their education. Many of us are brought to the verge of tears just thinking about what a terrible thing this would be for our children.

Those who favor CAI tend to talk about increased rates of learning, teacher productivity, individualization of instruction, and an increased range of learning opportunities. The picture of children learning more, better, and faster, and achieving their full potential, is heart warming.

Surprisingly, the panel discussion never got beyond these two extremes. There was no suggestion that a compromise position might be appropriate. It seems inevitable to me that during the next two decades our school systems will gradually move toward making substantial use of CAI. However, during that time human teachers will continue to play a dominant role in the overall educational process. Computers will gradually fill roles that they do better than humans. Humans will gradually move in the direction of filling roles that they do better than machines. We will have both humans and computers deeply involved in the instruction of our children.

I enjoy discussing which aspects of instruction might gradually be relegated to computers, and which aspects are best preserved to human teachers. The human brain is a wonderful thing, and there are many things that humans do far better than computers. Perhaps the most important of these is having a deep understanding of what it is to be a human being. This includes understanding human verbal and nonverbal communications systems. The very best work of researchers in artificial intelligence has not yet begun to develop computer systems that even show signs of eventually leading to systems that have such human abilities. Thus, to the extent that teachers are making use of these human abilities, they can far outperform the very best of current CAI systems.

But much of the educational process is not based on intimate, one-on-one human interaction that requires use of these human communication abilities found in all teachers. We cannot afford an educational system in which there is one human teacher for each student. Moreover, it is essential that students learn to learn from books and other resource materials, such as computerized information retrieval systems. Routine drill and practice is an important part of education. CAI can provide rich simulations, opportunities for trial and error explorations requiring higher-order cognitive processing, greater opportunities for individualized instruction than most current classrooms provide, and so on.

It seems obvious to me that our educational system would be better if it were based on a combination of well-prepared and dedicated teachers and an abundance of high quality CAI. The cost of providing a computer for every student and a wide range of CAI materials is quite modest compared to our current educational expenditures. If we devoted five-percent of current annual school budgets to this task, it would soon be accomplished. I strongly believe that we should be working toward this objective.

WHOLE GROUP DISCUSSION: Discuss the editorial. Does it adequately reflect a major controversy between CAI-oriented people and non-CAI-oriented people? What is the most likely long range outcome of this controversy?

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Session 8: Computer-Integrated Instruction

Goals

1. To define and illustrate computer-integrated instruction (CII).
2. To give arguments supporting a rapid increase in CII.
3. To give a plan for the teacher training and teacher support needed for increased CII.

What is Computer-Integrated Instruction?

The history of instructional use of computers in precollege education is long. In Oklahoma, for example, Professor Richard Andree was teaching computer programming to high school mathematics teachers during the late 1950s. The Plato project began roughly in 1958-59. Substantial work in computer-assisted learning, such as that done by Suppes, occurred during the 1960s (Taylor, 1980). In the early 1970s the idea of universal computer literacy began to emerge (Conference Board, 1972; Luehrmann, 1972). But at that time, computers were still too expensive to have a significant impact upon precollege instruction.

Microcomputers began to come into schools in the late 1970s, and computer literacy became a rallying cry. A high growth rate for computer availability began.

Even now, however, computers are still a relatively scarce item in precollege education. According to Paul Berg of the Alaska State Department of Education there was one microcomputer per 22 students in Alaska in December 1984. Alaska leads the nation in this regard (Berg, 1985). Most (relatively optimistic) estimates suggest that United States schools will reach an average of one microcomputer or timeshared terminal per 40 students sometime during the 1985-86 academic year. A TALMIS report indicated 730,000 personal computers in precollege education at the end of the 1983-84 school year, and it predicted the number would reach 1,200,000 at the end of the 1984-85 school year (TALMIS, 1984). Since there are about 45 million students, this would have provided a ratio of about one machine per 38 students. [Note added during 1988 editing. I left the above figures in because they give an historical perspective of growth of computer facilities in schools. My current estimate is that sometime during the 1988-89 academic year we will reach a ratio of one microcomputer or terminal to a timeshared system for every 20 students in precollege education available for instructional use. This would be somewhat over two million microcomputers. That figure should be contrasted with the more than eight million microcomputers sold in the United States during the past year. I estimate that there are at least five times as many computers in people's homes in the United States as there are in the precollege schools. And, of course, the number of microcomputers in government, business, and industry far exceeds the number in homes. Thus, schools have only a very small percentage of the total number of computers that have been sold in the United States.]

It is not only in the United States that this rapid increase in computer availability is occurring. By the fall of 1985 there was roughly one microcomputer per twenty students in the province of Alberta, Canada. Generally speaking, the availability of computers in schools is the same in the United States and Canada.

In any event, it seems highly likely that the decade beginning in 1984 will see computer availability grow by a factor of ten of more in our schools (Melmed, 1984). (Thus, by the 1994-

95 school year we might expect to find a ratio of one microcomputer or terminal for every 4-5 students.) Part of the evidence for this is provided in businesses; already many companies are approaching one keyboard per employee. Evidence is provided by the movement in a number of technical colleges and universities to require all students to acquire a microcomputer. Evidence is provided by home purchases of computers; the current home availability of computers for students seems to be more than five times the school availability. And most important, an examination of current computer applications in schools makes it is clear that computers can significantly enhance education (Kulik, Bangert, and Williams, 1983).

WHOLE GROUP EXERCISE: Have each workshop participant estimate the student-to-computer ratio in their school or school district. Gather data from the whole workshop. Note the wide differences that are observed if a number of different school districts are represented at the workshop. Some secondary schools now have one computer per five students, or an even better ratio This allows an hour or more of computer time for each student each school day.

WHOLE GROUP EXERCISE: Have each workshop participant estimate what percentage of teachers in their school or district have computers. Also, estimate what percentage of students have access to a computer at home. Share these estimates, and discuss how they affect instructional use of computers.

It seems reasonable to assume that computers will become more and more available to students. The critical issue is, what can be done to help ensure these computer facilities will actually help to improve education?

The instructional uses of computers are often divided into three major categories: learning/teaching about computers, learning/teaching using computers, and learning/teaching integrating computers (Moursund, 1983). This third category is called computer-integrated instruction (CII). It is similar to but somewhat more comprehensive than the tool mode of computer usage discussed in Robert Taylor's book (Taylor, 1980).

In learning/teaching about computers the subject of computer and information science is considered for its suitability as a precollege curriculum topic. Essentially all school districts have addressed this curriculum issue. Instruction in computer programming is now common. Indeed, Logo programming is taught in many elementary schools. Many high schools are offering a computer science course, perhaps designed to prepare their students to take the Advanced Placement exam. This session is not directly concerned with learning/teaching about computers.

In learning/teaching using computers (often called computer-assisted learning, or CAL) the goal is to make effective use of computers to help deliver instruction. There is substantial evidence that in a variety of situations CAL can help students to learn faster (Kulik, Bangert, Williams, 1983). This session is not directly concerned with learning/teaching using computers. However, certain computer applications, such as computer simulations, fall both into the CAL category and the CII category.

Learning/teaching integrating computers, which we call computer-integrated instruction (CII), is the integration of computer-as-tool into the school curriculum. We will examine two scenarios to give the flavor of CII. The combination of these two scenarios represents one possible way that computers may be a major change agent in education.

> **Scenario 1.** Students learn to keyboard while in the fourth grade, receiving 30 minutes of instruction and practice a day for nine weeks. At the end of that time they can keyboard faster than

> they can handwrite, and they have mastered the rudiments of correct use of the keyboard. Then they learn to use a word processor and are given instruction in process writing (prewrite, compose, revise, publish) in a word processing environment. Throughout the remainder of their schooling, students are given good access to word processors and are expected to use them. They continue to receive instruction in process writing in each composition course they take. From time to time they are given additional instruction in keyboarding that is designed to improve their speed and maintain appropriate methods/posture, etc.
>
> The students' word processors are provided with a spelling checker, dictionary, thesaurus, and grammar checker. Students spend less time using standard basal spelling and grammar texts, as the immediate feedback provided by the computer proves much more beneficial. The dictionary and thesaurus are supplemented by an encyclopedia and eventually computerized access to major databanks. This leads to significant changes in students' (conventional) library skills and increased use of reference materials.
>
> The students' word processing systems are provided with computer graphic artist software so that students can easily illustrate their writings and incorporate charts and graphs. The system includes a filer and students learn to create databases. The creation of appropriate databases becomes a standard part of research and writing projects in a variety of courses.
>
> Students are required to share their writings with other students, and telecommunication systems are used to facilitate this sharing. Students become adept at communication via telecommunication systems and develop networks of people that they communicate with via computer. Communication via computer becomes a standard part of students' academic, recreational and social lives.

Notice that this scenario was written from the point of view of the student. A teacher must provide initial instruction in keyboarding, word processing, and process writing. Other teachers must then work with students who have this background and who do their writing in a word processing environment. From time to time students learn to use an additional computer-based tool. All teachers who subsequently have these students in their classes are affected, but the disruption of the conventional curriculum and classroom is not too large.

> **Scenario 2.** Students learn to use a simple graphics package during their seventh grade general math course. This package can take a table of data and produce bar, line, and circle graphs. Students make use of this capability in social studies and science classes throughout the remainder of their schooling.
>
> Then students learn to use a package of mathematics application programs while in a first year algebra course. The package can graph functions in two and three dimensions. It can solve one-variable equations as well as systems of simultaneous linear equations. It can do algebraic symbol manipulation, and it can do polynomial curve-fitting to data. For example, it can fit a straight line to a set of experimental data. Students make extensive use of these capabilities throughout the mathematics and science courses they take in the remainder of their schooling.
>
> The ability to easily represent data graphically leads to increased use of quantitative data in a variety of courses. Substantial curriculum change is produced by the mathematical packages. In science courses, for example, more emphasis is placed upon making measurements that can be represented graphically or allow curve-fitting to develop models. This becomes part of the hypotheses formulation and testing that is core to a good science program. It also leads to more emphasis on process control and online data gathering via computer (Haney, 1982). In math courses, students find that many topics are more easily learned using graphics as a visual aid (Rambally, 1982). But then they find that their courses are spending a lot of time teaching to do by hand things that are more easily done by computer. This leads to conflict between students and teachers, and it eventually leads to a significant revision of the mathematics curriculum. The NSF-supported work of James Fey provides some insight as to the types of changes that could occur (Fey, 1984). Fey suggests teaching students to solve math problems using application packages, and providing only the barest introduction to the underlying algorithms. Research into the teaching

> of calculus (Palimeter, 1986) strongly supports giving students access to a powerful symbol manipulation system. In Palimeter's study, students learned twice as fast, and as well, in such a computer rich environment.

This second scenario was also written from a student-oriented view, but with more emphasis on curriculum change. Teachers will be faced by students who have the expectation their coursework will build upon and make appropriate use of the computer graphics tool and other mathematics application packages. It is hard to appreciate the pressure that is building here. More and more students have easy access to computers at home and are receiving computer training while still in elementary school. These students will be increasingly intolerant of the current secondary school curriculum (Regan Carey, 1985).

TRIAD GROUP EXERCISE: 20-25 minutes. Read the two scenarios given above. Discuss whether they are plausible. Does either seem likely to occur? Which is more likely? Suggest other scenarios for the massive increase in computer use in instruction.

DEBRIEF: Gather information from workshop participants on whether they think either scenario is likely, and which they think is more likely. A standard alternate scenario is massive increase in computer-assisted learning. Facilitate a discussion on whether CAL growth is more likely than CII growth.

The CII Problem

The two CII scenarios have several things in common.

1. All students in a school learn to use a particular applications package.
2. Students are expected to continue to make use of the application tool throughout the remainder of their schooling.
3. While the initial instruction may be given by a computer specialist, all teachers are expected to work with their students as they use computers on a routine basis. In particular, each teacher is expected to help students learn to make effective use of computer tools as an aid to solving the problems of the discipline the teacher teaches.
4. None of the applications require students to learn computer programming or to have a deep understanding of the computer science underlying the application packages.
5. Software for the applications is currently commercially available and is getting better each year. Prices of this software are declining and multiple copy discounts or licensing agreements are becoming common.
6. Computer-integrated instruction can lead to significant changes in the curriculum and affects a variety of courses. Thus, it can be quite threatening to teachers, curriculum coordinators and school administrators.
7. Little thought seems to have been given to the high-touch aspects needed if these high-tech innovations are to succeed.

Most leaders in computer education support CII and acknowledge the sample scenarios as representative of where schools are headed. However, few have thought carefully about possible effects of substantial use of CII. The current curriculum (that is, the before-CII curriculum) is a careful balance that copes with questions such as the following. What disciplines are deemed important enough to warrant a course or several courses in the curriculum? What are the key aspects of knowledge, skill, and attitudes most important in each discipline? What parts of these key aspects can the typical teacher deal with on a routine basis? What parts of these key aspects can students at particular developmental levels learn to deal with on a routine basis?

In summary, the current curriculum is a careful balance among discipline content, teacher capabilities, student capabilities, and the environment in which learning occurs. But computers make some tasks easy. They make it possible to solve certain important categories of problems by merely inputting the problem data to a computer. Thus, computers upset the balance among content discipline, teacher capabilities, and student capabilities. Computers allow (indeed, demand) change in this long-standing ecology.

WHOLE GROUP EXERCISE: 10 minutes. Give and discuss examples of major past changes in the ecological balance discussed above. One such change that has been suggested is that in the United States there may have been a decline in the average academic ability of new teachers during the past 10 to 15 years. Another possibility is that students spending a lot of time watching television over the past two decades may have changed the basic nature of students.

DEBRIEF: Our society is changing. We are now well into the information age. One characteristic of the information age is increased use of aids to processing information. This is evident in business, government, and industry. But the change in education has been slow. Computers are not yet an everyday tool of the typical student. Only a modest percentage of teachers routinely use computers for personal or professional purposes.

Teachers will play a central role in the CII-based changes. A critical question is, "How can teachers receive the training and support they need to facilitate CII-based changes?" This question surely requires examination of the high tech/high touch issue. The proposed technology changes the role of teachers and the nature of the teacher-student interaction. Research is needed in how to make teachers more comfortable with the proposed changes.

Research indicates that school administrators must be involved in such educational change. They are an essential part of the support system (Fullan, 1982). The plan discussed in this session explores one possible approach to solving the CII-based educational change problem.

Once schools open to the possibility of curriculum change based upon the ideas of CII, they will open themselves to a veritable flood of change. The two scenarios were based upon relatively simple software that is commercially available even on eight-bit microcomputers. But consider artificial intelligence (AI) and the knowledge-based expert systems it is now beginning to produce. In a simple-minded sense, a word processor with spelling and grammar checker is an example of a knowledge-based AI system. So is a mathematics package or a graphic artists package. But AI is producing much more sophisticated programs that can solve or help solve an increasing variety of hard problems.

What does it mean to be educated in an area that has extensive availability of such AI systems? If a computer can solve or help solve a certain general category of problem, what do we want students to learn about that category of problem? That is the question that lies at the core of CII. The question is quite difficult, which is why we need well-qualified educational leaders to attack it.

TRIAD GROUP EXERCISE: 10-15 minutes. Discuss the question of what constitutes an appropriate education for life in a society that is making very extensive use of artificially intelligent aids to problem solving. What needs to happen in our schools so that this type of education can be provided to students?

DEBRIEF: My current guess is that increased use of computer-as-tool will increase the value of a good liberal arts education that emphasizes problem solving and higher-order skills. Knowing how to learn, being skilled at acquiring new bodies of knowledge, and being good at using sources of information will all be increasingly important. People skills will prove to be of increasing importance. A well-educated person will have an appropriate balance between high-tech and high-touch skills.

In the discussion of education for he Information Age, we must remember that more than half of the Information Age Jobs are actually relatively low tech, low pay, service oriented jobs such as clerk in a fast food store. Thus, our school system must simultaneously deal with preparing people to be secretaries (who will make extensive use of high tech) and fast food store clerks who need good people skills but only modest high tech skills.

Currently there is a severe shortage of educators well qualified in CII, and most instructional materials ignore the potentials of CII. It is difficult to find classrooms or schools where CII has had a significant impact. Most educators involved in this area are self-taught, with little formal knowledge of either the underlying computer science or of computer-assisted problem solving. Often they also lack formal training in curriculum design as well as in change processes in education.

Importance of the CII Problem

A number of approaches have been taken to a grassroots identification of the most important problems of computer education. Mounting evidence suggests that educators consider CII to be the most important issue, and they feel they need leadership help in dealing with the problems associated with CII. This section lists a few examples of such evidence.

Possible roles of computers in education received considerable national publicity in the 1983 report A Nation at Risk: The Imperative for Educational Reform. That report recommended that all students take a half-year computer course while in high school. The course would emphasize computer applications and other aspects of computer literacy (A Nation At Risk, 1983). A number of professional organizations have followed up on that report. For example, the American Association of School Administrators produced a "Critical Issues" report that gives an excellent overview of the problem (Neill, 1984). The report highlights the following quotation.

> We are now at a place where computers can revolutionize education. However, we also have a discontinuity. That is, we cannot continue to add computers, just for the sake of adding computers. We must restructure our schools, our curriculum, and our teacher training if we are to meet the challenge of the information society. And it is going to be very difficult for us to let go of what we have been doing. Education is at the stage of knowing what to do, but being afraid to do it. In order to accomplish this transformation, we will have to reevaluate our educational institutions and the mechanisms we use to finance them.
>
> Andrew Molnar, Program Officer
>
> National Science Foundation

David Moursund interviewed a number of computer coordinators from throughout the country while writing a book (Moursund, 1985). All identified CII as the most important and the most challenging aspect of instructional use of computers. All cited difficulties associated with curriculum change and with having appropriately trained leaders in this area.

The Northwest Council for Computer Education is a professional society of computer educators in Oregon and Washington. It funded a study of computer-related teacher education problems (Moore, 1984). This was a grassroots effort, and it included a survey of the organizations' membership. Part of the study focused on what all teachers should be learning about computers. Of the five most highly ranked items, number one is “The teacher should have an appreciation for using the computer as a tool for solving problems.” Number four is “The teacher should be able to use the computer as a tool (using applications such as word processing, spreadsheet analysis or database management).”

The Northwest Council for Computer Education study also examined possible competencies for teachers intending to gain deeper computer-oriented knowledge. The top two items on their recommendations for such secondary school teachers are that the teacher should meet the general competencies (such as mentioned above) and “The teacher should be familiar with the suitable range of computing topics at the secondary level (including applications and vocational opportunities).”

During its first year (1983-84), the Center for Advanced Technology in Education at the University of Oregon did a survey of Oregon education leaders, asking them to identify technology-oriented areas in which they felt they needed help. Problems associated with integration of computers into the overall curriculum received top priority (Fletcher, 1984).

In the fall of 1984 the Lane County Educational Service District (Eugene is in Lane county) hired Sam Miller as a curriculum specialist. He met monthly with 16 computer coordinators, who represent the 16 school districts in Lane County. This group reported that problems associated with computer-integrated instruction were their highest priority (Miller, 1985).

In the fall of 1984 the Eugene school district invited its schools to compete for money (five $8,000 grants) to attack specific computer-related problems of their choice. Almost all of the 32 proposals centered on CII-related issues and all five awards went to schools attacking these issues (Turner, 1984).

Another approach to assessing grassroots interests is provided by an examination of enrollment patterns in computer-related inservice courses. The Continuation Center of the University of Oregon and the Eugene 4J school district work closely together in offering a number of introductory courses. The actual courses to be offered are based on a needs assessment conducted by the local school systems. In fall and winter of 1984-85 by far the most heavily enrolled were the computer application courses. Indeed, courses on AppleWorks (an integrated application package) were oversubscribed (Rathje, 1985).

[Note: In doing the revisions for the 1988 printing of this book, I decided to leave unchanged the above citations on the emerging role of CII. Four years ago CII was beginning to emerge as a central issue of computers in education. Now it is well established.]

WHOLE GROUP EXERCISE: 10-15 minutes. The above sequence of arguments were written to support a proposal being submitted for possible federal funding. (Moursund received a three-year National Science Foundation grant that began in September 1985 based on these materials.) What evidence do you have that CII is an important issue in your school district? List evidence or possible ways to obtain this evidence.

DEBRIEF: Many school districts have done a needs assessment. A needs assessment provides information to support long term planning, obtaining funding, deciding on what inservice courses to offer, and so on. Have workshop participants share some of the results of needs assessments they have conducted.

A five-Step Approach to Teacher Training for CII

A brief outline of the five steps in the approach is given here. More detail is provided later in this section. Note that the general ideas presented here were written for a proposal submitted to a federal agency for possible funding. The Eugene, Oregon metropolitan area is to be served by this project, but the results are to be disseminated nationally. These ideas will likely require modification to fit the needs of a school district providing its own funding for CII inservice training of educators.

1. Work with computer coordinators and school administrators at the building and district levels to improve their computer education leadership performance using a Four-Part Inservice Model (described later in this section).
2. Develop CII model teachers, using a Four-Part Inservice Model. When possible, several teachers should be selected from each school to be impacted. (Research suggests that a school, rather than an individual teacher, is a more effective unit of change.)
3. Develop Leadership Resource Notebooks (described later in this section) of support materials for computer coordinators, school administrators and CII model teachers.
4. Evaluate, using both formative and summative evaluation.
5. Disseminate both the leadership development Four-Part Inservice Model and the Leadership Resource Notebooks.

The approach will be to work with two main categories of educators.

1. School-level and district-level computer coordinators and school administrators living within commuting distance of Eugene.
2. Classroom teachers who already have an introductory level of computer knowledge and experience, who want to become CII model teachers, and who live within commuting distance of Eugene. The major emphasis will be placed on elementary school teachers and on secondary school teachers of the sciences, math, and social sciences. To a great extent, these teachers will be chosen in clusters from a small number of schools.

A Four-Part Inservice Model

The Four-Part Inservice Model is based upon Moursund's many years of study and experience in computer education, and upon recent research on effective inservice. The first part of the model of instruction is an intense one-day leadership development workshop. This will ensure a common foundation of knowledge and begin to develop a spirit of camaraderie within the group. Such camaraderie is important to the success of the project.

The participants will then be split into smaller groups for the second and third parts of the model of instruction that occur for ten weeks or more during the remainder of the academic year. During the first year there will be three groups: computer coordinators and school administrators; elementary school CII model teachers; and secondary school CII model math teachers. Each group will meet for about two hours of formal instruction and interaction every two weeks. A member of the project staff will meet individually with each computer coordinator once every two weeks. In addition, the project staff (assisted by the computer coordinators participating in the project) will visit each CII model teacher's classroom once every two week or more frequently. School administrators will meet informally with their teachers who are involved in the project.

The second and third parts of the model are based on the staff development research of Bruce Joyce and Beverly Showers (Joyce and Showers, 1980). Initial implementation of these ideas in a computer-oriented environment was done by Graham Ferres in his 1983 dissertation under the supervision of Moursund and Showers (Ferres, 1983). Key ideas include modeling and practicing of desired classroom behavior, coaching (on the job feedback), peer support groups, and adequate and continuing support from resource people. Ferres worked very successfully with a small number of elementary school teachers as they learned some Logo and introduced use of Logo into their classrooms. The project was very labor intensive (high-touch in a high-tech environment).

The role of school administrators as instructional leaders has been investigated in a number of recent studies. The results are leading to new emphasis on the school principal as an instructional leader (Doris Carey, 1985). Curriculum change is much more likely to occur when the school administrators are actively involved (Gall et. al., 1982, 1984). Thus, an important part of the Four-Part Inservice Model is the involvement of school administrators. However, it is not essential that school administrators learn all of the detailed content of the curriculum changes being introduced. Rather, they must play a supportive role, indicating that the changes have their backing and are important.

The final part of the Four-Part Inservice Model is another one-day leadership development workshop for all project participants. It is a time for sharing, evaluation, and debriefing.

Leadership Resource Notebooks will be developed for each of the major categories of educators participating in the Four-Part Inservice Model. During the three years of the project there will be six such categories: computer coordinators, school administrators, elementary school teachers, math teachers, science teachers, and social science teachers. Part of the materials will be common to all notebooks, reflecting the Four-Part Inservice Model, general ideas of computer-integrated instruction, and the current state of the art of computer education. Part of the notebook materials will be individualized to each category of educator, to fit their specific needs. It is evident that the types of support materials needed by a district-level computer coordinator are different from those needed by an elementary school teacher or a secondary school science teacher. The category-dependent parts of the notebooks will carefully detail desirable behaviors and include resource materials needed to learn and implement these behaviors. For example, we want mathematics teachers to make certain types of use of computer graphics. Specific classroom behavior, along with sample lessons, will be in the notebook for math teachers.

The Leadership Resource Notebooks will be developed by a combination of the project staff and the educators receiving training through the project. The project staff will provide initial materials and a framework for the notebooks. But each category of participants will have as a group project the fleshing out of these initial materials. They will be trying out the materials on the job, seeing what works and what doesn't. They will be intimately involved in formative evaluation of the materials.

A critical part of the overall project design is the focus on individual schools and specific programs within the schools. Research on educational change indicates that one must pick a unit—either a school or a school district—and concentrate efforts within the unit to produce significant change (Fullan, 1982). This project focuses mainly on school-sized units. During the first year, for example, it is expected that almost all teacher-participants will be concentrated in six schools, approximately five participants per school. Three will be elementary schools and three will be middle school or high schools. At the middle and high school levels, the first year will focus on the mathematics curriculum.

This concentration on a small number of schools will continue during the second and third years of the project. Some of the initial schools will have a second, and perhaps even a third group of participants. During the second year of the project the Eugene 4J school district expects to be starting a "high technology" magnet school. Likely its teachers will participate in the project.

[Note: At the time of the 1988 revision to this book, most of the work of the three year NSF project had been completed. Four Notebooks are in varying stages of being readied for publication. The first to be completed will be on secondary school mathematics, and it should become available during October of 1988. It will be published by ICCE. Three other Notebooks, on Elementary Education, Secondary School Science Education, and Secondary School Social Studies Education, will be available later during the 1988-89 academic year. They are also being published by ICCE.

Detailed reports on the NSF project are available in Hanfling (1986) and Johnson (1988). The latter dissertation also contains a substantial amount of information about what is known about effective inservice.]

TRIAD GROUP EXERCISE: 15-20 minutes. Research suggests that the typical inservice intervention is not very effective. The above model for inservice education incorporates many of the ideas that have proven to be effective. Compare and contrast it with the types of inservice held in your school district. One possible focus might be on "one shot" inservices versus multiple session inservices with follow-up support for the teacher in the classroom.

DEBRIEF: While research suggests that most inservice education is not very effective, this is subject to debate as to what we mean by being effective. Do we expect that workshop participants will learn all of what is presented and implement all of it on their jobs? Certainly not. What would constitute a good measure for effectiveness of this High Tech/High Touch workshop?

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Session 9: The Computer Coordinator: Responsibilities and Preparation

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This session draws heavily from The Computer Coordinator, a book written by David Moursund, published by ICCE in February 1985. Substantial material from a preliminary edition of the book is quoted. The book is $10 (US) from the International Council for Computers in Education.

Goals

1. To increase your awareness of the broad and deep responsibilities placed on building-level and district-level computer coordinators.
2. To provide a summary of the general types of qualifications needed by a computer coordinator.
3. To discuss levels of preparation of computer educators, and to suggest desirable levels of preparation for computer coordinators.

The Position of Computer Coordinator

In the past few years, many people have been placed in the positions of building-level computer representative, building-level computer coordinator, and district-level computer coordinator. Often these are part time or unpaid positions, with duties to be carried out in addition to one's regular teaching assignment. Increasingly, however, the importance of these positions is being recognized and appropriately rewarded.

WHOLE GROUP EXERCISE: Ask for a show of hands for how many people are already computer coordinators at a school level; at a district level? Ask for a show of hands for people who don't yet have such a position, but think they would like to be a computer coordinator. Ask for a show of hands for how many people receive release time from their other duties in order to be a computer coordinator. Ask for a volunteer who is a computer coordinator. Spend a few minutes interviewing that computer coordinator. Obtain information on the nature of the work they do, whether they enjoy it, and whether it is stressful.

Many school districts have identified or designated a computer contact person in each school building. Sometimes these contact people are given special training. Others are merely expected to assume the duties, even without training or particular interest. For example, in some districts the elementary school library media specialists are designated as computer contact people.

At the school district level it is now common to find a person designated as computer coordinator. This person may have a full time job as computer coordinator. More common, however, is to assign the title to a curriculum coordinator, a math coordinator, an inservice coordinator, or someone else who already had a full time job at the district level.

The following material is from Chapter 8 of a preliminary edition of Moursund's computer coordinator book. It is a list of possible responsibilities of a district-level computer coordinator.

1. Provide leadership in all aspects of developing, and periodically evaluating and updating, a district plan for instructional use of computers. This requires work with district and school

administrators, curriculum coordinators, building-level computer coordinators, a district computer education committee, and others, such as out-of-district consultants. The plan should cover learning/teaching about computers, learning/teaching using computers, and learning/teaching integrating computers. It should be consistent with state, provincial, and national computer education goals. It should mesh with overall district educational goals. It is essential that the plan be flexible and provide for easy updating. The revision cycle needs to be quite short, such as yearly. David Moursund and Dick Ricketts have written a book on long-range planning for computers in schools (1987). It provides extensive help in developing a long-range plan for use at the building or district level.

2. Provide leadership in implementing the district plan for instructional use of computers; the implementation should include provisions for evaluation and periodic updating. Work with principals, department heads, building-level computer coordinators, teachers and others who will help implement the district plan. Develop a cadre of school-level computer coordinators and computer teachers who are committed to implementing the district plan. The district computer coordinator should meet regularly with these school-level leaders. Each school should have a computer committee charged with developing and implementing a plan for instructional computing in their school. These school plans will vary from school to school, but should all be consistent with district plans. Make sure the school plans provide for procedures to assess progress in achieving the goals set in the plan. Establish evaluation guidelines so that data from different schools can be compared and can be used as part of the evaluation of district progress.

3. Understand the district budget, budgeting process, and spending process; work within this system to secure adequate resources for instructional computing. Provide budgetary leadership in the instructional computing field. Make effective use of one's own budget and staff. Help to ensure that building-level budgets and the district budget adequately support the district's instructional computer plan. Be especially aware of equity issues when doing budgeting and distributing resources.

4. Develop a district computer resource center to be used by building-level computer coordinators, computer teachers, computer-using teachers and others. The resource center may contain hardware, software, courseware and instructional support materials such as books, magazines, journals, films and video tapes. [Note that during the 1987-88 academic year ICCE developed a Policy Statement for Software Preview Centers. Write to ICCE for a copy; please include $1 to cover postage and handling.] When an especially nice piece of hardware or software comes out, obtain it for the resource center. Even a temporary loan, with an open house and publicity to the district personnel, can be quite helpful. A district computer resource center may be a lending library for both software and hardware that particular schools need only infrequently. It may be used as a meeting place for computer education committees and as a lab for computer inservices. Help to develop resource centers in every school. These resource centers may be an integral part of the facilities needed for inservice education. A school resource center should take into consideration the needs of teachers in the school.

5. Develop and maintain a list of resource people. Some parts of this list may be suitable for distribution throughout the district. Other parts may be just for personal use. The list might include the entire district staff, with information about the computer background, interests, and involvement of each person. Identify at least one computer leader in each school (including elementary) and one computer-oriented leader in each academic discipline. Encourage each school to develop a list of parents who might volunteer their services as computer aides, technical assistants or fund-raisers. Develop contacts with vendors who are willing to provide loans of hardware and software; some vendors provide free training to educators.

6. Develop, implement and periodically evaluate a district computer-oriented inservice plan. [Note: During the academic year 1987-88 ICCE developed five "distance education" graduate courses for computer education leaders. These courses are completed by corresponding with an instructor via the mails, and so can be done by people located throughout the world. The courses carry graduate credit through the State of Oregon's Office of Independent Study, State

System of Higher Education. Current courses cover the areas of Problem Solving, AppleWorks, Long-Range Planning, Fundamentals of Computers in Education, Logo, and Math. Additional courses are under development and will become available during 1989-90. Write to ICCE for more information.] One goal of this inservice plan should be to identify and/or help develop resource people in every discipline and at every grade level who can provide leadership in working to accomplish the district instructional computer plan. A second goal should be to help all teachers and school administrators become functionally computer literate and learn their roles in accomplishing the district instructional computing plan. Ideally, every educator in the district should have a personal plan for becoming more computer literate.--that is, to gain the computer-related knowledge and skill appropriate to their job. A district inservice plan needs to take into consideration workshops and courses available from other school districts and from nearby colleges and universities. Private businesses may provide appropriate training on a contract basis; sometimes they will provide free workshops, perhaps to encourage possible purchase of a new product.

7. Help the district to develop and implement plans for the acquisition and maintenance of hardware and software. Acquisition will likely involve going out for bids for both hardware and software about once a year, although one may be able to piggyback on a county, state , or provincial purchasing contract. It is highly desirable to have all schools take advantage of the prices obtained through these bid processes. Thus, the school district acquisition plan should be followed by the individual schools and the school district. However, the overall acquisition process must be flexible. Schools and individual teachers may have needs that cannot easily be met working through a district acquisition plan. For example, a special education teacher may need an input device controlled by eyebrow movements. A magnet arts school may need special graphics equipment or music synthesizers. Such special needs should be met in a timely fashion.

   Maintenance will include routine preventative maintenance as well as more general repair and replacement. It might prove desirable to have one teacher in every school trained to do a minimal level of maintenance. In secondary schools one might want to have some students trained to provide this service. A district may want to maintain a supply of spare parts and hire a person who can repair the types of equipment the district is acquiring.

   The district software policy should also address the issue of whether the district or individual schools will support, encourage or discourage software development. It should contain a clear statement against software piracy. District inservice programs should address the software piracy issue; the goal is to have the district policy understood and supported by all school personnel.

8. Maintain an accurate inventory of computer hardware and software that belongs to the district and to individual schools in the district. Help set policy on the possible creation of a district-owned pool of hardware and/or software that resides in particular school buildings and that can be moved from school to school as needed. Help establish procedures for schools to borrow software from each other. Work to establish as a school district policy an “effective life” for hardware and software, so that hardware and software that are no longer appropriate to use can be removed from service. Plan for the disposal of hardware and software that is no longer useful.

9. Help develop and implement a district procedure for the evaluation of software, hardware and courseware, and for the sharing of the results of such evaluation. Tie in with other school districts and with national organizations that are doing software evaluation. Acquire books and periodicals that evaluate software.

10. Disseminate computer-related information throughout the district via a newsletter, computer bulletin board, presentations at district and school staff meetings and so on. Establish a liaison committee of key people in the community and meet periodically with this committee. Help to create and/or work with a local computer-using educators group. Work with a state or provincial group of computer-using educators. Be an active participant in local and regional non-computer education conferences, perhaps doing presentations on computer applications.

11. Work on community relations by speaking to parent and professional groups, publicizing the district computer plan and progress. If possible, arrange for newspaper, radio and television publicity. Consider having the district or individual schools participate in computer-oriented science faires and in computer programming contests. Encourage schools to have computer-oriented open houses for parents, with students demonstrating what they have learned about computers. A school computer club might want to raise money by using school computer equipment to instruct parents in how to use computers.
12. Encourage the development and implementation of a district hiring policy that takes into consideration the computer knowledge and experience of applicants and gives preference to applicants who are functionally computer literate. Communicate to teacher training institutions that your school district is only interested in hiring computer literate teachers.
13. Help the district to obtain outside funding by participating in grant planning and proposal writing. Be involved in district research projects to evaluate instructional use of computers. Try to find funds to support individual teachers in developing pilot studies on various instructional applications of computers. The idea of pilot projects is important, even if extra funding is not available. Eventually your district must decide at what level to teach keyboarding and touch-typing. Who will teach it, and how long will it take? Eventually all students will learn to use a graphics package. Is this a mathematics department responsibility, and at what grade level? Pilot studies can help answer such questions.
14. Be sensitive to computer-related equity issues and work to resolve inequities.
15. Do long range planning on such topics as making use of computers at home, building-level and district broad band networking, videodisc-based CAL, access to databanks, and greatly increased instructional use of computers. Encourage the district to develop pilot projects to test the value various major changes in computer usage. A large district could be experimenting with a school or certain courses in a school having greatly increased computer access. Certainly every large school district should now be experimenting with videodisc-based CAL.
16. Remain technically competent. Continue to grow as a professional computer educator, as an educational leader and as a human being. Be professionally active (attend meetings, give talks, write articles) at a regional or higher level. Subscribe to computer-oriented educational publications and schedule regular time to read them. Be aware of the idea of the half-life of a technical education. The computer field is changing rapidly. A computer coordinator who doesn't spend substantial time acquiring new knowledge and skills will eventually be technically incompetent.

INDIVIDUAL AND TRIAD GROUP EXERCISE (20-30 minutes): discuss the above list, making additions as necessary. If you are a district-level computer coordinator, mark each of the items (on your expanded list) on a yes-maybe-no scale as to whether you consider it part of your job description. Then rate each of the ones you labeled either yes or maybe on a five-point scale as to how well you feel you do the task. Use 1 for “poorly” and 5 for “quite well."

If you are not a district-level computer coordinator, do the same exercise for a computer coordinator you know, and rate that person. Or, pretend that you are a district-level computer coordinator. Small group discussion in triads is to be used to share results and complete the exercise. Note that the latter form of the exercise, rating a computer coordinator, may be embarrassing or threatening to district-level computer coordinators. It should be used in a constructive, helpful fashion rather than in a destructive manner.

The extensive list of possible duties of a district-level computer coordinator can serve as a starting point for writing a job description. Or, it can help a computer coordinator to realize how extensive the job is, and why one never seems to catch up with the work.

The following material is from Chapter 9 of a preliminary edition of The Computer Coordinator. It discusses possible qualifications for a building-level computer coordinator or computer representative.

> Chapter 3 contains a brief list of possible responsibilities of a building-level computer coordinator and Chapter 8 contains an extensive list (see above) of possible responsibilities of a district-level computer coordinator. These lists give an indication of the types of activities a computer coordinator may be called upon to perform. From these lists one can determine the types of qualifications a computer coordinator might need. In this chapter we list and discuss these general types of qualifications.
>
> At first glance it could seem that the variety of knowledge and skills a computer coordinator might need is beyond that of an ordinary mortal. A frequent statement made by teachers who might want to become a computer coordinator is, "If I had all of those qualifications, I'd leave education and get rich." And yet, many people satisfy the requirements, do remain in education, and eventually become computer coordinators. Being a computer coordinator is a challenging, but rewarding career. It is a career offering the opportunity to make a significant contribution to the world and to make substantial personal growth.
>
> The general qualifications to be a computer coordinator can be divided into four main categories. The categorization is somewhat arbitrary and you may feel there is some overlap among categories—still, this categorization-approach is useful.
>
> 1. A broad general education and dedication to lifelong learning. Overall intelligence and perseverance; a strong work ethic; self-confidence; good time-management skills; budgeting and other fiscal skills.
> 2. Knowledge of and support of our educational system; good skills in teaching school children as well as in teaching educators and other adults.
> 3. Interpersonal relations skills; skills in written and oral communications; administrative and group facilitation skills.
> 4. Technical knowledge in the fields of computer science and computer education. Substantial experience in working with students and educators in the computer field.

WHOLE GROUP EXERCISE: (Five minutes) Arrange the four general types of qualifications into an "ideal" order, from most important to least important. Use the form given below. Be aware that this is a matter of opinion, and you are merely expressing your opinion. By show of hands, see how many people listed each of the four as most important. How many listed each of the four as least important?

CONTINUE THE WHOLE GROUP EXERCISE: (Five minutes) Next, rank your own qualifications in these four areas, from highest to lowest. Spend a minute or so thinking about the two lists you have created. By a show of hands, how many people have their greatest strength listed as the most important qualification? How many people have their least strength listed as the least important qualification?

Category	**Ideal**	**Self**
1. A broad general education and dedication to lifelong learning. Overall intelligence and perseverance; a strong work ethic; self confidence; good time-management skills; budgeting and other fiscal skills		
2. Knowledge of and support of our educational system; good skills in teaching school children as well as in teaching educators and other adults.		
3. Interpersonal relations skills; skills in written and oral communications; administrative & group facilitation skills.		

4. Technical knowledge in the fields of computer science and computer education. Substantial experience in working with students and educators in the computer field.		

TRIAD GROUP DISCUSSION: (Ten minutes) Share your "ideal" rankings and (if you like) your self assessment. Discuss.

The above exercise has now been used with several hundred computer coordinators or people who would like to be computer coordinators. Invariably the "Technological Knowledge" category receives the lowest ratings and the "Interpersonal Skills" category receives the highest ratings. This is interesting in light of the high-tech orientation of the people doing the rating. They see high touch as much more important than high tech.

However, the technical qualifications issue is perhaps the most interesting to discuss. And it is an issue not only for computer coordinators, but also for all other educators involved with computers. The John Naisbitt Megatrends book notes that the technical competence of middle level managers in the United States is low relative to similar people in Japan and West Germany. This is suggested as a partial explanation for why the United States not doing well in competing with these countries.

Most computer coordinators are hired because they appear to have high technical qualifications in the computer education field. Usually they do have high technical qualifications relative to the administrators doing the hiring and perhaps relative to other teachers in the district. But in absolute terms, their computer-oriented technical qualifications are often quite low.

Consider the following list of "levels" of computer preparation. The assumption is that a person at any level has completed requirements at the previous levels. Thus a Level 2 person has completed both the Level 1 and Level 2 requirements.

Level 1. 4-8 hours. How to turn on a machine, load and run software, handle modest problems. Brief overview of computer education. This level can be obtained in a half-day or one-day workshop.

Level 2. 16-20 hours. Enough training experience to work with students who have Level 1 instruction and perhaps to help them reach Level 1. Selection and use of software for one's own classroom. Introductory practice in using an application such as word processing.

This is the beginning of a functional level of knowledge in computers-in-education. The combination of Level 1 and Level 2 is approximately a one-credit course on a quarter hour system. (One-quarter hour corresponds to approximately ten hours of formal instruction and 20 hours of homework. One semester hour corresponds to approximately 15 hours of formal instruction and 30 hours of homework. In both cases we are talking about standards adhered to by high quality undergraduate colleges and universities. Graduate courses generally require still more homework relative to hours in class.)

Level 3a. A 3-credit, semester-length course in computer education (approximately 135 hours of study and instruction if it is an undergraduate course, and somewhat more if it is a graduate course). Approximately one-half of the instruction and homework is hands-on experience. However, not more than 25% of the total course is computer programming. Includes reading a substantial number of articles and/or a couple of introductory books, and examining a substantial amount of software.

Level 3b. A 3-credit, semester-length course in computer science. (In many colleges and universities the freshman computer science course is quite a bit more difficult than average freshman courses, and thus requires considerably more time than suggested in 3a above.) A solid introduction to computer science and structured computer programming. The language used might be BASIC or Logo; however, Pascal or Modula 2 is the language of choice of most major universities.

Level 4a. Computer applications-oriented computer education certificate; approximately three semester-length, three-credit, courses above the combination of all levels listed above. Includes a second course in computer science and courses or coursework in such areas as word processing, databases, spreadsheets, computer graphics. Includes a substantial course in computer-assisted learning and work on integration of computers into the overall curriculum. A person completing Level 4a is expected to program quite well in one language, or moderately well in two languages.

Level 4b. Computer science-oriented computer education certificate; approximately three semester-length, three-credit courses above the combination of everything in Levels 1 through 3a, 3b. At least two of the additional courses are "pure" computer science courses. This includes mastery of Pascal or an equivalent language as well as good knowledge of a second language. Level 4b includes roughly the equivalent of the first two years of an undergraduate computer science major's computer coursework. Thus it covers the full Advanced Placement course, including quite a bit of information structures and some machine organization and assembly language.

Level 5a. Computer applications master's degree in computer education. Includes all of Levels 4a, but may require less pure computer science than 4b, and additional requirements for a master's degree. Likely requires coursework in learning theory, curriculum design, curriculum development, and how to find and read research. A master's project includes development of materials for students or for teacher training, or some other practical work.

Note that relatively few applications-oriented master's degree programs in computer education set such high standards. Frequently such programs of study allow students to take fewer "solid" computer science courses and instead to take more applications courses. Often these application courses are the study of specific application packages, such as particular brands of spreadsheet, word processor, database, graphics, etc. Such applications courses often have little or no prerequisite.

Level 5b. Computer science education master's degree. Includes all of Levels 4a, 4b and additional "pure" computer science. One might view this as including the first two or three year sequences of an undergraduate computer science major's program plus additional courses appropriate to the needs of a computer educator.

Level 5b may contain a number of application courses, but they will be relatively general and not centered on specific pieces of software. Introductory courses in computer graphics, information retrieval, modeling and simulation, and artificial intelligence might be included. All such courses would assume introductory knowledge of computer science and would include writing substantial computer programs.

Level 6a. Doctorate in application of computers in education. This might be built on a prerequisite of either 5a or of 5b, depending on the university and the interests of the student. Students in this program have usually had several years of experience in using computers in the classroom and/or as a computer coordinator.

Level 6b. Doctorate in computer science education. Includes all of Levels 5a, 5b plus substantial additional coursework in education, computer science, and computer education.

Note that the doctorate programs in both 6a and 6b generally represent the equivalent of 3-4 years of full time study beyond a bachelor's degree, plus substantial work experience. (But for most people entering such a program, a master's degree in a field outside of computer education generally counts as part of the required 3-4 years.) A research-oriented dissertation in a doctorate program is generally equivalent to approximately nine months of full time study, but may be more or less depending on circumstances.

TRIAD GROUP EXERCISE: (Ten minutes) Determine your current “level” and your goals for the next few years. Take into consideration self-taught knowledge, but be realistic. There tends to be quite a difference between the typical university-level introductory computer science courses for computer science majors and the typical self-taught Pascal knowledge. Discuss in your small group.

WHOLE GROUP DISCUSSION: What levels and/or types of education are desirable for all teachers, for computer teachers, and for computer coordinators? How is your district doing? By a show of hands, find out which districts have most of their teachers at Level 1, Level 2, or Level 3a. How about the computer teachers and building-level computer coordinators in the districts? In the same way that we now have considerable inequities of computer access in different schools and school districts, we have considerable inequities of teacher preparation to help their students learn to work with computers.

TRIAD GROUP DISCUSSION: Should all current teachers be required to learn to program (or, should all future teachers be required to learn to program)? In discussing this topic, define what you mean by “to program.” Does your definition cover such areas as handling a very sophisticated integrated package that includes database, spreadsheet, graphics and word processor? Does it cover knowing how to represent procedures in a language understandable by a computer? (Where does HyperCard fit into this?) Is it reasonable to expect that a typical district-level computer coordinator should be able to teach the full range of courses required to make teachers in the district be computer literate?

WHOLE GROUP DISCUSSION: What does the future hold for people who are half-time or full-time computer coordinators? Is this likely to be a secure position? (Note that relatively few people have tenure as computer coordinators. More often their job security is tenure as a classroom teacher; if they lose their computer coordinator position they can return to the classroom.)

Note that the International Council for Computers in Education has established a Special Interest Group for Computer Coordinators. The SIGCC has a periodical publication, helps arrange sessions at conferences, and promotes the development of local chapters. For more information please write to ICCE.

References

Moursund, David and Ricketts, Dick. Long-Range Planning for Computers in Schools. Information Age Education, Eugene, Oregon, 1988.

Session 10: Evaluation

Goals

1. To increase your awareness of reasons for evaluation and some evaluation responsibilities of a computer education leader.
2. To discuss formative and summative evaluation ideas that can be implemented by a computer education leader.
3. To discuss ways to involve others in evaluation of a school or district plan for use of computers in education.

Why Evaluate?

For many educators the terms “evaluation” and “assessment” are not met with roars of approval. They may instead evoke memories of “wasting” time filling out forms and/or having students take standardized tests. District, state, and national assessment or competency testing are all part of evaluation.

If you have ever run a funded project, the idea of evaluation may evoke memories of an outside evaluator messing around in “your” business, perhaps even using part of your project funds. Or, evaluation may evoke memories of being evaluated on your job performance, perhaps by someone with little understanding of what you do or how well you do it.

I find that my tolerance for evaluation and my interest in evaluation is increased by considering education from a problem solving point of view. That is, I think in terms of givens, guidelines, and goals. An educational system or a component of an educational system exists to solve or help solve some relatively well-specified problem. We establish goals for our educational system, and the system itself provides resources to achieve the goals. Evaluation is the process of determining how well we are achieving the goals and possible ways to better achieve the goals.

WHOLE GROUP EXERCISE: 10 minutes. Ask the participants for personal experiences they have had in running funded projects that included a substantial evaluation component. Was the evaluation formative, summative, or a balanced combination? Did the evaluation seem to be a useful component of the project?

WHOLE GROUP EXERCISE: 5 minutes. In your school or school district, how many days a year are devoted to school-wide or district-wide evaluation and assessment? Collect results from all workshop participants. You are apt to get responses such as “Too many.” Many teachers would be happier if less time were devoted to this activity.

Evaluation can be thought of as a natural and essential process that is always going on. As teachers we evaluate our students. We judge how well they are learning what we are teaching (that is, we use formative evaluation) and adjust our instruction to fit their needs. Likely we give unit tests or end-of-term tests (summative evaluation) in order to assign grades or help students monitor their own progress.

Both unconsciously and consciously we constantly monitor our own performance (self-evaluation); we monitor the performance of our peers and the progress of each program we are involved with. We make decisions based upon these evaluations. When evaluation is viewed as in these ways, it becomes clear that we are all evaluators and that evaluation is not such a bad thing.

Evaluation can be covert or overt. If your school or school district makes any instructional use of computers, then you can be sure that people are asking questions about what roles the computers are playing in the curriculum and how successfully they are playing these roles. Often this is done covertly by people with little knowledge either of the computer education field or of the goals for computers in education. To the extent that we make evaluation overt, we can make it more useful to us and our aims. Thus, every computer education leader should be involved in evaluation.

TRIAD GROUP EXERCISE: WHY EVALUATE? Working individually, make a brief list of the best arguments you can think of in favor of careful evaluation of computer education in your school and/or district; make another list of good arguments against such evaluation of computer education or problems that such evaluation might cause.

Then share your lists with other members of a triad. Look for major agreements and major disagreements. Use this discussion time to increase your understanding of how others view evaluation. Is there general agreement within your triad that evaluation of computer education is a good idea? Why, or why not?

WHOLE GROUP DEBRIEF: Look for some general agreement on values of evaluation as well as general agreement on arguments against evaluation. For example:

1. Evaluation that leads to improvement of a product or process is good (here we are assuming that there is general agreement on the value of the product or process).
2. Evaluation can be done in a manner that promotes learning, growth, improved attitude, etc. That can be good.
3. Self-evaluation is good, but evaluation by an outsider may be quite threatening and perhaps not useful.
4. Evaluation can be used in a threatening or punitive manner, and that is bad. “I am particularly concerned about being evaluated by a supervisor who doesn't understand my field or what I am doing.”
5. Evaluation uses up time, money, and other valuable resources. These resources might instead be used for other (presumably better) activities.
6. “Evaluation forced us to clearly state our goals. That was a useful exercise.”
7. “Evaluation forced us to design and run our project to fit the views of the evaluator, and the evaluator did not understand what it was we were trying to accomplish.”

TRIAD EXERCISE: In triads, discuss the covert and overt evaluation of instructional use of computers in your school or district. Make sure each person in your triad gets a chance to talk. We are particularly interested in finding very good examples as well as examples in which there appears to be little covert or overt evaluation going on.

WHOLE GROUP DEBRIEF: By a show of hands see how many people are involved in a school or district computer education program that includes a reasonably formal evaluation plan. Ask for examples of covert evaluation.

Example: "A feminist on our school board counted the number of girls and the number of boys in our computer class. It turned out that there were three times as many boys as girls. She really gave us a bad time on this. Now we do all we can to encourage girls to take the class, and we have roughly equal numbers of girls and boys in the class."

Example: "One of our school board members asked if we knew how many students had access to computers at home, and whether we were taking that into consideration in our computer planning. We had to admit that we knew that some of the kids had access to computers at home and were using them to write their term papers. We hadn't given much thought to the equity issue this posed. It turned out that the reason behind the question is that the school board member's daughter had access to a computer at home, but she had a friend who didn't."

Formal evaluation is generally done taking into consideration some set of goals (which themselves may be formally stated or merely tacitly assumed). For example, part of a school district's evaluation of educational use of computers might include counting the numbers of girls and boys in advanced computer classes, or counting the numbers of students from various racial groups in these classes. While superficially this would appear to be a straightforward collection of statistical data, it could also be interpreted as part of an evaluation of sexual and/or racial equity in the computer education program.

Evaluation of Computer Education Leaders

Formal evaluation of the job performance of individual people is common. If this is to be done appropriately, there must be an agreed upon job description which includes duties/responsibilities, authority, resources, and so on. Often an employee will be asked to set some goals each year, and evaluation may be done both against the general job description and the goals set for the year. Often part of the evaluation of an employee will be a self evaluation.

INDIVIDUAL EXERCISE: Do you have a formal, agreed-upon job description against which you are evaluated? If your answer is no, discuss why not and whether you are satisfied with this situation. If your answer is yes, who wrote the job description, is it appropriate, and how is it periodically updated? What role do you play in helping in this evaluation process? That is, do you prepare periodic reports that can be compared against statements in your job description to help someone evaluate you? Is it useful to you to have a job description and to be periodically evaluated?

DEBRIEF IN TRIADS AND WHOLE GROUP: The standard pattern for a computer coordinator is to first undertake the job on an informal, non-paid, volunteer basis. The duties gradually grow, and perhaps become more formal. Perhaps release time is eventually granted. Someone (a principal, a superintendent) begins to depend on the computer coordinator and begins to assign specific duties. By the time this stage is reached it is important to have a formal agreement defining responsibilities, authority, resources, evaluation, duration of this position (job security), pay, length of the contract year, etc.

This is particularly important in computer education because the possible duties are so diverse and time consuming. No matter how well qualified you are and how hard you work, there will be lots of computer-education-related things that don't get done or don't get done as well as someone would like. Many may be completely beyond your ability to have any significant influence on, but still you might be held accountable.

Evaluation of Computer Education Programs

Computer education is a young and rapidly changing field. This suggests that most evaluation of computer education programs should be formative rather than summative. But in either case one needs a set of program goals against which to do evaluation. Let's look at an elementary school for an example. Consider a district that has computer education goals that include:

1. All elementary school students shall become functionally computer literate in use of a computer as a general-purpose tool and in use of a computer as an aid to learning.
2. All elementary school educators shall become functionally computer literate at a level that allows them to be professionally competent in facilitating and carrying out goal 1 listed above.

Of course, these are very general goals. They would be backed up by more detailed measurable behavioral objectives. For example, one might have as a measurable behavioral objective that upon completion of the third grade a student shall be able to go to the computer software library, check out a computer simulation, boot the computer system using the simulation, run the computer simulation and interact with it in a style appropriate to learning from it, etc. Such a specific set of behaviors would suggest that the third grade teacher should not only be able to help a student learn to do all of these things, but should have specific knowledge of compute simulations appropriate for use in the third grade curriculum.

Such detailed goals and measurable behavioral objectives allow formative evaluation of the elementary school computer education program. One can evaluate the availability of sufficient and appropriate hardware, software, curriculum materials, scheduled time in the curriculum, and so on. One can evaluate the adequacy of the teacher training that has been made available, or one can look more specifically at the performance of individual teachers.

WHOLE GROUP DISCUSSION: Does your school or school district have detailed goals and measurable behavioral objectives for computer education?

The discussion can focus on advantages of having such detailed goals and measurable behavioral objectives. Or, it might focus on the difficulties in developing such goals and objectives. Or, it might focus on good reasons for not doing this work. (The field is changing rapidly. A school or district could easily get locked into a poor and inappropriate set of goals and objectives, with no good mechanism for improving them.)

WHOLE GROUP EXERCISE: NON-OBTRUSIVE MEASURES: There are many non-invasive or non-obtrusive measures that can be used to help evaluate a schools instructional use of computers. For example, wander into a room in which students are using computers. Do the students look happy, or unhappy? Does the teacher supervising the room and helping the students seem “connected” to the students and computers, or withdrawn? Are the students interacting with each other, or working individually. Is there paper in the printers, and is the print quality dark enough to be easily readable? Are there resource books and manuals available? Is the room decorated with computer graphics output?

Begin talking to a teacher or school administrator about computers in their school. Does information get volunteered, does it reflect a certain type of computer use (“yes, I often see students playing computer games during lunch hour.”), does the teacher or school administrator discuss first hand or second hand knowledge, etc.

Talk to a student in a computer room. Does the student volunteer information about how s/he is using the computer, showing enthusiasm and knowledge? Is the student eager to show you a computer application?

Have workshop participants relate personal examples of non-obtrusive evaluative techniques they use.

Who Is the Evaluator?

A key issue in evaluation is who does the evaluation. Is it done by a complete stranger (the district evaluator or an outside evaluator), by a person conducting the project being evaluated (perhaps the computer coordinator in a building both trains teachers and evaluates the performance of the teachers), or by participants in a project (the teachers being trained learn to do self-evaluation).

The use of an outside evaluator is important when one wants unbiased reports on the efficacy of the treatment being evaluated. In medicine, for example, use is made of "double blind" experiments. Neither the patients nor the doctors know what treatment is actually being used. In educational research it is common to have control groups and experimental groups. Generally it is not desirable for the teacher of the experimental group or control group to also be the evaluator.

The concept of self-evaluation is particularly interesting. Suppose that you are a building-level computer coordinator conducting inservice training designed to help teachers in your building perform in a certain fashion. Working with these teachers, you could come up with self-assessment measures that would allow the teachers to determine if they are performing as desired. The teachers could learn that it is their profession responsibility to acquire certain skills and knowledge. How they do it is up to them, and you are available to help. But by and large it is not your job as a building-level computer coordinator to evaluate the teachers in your building. (If this is to be part of your job you would certainly want it written into your job description and be paid at an administrative level for undertaking such responsibilities.)

The Association for Computing Machinery (ACM) has developed and published a number of self-assessment instruments for its members. In summer 1988 the students in Dave Moursund's graduate seminar began work on several self-assessment procedures for precollege computer educators. The intent is to have this project continued by various ICCE committees.

TRIAD GROUP DISCUSSION: Pretend that all of you in your triad are building-level computer coordinators whose responsibilities include conducting inservice training of teachers in your building. Make a list of self-evaluation ideas that you could have your teachers learn to use. Talk about ways to get the teachers to make use of these self-evaluation ideas—to get the teachers to work with and for you, rather than having an adversarial relationship with you.

Here are a few ideas for self-evaluation of teachers. Workshop participants should add to the list.

1. I am confident in my ability to take a piece of CAI software designed for use in the courses I teach, read its directions, run it on a computer, and evaluate it for possible use in my classroom.
2. I know how to use (specify a particular type of computer application tool, such as a word processor, graphics package, spreadsheet, database program, etc.) well enough

so that when an appropriate use arises in my classroom, I can help my students to make this use.

3. I know how to go to a software resource catalog, look up the names of software that might possibly meet some needs that I have in mind, and then check if our district software library has these pieces of software.
4. I know my building-level (or district-level) computer coordinator well enough so that I feel free to contact him/her and seek answers to computer-related questions that arise in my classroom.
5. I am a member of the International Council for Computers in Education and I regularly read their periodical, The Computing Teacher.

Computer coordinators at the school district level and others with considerable budgetary responsibility face a particularly difficult evaluation task. A school district may be spending one-percent or more of its funds for hardware, software, supportive materials, teacher training and computer coordinator salaries. This is a large amount of money, and the money is being spent year after year. What does the school district have to show for this expenditure of funds? In what ways are the overall educational goals of the district being better met because of these expenditures? Why should the district continue to spend the money in this way? Might the money better be spent in some other manner? (Notice how much would be saved if the district didn't have to pay the salary of a computer coordinator.)

Most school districts have an evaluator on staff, or make use of professional outside evaluation services. A district-level computer coordinator can make use of the district's evaluator. But this requires carefully stated district goals for computer education. The goals must be such that one can measure progress towards their attainment.

It is not enough to merely count the number of computers, the number of pieces of software, the number of students using computers and the number of teachers using computers. Evaluation must get at deeper issues such as how computers are contributing toward accomplishment of the overall district goals. (Of course, the district computer goals are part of the overall educational goals.) For example, a district might set as part of its language arts goals that all students shall learn to touch type on a computer keyboard at a speed of 15 gross words per minute before graduating from the sixth grade. This is a specific, measurable goal.

Contrast this with the goal that all students shall learn to use a word processor to improve their writing skills. The computer coordinator might implement a program that would lead to all students learning to use a word processor (how well is not specified). But there is no guarantee that this will lead to better writing skills. Thus, if evaluation is done on the writing skills of students, one may find no change as a consequence of devoting computer and school resources to teaching use of a word processor. Improvement of writing might occur if teachers are trained in the teaching of process writing, students are taught to make use of a word processor to do process writing, students are taught to keyboard at a reasonable speed, students are given good access to computers for doing their writing, and appropriate amounts of time are devoted to writing. Many of these things are beyond the control of a computer coordinator.

EXERCISE FOR DISTRICT-LEVEL COMPUTER COORDINATORS: Does your district have a set of computer education goals along with measurable behavioral objectives? Does your district have a plan in place for the periodic evaluation of how well the objectives are being accomplished? Discuss in triads and in the whole group.

Note that a district can easily measure the numbers of dollars going into hardware and software. It can determine the number of students per microcomputer or the number of pieces of software per student. It can count the number of inservice courses given and the number of educators attending these courses.

But there are many more difficult things that are important. Does each school building have a well-qualified building-level computer coordinator (how does one define well qualified)? What is the level of computer literacy of each teacher and school administrator relative to that needed for them to be professionally competent in carrying out their part in accomplishing the district and school computer education goals? Are computers making a measurable difference (either positive or negative) in accomplishing the overall educational goals of the district and the schools? The development of evaluative instruments and plans to find answers to these questions will likely involve the school district's evaluation specialist. Substantial resources may need to be devoted to such evaluation.

WHOLE GROUP EXERCISE: 10-15 minutes. How can one evaluate the effectiveness of a district's computer-oriented inservice program? Have workshop participants share experiences on ineffective versus effective workshops they have conducted or taken. How can one tell what is effective and what is ineffective?

WHOLE GROUP DEBRIEF: The NSF project that Dave Moursund directed during 1985-88 on effective inservice had a substantial evaluation component. The Notebooks that will be the final report of this project contains substantial amount of material on evaluating an inservice program. See also the 1988 Ph.D. dissertation of Vivian Johnson at the University of Oregon. It was based on an evaluation of the NSF project.

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Session 11: The "I Can't Write" Syndrome

Goals

1. To increase awareness of the need for an educational leader to write freely and easily.
2. To increase understanding of why many educators feel they can't write.
3. To explore how computers affect writing.

Writing for Communication and Problem Solving

Writing serves two main purposes. First, it is a method for communication over both time and distance. Thus, it provides an important aid to building on previous work of oneself and others while working to solve problems. Second, it is an aid to organizing one's thoughts while doing problem solving. These two purposes are so valuable to people in our type of society that writing is one of the basics of education. Our educational system sets as one of its primary goals helping all students learn to write.

As a consequence, essentially all educated people in our society can write, at least at a modest level. And teachers, being educated people, are no exception to this. The typical teacher is reasonably comfortable in writing material for handouts to students or writing comments on student papers. Of course, there are exceptions even at this level of writing. Moreover, occasional embarrassments occur. For example, we occasionally see a newspaper article quoting a written note from a teacher to a student's parents, with significant errors in spelling and grammar.

National assessment in writing in the United States indicates that the quality of writing produced by many students isn't as good as we would like. While some improvement seems to be occurring in recent years, many students write rather poorly. Now that computers are becoming reasonably available, there is considerable interest in having students learn to write using a word processor. The call is for "Process writing in a word processing environment."

The use of computers in schools has been a grass roots movement. Large numbers of teachers have taken the initiative in learning to use computers and introducing computers into their classrooms. Interestingly, however, publications such as The Computing Teacher find that there is a severe shortage of teachers willing and able to write practical, down-to-earth articles on what they are doing with computers in their classrooms. A typical situation the editors of The Computing Teacher encounter is that they identify a classroom teacher who is really doing good things with computers. The teacher has developed materials, applications, classroom management procedures and/or other ideas that are well worth sharing with other teachers. But when asked to prepare an article for publication the response is often "I can't write."

My response is "Nonsense!" Such teachers have all three of the qualifications needed to write a useful article. These are:

1. Good knowledge of the information that is to be communicated.
2. Good knowledge of the type of person who will read the material--in this case, teachers like themselves.

3. The ability to write well enough to get through high school, college, and the teacher education courses required for certification.

My feeling is that the problem is twofold. First, there are the "real" difficulties such as teachers are quite busy and that they get relatively little practice in writing for widespread distribution. Second is the "psychological" problem—the "I can't write" syndrome.

The first difficulties can be overcome relatively easily. The type of teacher we are talking about always has too many things to do. But, the teacher sets priorities and does many things. The time to write can be made available by a readjustment of priorities. One's college-day writing skills soon return, and continued practice at writing leads to improved skills. The fact that one gets both better and faster at writing through practice in writing is important. We will return to it later.

The psychological barrier is harder to overcome. Thus, several of the exercises in this workshop session are designed to help address some of the psychological barriers to writing. It is interesting to note that many teachers have reported using a word processor has helped them to overcome whatever barriers were keeping them from writing for publication.

Writing

INDIVIDUAL ACTIVITY: When was the last time that you wrote something and showed it to a peer for evaluation? What were your feelings and how did you express these feelings as you dealt with this sharing of your writing? Make a few notes for yourself to help in the triad sharing exercise which follows.

TRIAD ACTIVITY: In groups of three, share what you learned by the above exercise. In what ways is writing difficult because of fear of what one's peers will say? What are other psychological barriers to writing? Where are these barriers developed? Specifically, what goes on in the teaching of writing that helps create psychological barriers to writing and sharing with one's peers?

Perhaps the biggest psychological barrier to writing is an unreasonable view of the writing skills of professional writers. One's mental picture of a person who writes articles and books is of a person who sits at a word processor, composing new material at lightening speed. A quick pass through a spelling checker, a couple of minor revisions, and it's off to the press with another finished product. It would appear that the effort to produce an entire book is minimal.

To repeat a previously used expression, "Nonsense!" Very few writers have such skills. Those who do have gained them through many years of practice and study. The people who say "I can't write." don't write, so they don't get the practice and feedback that they need to become better writers. For most writers, the key is persistence. It takes substantial time and effort to produce a significant piece of writing. However, sometimes one can produce a first draft relatively rapidly. The following exercise illustrates this point.

WHOLE GROUP EXERCISE: Select a passage, perhaps from the materials of this book. Have someone time you as you read it out loud at your ordinary talking/lecturing rate of speed. Read for one minute and count your words read. This will give you a rough estimate of how many words per minute you can put together and deliver in a talking mode.

Next, use the same passage and copy from it onto a piece of paper using your usual handwriting. Copy for one minute, and determine your approximate handwriting speed. A typical adult has a speed of 20 to 30 words per minute. How does your handwriting speed compare to your speaking speed? Can you touch type? If so, how does your touch-typing speed compare with your handwriting speed?

Finally, suppose that you could produce final, finished copy at a rate of just five words per minute. This is 300 words per hour or 2,400 words per eight-hour day. At this rate you could produce a book of significant length in a couple of months. Think about this analysis and whether you feel you could sustain a writing productivity of five words per minute on a long project.

DEBRIEF: In the group discussion make sure the role of word processing receives appropriate attention. Note also the difficulty of conceiving and organizing a large project. Most of the time is spent in thinking, organizing, and (as the writing proceeds) revising.

As indicated previously, a major key to writing is persistence. A word processor can make writing a little more fun and help substantially in the revision process. But writing existed a long time before computers and word processors came on the scene. Providing a non-writer with a word processor does not magically make the person into a writer.

Roles of Editors

Most writers follow a traditional route that includes prewriting, composing, revising, (repeat the previous steps as many times as necessary), and publication. That is, they follow the steps of process writing—the same steps we want students to learn as they learn to write in a word processing environment. A major step in process writing is revision. Revision is based upon the editing help one can provide for oneself and the editing help one gets from other sources. For example, computerized spelling and grammar checkers can serve a useful editing aid.

Even more important, however, is that most writers need editors. That is, few writers can adequately serve as their own editors. Three types of editing are needed. First is mechanical. Are the spelling and grammar correct? Is the writing level and style appropriate to the intended audience? A computer can help in this area. Much of the writing instruction in our schools focuses on these mechanical aspects. However, no amount of focus on mechanical aspects helps to improve the content or the overall quality of communication that is essential to good writing.

The second type of editing needed is for correctness of content. In a technical field such as computer science education one needs a content editor who is quite knowledgeable in both the computer and the education fields. Note that the content editor can be a colleague and/or others for whom you are writing. That is the basis for the review process used by many professional journals.

Finally, one needs an editor who understands style and effective communication. Does the material "flow?" Will the writing actually communicate to the intended audience? Once again, a good way to find this out is to have some members of the intended audience read what you write and provide feedback.

A writer needs to learn to make appropriate use of editors (both professional editor's and the type of peers described above). This takes training and experience. Few writers have an opportunity to take a course on how to work with an editor, since this is not a regular course in most schools. Rather, one must learn by doing. One must write, seek out editorial help, and learn what to expect from an editor. Good editorial help can greatly improve one's writing.

Undoubtedly many writers think that the editor's task is relatively easy, while many editors feel the writer's task is easy. Actually, both are necessary and both are relatively difficult. It is instructive for a writer to practice at the editorial task. The next exercise is of that sort.

TRIAD GROUP EXERCISE: In groups of three, discuss the quality and appropriateness of the short passage given following the next paragraph. If you were an editor, what would you do with this material? Keep in mind that it was intended to be the second page of the first chapter of a junior high school computer literacy text.

The following material is quoted from a computer literacy book manuscript submitted to a publisher a couple of years ago. The book was already under contract. It was being written by a carefully selected team of experienced writers. The intended audience is junior high school students. The manuscript begins the book with one page of discussion on computer games. The assumption is that all junior high students are familiar with and play computer games, so that this is a good way to get the book started. The second page continues:

> Hardware and Software
>
> Whether you are using a computer for any other purpose, you need both hardware and software. The hardware is the physical equipment of the computer system. It includes the monitor screen, the keyboard, the printer, and the computer itself. It even includes whatever is inside the computer, such as wires and screws.
>
> Hardware is designed to operate with software. Software is the instructions and information in a computer that tell it how to work. Software includes the programs that you buy on floppy disks and tapes and programs that you write yourself.
>
> You may find it difficult to determine what is hardware and what is software. If you are playing a computer game, for instance, the terminal that you are using is hardware. The terminal and screen are connected to a computer, which is also hardware. The game itself is run by a program, which is software. The pictures on the screen are created by the game software.

DEBRIEF: As groups first discuss this material they may focus on the grammar, writing level, or style. Are the spelling and grammar correct? Is the writing level appropriate to junior high school students? Does it "talk down" to them? Does it build upon their previous knowledge and experience?

Then the discussion might change to content. Note the number of new vocabulary words. Is this too many? Or, will most students know the words from their previous studies and experiences. Can students learn this many new words so quickly and with so little explanation?

What does the writing tell us about the writer? For example, does the reference to "wires and screws" suggest a particular insight into computer hardware? What about the reference to "the computer itself" as part of the hardware? How does one distinguish between "the computer itself" and the rest of the hardware?

Finally, note the last paragraph that indicates there may be difficulty in distinguishing between hardware and software. If there is difficulty, what is to be gained by learning to distinguish? (What do you think a teacher will do at this stage if a student asks about firmware?)

Have the whole workshop group debrief the above exercise. What are the best features of the writing? What are the worst features? If you were serving as editor, could you improve the writing and/or help the original author improve the writing? If time permits, rewrite this material.

In analyzing a piece of writing such as the above, it is helpful to focus on interactions among the elements of a triangle whose three vertices are labeled A: Writer, B: Reader, and C: Content/Information. What is the world view (totality of knowledge, thoughts, skills) of the writer? Similarly, what is the world view of the intended reader? What are the essential elements of content and information that are to be communicated?

A key insight one might gain from the Writer-Reader-Content/Information model is that a computer education leader who wants to write for other teachers likely has strength in all three areas. First consider just the area of Reader. Who knows teachers better than other teachers? Who knows better what will be of use to teachers, and who better knows the pressures that teachers face on the job?

Or, consider Content/Information. This must be both accurate and appropriate to the intended audience. A person who is a computer teacher or computer coordinator typically has appropriate technical knowledge, since this is necessary to do the teaching or computer coordination job. Moreover, the teacher or computer coordinator has good insight into what technical knowledge is appropriate to other teachers and computer coordinators.

Oral Communication

It is the third area, actually writing, in which many educators feel inadequate. Writing is one form of communication. Almost all educators are skilled at oral communication. Consider the following list of some types of oral communication.

1. Internal dialogue (a self-conversation).
2. One-on-one conversation with a close friend.
3. Conversation with a small group of your friends or your students.
4. Presentation to the whole class that you regularly teach.
5. Informal presentation to a group, such as responding to a question at a PTA meeting.
6. Formal lecture to a large group, such as at a professional meeting.
7. Radio or television presentation.

TRIAD EXERCISE: In groups of three, discuss what makes items near the bottom of the list more difficult to do than those near the top of the list. Expand the list as seems appropriate. Reorder the list so that it moves from least difficult to most difficult for your triad. Can you reach consensus in your group?) Discuss differences in difficulty ranking that may exist in your triad (what is easy for one person may be difficult for another).

WHOLE GROUP DISCUSSION: One major factor differentiating the types of oral presentations listed above is the nature and quality of feedback. An internal dialogue provides high quality feedback from the listener. The large group formal presentation provides less feedback as well as the possibility of negative feedback from an internal voice saying “You aren't doing very well.”

The order of difficulty of the oral communication modes will vary with the individual. For example, a person might find that the intimacy of one-on-one conversation with a close friend is more difficult than the less intimate type of communication that one has with a small group of friends or students. Some people feel that informal presentation to a group such as at a PTA meeting is much more difficult than a formal presentation. This is because of the lack of opportunity to carefully prepare, and perhaps practice, the presentation.

Written Communication

Now we are ready to repeat the oral communication exercise, but this time we will explore various types of written communication.

INDIVIDUAL AND TRIAD EXERCISE: Each individual is to spend about five minutes making a list of different written communication situations and then order their list from easiest (for them) to hardest. Then get together in triads and prepare a master list for your triad. The list is to be ordered from easiest to hardest and might begin with:

1. Brief noted to self, written in one's personal appointments book.

The triad group discussion should also focus on similarities and differences between oral and written communication.

Debriefing might follow the same approach that was used with the oral communication exercise. Two sample lists produced by small groups of workshop participants are given below.

List 1

1. Note to self.
2. Note to a friend.
3. Letter to a friend.
4. Letter to a professional colleague.
5. Paper for a class one is taking (weekly assignment).
6. Term paper for a class.
7. Dissertation proposal (all members of this group were doctoral students).
8. Journal article.
9. Dissertation.
10. Comprehensive exams for a doctorate program of study.
11. Book

List 2

1. Note to self.
2. Note to others.
3. Friendly letters.
4. Business or formal letters.
5. Coursework (written homework assignments).
6. Professional publications.

While the list produced by the second group is short, their discussion was heated. They distinguished between "creative" writing and factual exposition. Generally, creative writing is considered to be more difficult. The group also noted that written communication via a computer network is different than communication via writing on paper. However, within the group there was not agreement as to which is easier.

One key difference between oral and written communication is feedback. In oral communication one is better able to provide one's own feedback. A second difference is the permanency of errors—in writing, errors stay around to haunt you! The discussion might move in the direction of how all of this is affected by writing in a word processing environment making use of a spelling and grammar checker, following ideas of process writing. In many cases hard copy is produced only after appropriate cycles of editing/revision.

Another interesting point is the time factor. A typical person can talk perhaps 125 words per minute. A typical person can hand write perhaps 20 words per minute. (Note that some people compose at the keyboard and may well compose at 40 to 50 words per minute!) Roughly speaking, it takes six times as long to get a set of words on paper (in a hastily written draft) as it would to speak the words. This longer time frame gives the opportunity for more careful consideration of what is being communicated and how it is being communicated. That is, one can do more self-editing while writing. Moreover, in writing one usually has the time to go back and revise.

Voice Input

Voice input to computers is not yet inexpensive enough for most schools to afford. However, voice input is decreasing in cost and improving in reliability. There are two general types of voice input systems. One type requires a brief pause, perhaps 3/100 of a second, between words. The size of vocabulary that such systems can handle has gradually been increased, and 10,000 word systems are now available.

The second type of system handles connected speech, the ordinary type of talking that people do. This has proven to be a difficult computer problem, and it is only in the last couple of years that the first commercially viable products have come to market.

At first glance, voice input seems like it might have a significant impact on education. Imagine an introduction to writing, starting in the first grade, using a voice input system. Learning to read and write would be much more closely tied to the speaking/listening skills that students have developed long before they enter school.

But the value of voice input for ordinary writing is not so clear. Many business executives dictate letters and memos, which is somewhat similar to using a voice input system. But these dictated materials are filtered through a very good executive secretary, who typically does extensive rewrite.

WHOLE GROUP EXERCISE: Discuss how voice input to computers might affect the teaching of reading and writing.

Writing Computer-Assisted Learning Materials

It is common to be critical of the quality of available computer-assisted learning materials. Often the people criticizing available materials suggest that if teachers were involved in writing the materials, they would be much better. But this is a gross simplification of the difficulty in developing and writing good CAL materials. Almost all of the small companies doing this work were started by teachers and are run by (ex) teachers). All of the larger companies involved in this business make extensive use of teachers and ex teachers.

Part of the difficulty is that CAL is a new media, and few people have had substantial experience in developing and implementing CAL materials. The computer environment is quite complex and offers a large number of possibilities. It takes many years of study and practice to learn to make appropriate use of the CAL media. Part of the difficulty is that the feedback mechanism in this situation is different from either oral or written communication. This is a key idea. The "I can't write." syndrome has substantial justification in the relatively little practice that teachers get in writing. It can also be justified through teachers' lack of access to non-threatening feedback mechanisms.

Kids Growing Up in a Process Writing Environment

Still another very interesting idea is that students who are being taught process writing in a word processing environment :

1. Are being given increased experience in receiving feedback from teachers.
2. Are (often) being trained in providing feedback to each other.
3. Are being given training in providing feedback to themselves. (Read out loud what you have written. How does it sound to you? Use the spelling checker. Correct the errors it detects.)

The giving and receiving of feedback in a writing environment need not be any more threatening than doing so in an oral environment. Thus, process writing in a word processing environment might lead to a new generation of students who don't have an "I can't write." syndrome.

Closure

The ability and willingness to write freely and easily improves with practice and training. It is very useful in many academically-oriented careers. "Publish or perish" is certainly representative of many university teaching positions. It is, of course, important to keep in mind that one must have something to communicate if one intends to write. Thus, all of you (by taking university courses, attending this workshop, studying, learning about computers in education) are enhancing your abilities to communicate. However:

INDIVIDUAL EXERCISE: Make a personal list of what you have done over the past five years to improve your written communication skills. Then add to the list what you intend to do during the next year or so.

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Session 12: Some Thoughts On Mathematics Education

Goals

1. To explore the “I can't do mathematics” syndrome and consider its implications for computer science education.
2. To explore how computers may change mathematics education.
3. To suggest some ways to begin to implement changes to the mathematics education curriculum.

Logical-Mathematical Intelligence

Both my father and mother were Mathematics Department faculty members at the University of Oregon. Thus, it does not surprise me that my first grade teacher reported in 1943:

> David is showing steady improvement in all school work. Now that we have started number combinations, David shines in the class as our number wizard.

The combination of genetics, home environment, and our school system led me rather quickly and painlessly to a Ph.D. in mathematics. For me, our mathematics education system was a success. I both enjoy and use mathematics. At one time I did mathematical research, adding to the accumulated pool of mathematical knowledge. Now I am a computer educator, and I still enjoy mathematics.

Howard Gardner's book, Frames of Mind: The Theory of Multiple Intelligences, discusses Logical-Mathematical Intelligence as one of seven major categories of human intelligence. Gardner argues that we all have some ability in this area, but that people vary considerably in the levels of this ability. Appropriate training can help us to develop our logical-mathematical abilities.

Our Mathematics Education System

It is clear that a certain level of mathematical knowledge and skill is quite important in our society. For that reason, mathematics (arithmetic) is considered to be one of the three basics of education, and math instruction is built into the core curriculum starting in the earliest grades. All students are expected to learn to count, represent quantities using numbers, perform simple calculations both mentally and using pencil and paper, recognize and name simple geometric shapes, and so on.

Very few people use mathematics above the typical sixth or seventh grade math curriculum in their everyday (non-work) lives. Indeed, relatively few people use more advanced math in their work. It is within the logical-mathematical capabilities of a majority of our population to achieve this sixth or seventh grade functional level of mathematical knowledge and skill. Many people do so, and in that sense our mathematics education system is a success.

Note, however, that for many students it takes a number of years of study beyond the sixth or seventh grade to achieve this basic functional level of knowledge and skill. That is, people seem to have widely varying abilities and interests in mathematics. Our school system has set certain goals for mathematics education, and it works hard to achieve these goals. Some students never achieve the desired goals, and others take substantially more than an "average" amount of time to do so.

Note also that the required mathematics curriculum does not stop with the content of the sixth or seventh grade mathematics courses. Many are capable of going much beyond this level, and certainly there is a substantial body of important mathematics that lies beyond this level. Who can deny the importance and value of algebra, geometry, statistics, probability, and calculus? All are essential to large numbers of workers and researchers.

As a consequence, we attempt to require all students to learn a considerable amount of mathematics above the levels that they would normally encounter in their everyday (non-work) lives. In doing this, we tend to push many students to and beyond the level at which they can experience reasonable success. In some sense, the great majority of students eventually experience failure in their mathematics studies. Indeed, at the higher levels (that is, beginning with high school algebra) many mathematics education systems seem to be designed mainly to weed out students with lesser logical-mathematical abilities.

My personal feeling is that for most people our mathematics education system is not very successful; indeed, for many it is a downright failure. In this session we will explore some of the features of mathematics education that lead to so many students having bad experiences (if not outright failure) in this part of their educational careers. Our underlying agenda is to explore whether computer science education is following (and/or needs to follow) the same track.

What is Mathematics?

Essentially all educators have studied mathematics through at least the tenth grade plus some math courses in college. Thus, we all carry in our heads some sort of answer to the question "What is mathematics?" But our definitions vary considerably; many bear little resemblance to definitions provided by professional mathematicians. Thus, when people say "I can't do mathematics." they may have considerably different ideas in mind as to what they mean.

TRIAD GROUP EXERCISE: WHAT IS MATHEMATICS? (Ten minutes) Spend a couple of minutes writing down your own ideas on "What is mathematics?" We are looking for first impressions—an off the top of one's head definition. Provide enough detail so that one can distinguish this discipline from other disciplines. When you are finished, share your responses with the members of your triad. Search for similarities and differences in responses.

WHOLE GROUP DEBRIEF: This is a relatively difficult exercise. Most people are not used to the idea of providing a quick definition of an entire discipline. By a show of hands, see if there was considerable agreement within any triad. Ask for a sample answer from such a triad or from a volunteer. Write it on the overhead without comment. Ask if others wrote the same ideas; then ask for major ideas from other workshop participants.

Typical responses will include ideas such as the following:

1. Learning formulas and how to plug numbers into formulas.
2. Proving theorems.
3. Memorizing definitions and notation.
4. Solving story problems.
5. Clear and logical thinking.

6. Getting the right answer.
7. Solving real-world problems.
8. Paper and pencil arithmetic.
9. Solving problems using fractions and decimals.
10. Mental estimation and exact mental arithmetic.
11. Arithmetic, algebra, geometry, calculus and higher math.

Each of these responses can be examined in terms of the mental model it represents for the person giving the response. Suppose, for example, that a third grade teacher suggests that mathematics is: 6. Getting the right answer. What might one guess about the math background and understanding of that teacher? What will students in that teacher's classroom learn about mathematics?

Each of the responses can also be examined in terms of capabilities of calculators and computers. For example, how might the ready availability of calculators and computers affect: 10. Mental estimation and exact mental arithmetic? Contrast this with possible roles of computers in: 1. Learning formulas and how to plug numbers into formulas.

Mathematics education can be analyzed in terms of the following four major goals:

1. Cultural/historical. To preserve and pass on the cultural/historical aspects of mathematics; mathematics is an important part of human history and human endeavor.
2. Recreational/artistic. To have students understand and appreciate recreational/artistic aspects of mathematics as a human endeavor.
3. Problem solving. To have students learn to represent problems using the language of mathematics and to solve problems using mathematics. Especially, to learn to apply mathematical knowledge to fields outside mathematics, such as social science, science, and engineering.
4. Advance the field. To produce sufficient research mathematicians and high level faculty to continue to advance mathematical frontiers.

Each of these four goals can be analyzed for possible impacts of computers. For example, suppose that someone suggests dropping the study of Roman numerals from the curriculum. That is in conflict with Goal 1. It is also somewhat in conflict with the second and third goals.

TRIAD GROUP EXERCISE (10 minutes): Discuss the dropping of paper and pencil long division of multi-digit numbers from the curriculum, replacing it with instruction in use of a calculator. Analyze this issue from its potential impact on Goals 1-4 above. Note the tradeoff between a possible gain in Goal 3 and a loss in Goal 1. Note how the fourth goal is supported by a mathematics education system that begins with all students and gradually filters out all but the most capable. Perhaps learning paper and pencil computational skills serves as a good filter?

Your Early Mathematical Experiences

Many people have vivid memories of some of their early mathematics education experiences. These memories may be of either good or bad situations. They can lend insight into the nature of our mathematics education system.

WHOLE GROUP EXERCISE ON EARLY MATH EXPERIENCES: The following exercise can be done as stated, with a person merely remembering past experiences. Or, it can be done using age regression techniques from psychotherapy. The latter may be particularly effective if a person has a strong “I can't do math.” syndrome rooted in early childhood.

> Think back to your mathematics education experiences during your early grades in school. Let come to your mind the most enjoyable experience you can remember. Write it down. Let come to your mind the least enjoyable experience you can remember. Write it down. How did your early mathematics education experiences affect you in your later studies of mathematics and how do they affect your current attitudes in this discipline? Was our mathematics educational system successful with you?

TRIAD GROUP AND WHOLE GROUP DEBRIEF: Debrief the above activity in triads. Each person should share their experiences and early memories. To what extent do we find examples of “The way the twig is bent ...?” Ask for a show of hands on how many people feel our mathematics education system was successful for them.

Math Anxiety

Sheila Tobias has written a book titled Overcoming Math Anxiety that addresses math anxiety problems of adult women. Many of the problems can be traced to the way math is taught and to inequities in treatment of women in math education. Many computer educators fear that we are making the same mistakes in computer science education.

Sheila Tobias treats math anxiety much like one would treat any other psychological problem. In essence, she suggests methods of psychological counseling are appropriate for treatment of the math anxiety problem. Thus, her 1978 book provides an interesting early example of applying a high-touch technique to a high-tech problem.

Viewing mathematics as high tech suggests that we examine our mathematics education system and ask “Where is the corresponding high touch?” Perhaps many people are turned off by math because it lacks a high touch component. Perhaps some of the success of math lab and concrete, hands-on approaches to mathematics education in the early grades can be explained by their high-touch approach. Once again one can ask if we are doing the same thing in our computer and information science education system.

These are critical questions. Ideas of “getting the right answer” and of success/failure are built into our mathematics education system from the very beginning. Contrast this with the ideas of Seymour Papert in which he talks about using Logo to create a learning environment in which one can explore, discover, develop and debug procedures, and grow.

In the early 1980s, the early adopters of Logo tended to follow Papert's ideas. Now, however, Logo is beginning to become institutionalized. It is becoming part of the regular, required curriculum. Many teachers are treating Logo much like they treat mathematics. They follow a scope and sequence designed to ensure all students cover the Logo topics that have been assigned to their grade levels. They give tests designed to measure progress in learning Logo.

INDIVIDUAL EXERCISE: Logo instruction in the elementary grades could be patterned after mathematics instruction. Indeed, it could be integrated into the math curriculum, using part of the time slot devoted to mathematics. But there are other disciplines that Logo instruction might be patterned after. Examples include art, reading, writing, music, and physical education. Select a discipline other than math, and think about what Logo instruction would be like if it was patterned after methods of instruction in that discipline.

DEBRIEF IN TRIADS: Have each person share the analogy or pattern they thought about. How would these approaches be different from the mathematics education approach?

Some schools have selected art education as being most like Logo education. Note that in elementary school art education there tend to be no grades, no right/wrong answers, and considerable emphasis on self-actualization. Seymour Papert recommends an approach of learning by doing and children learning from each other, with minimal formal instruction from adults. This is a discovery-based approach.

Some Roles of Computers in Mathematics Education

Mathematics instruction receives a significant time slot in the scope and sequence followed by most students. National assessment, personal observation, and other sources of information provide insight into the success of our mathematics education system. Success, of course, is a relative thing. Our current system seems to produce adequate numbers of researchers and college faculty. (Actually, it isn't clear that this is happening. We may be facing a shortage of Ph.D. mathematicians. A 1986 report indicated that only 55 percent of current mathematics graduate students in the United States are from the United States. The suggestion is that we are not producing enough doctorates who will remain in this country to meet our needs.) At the same time, it brings a number of people to less deep levels of mathematical knowledge—levels sufficient to go into professions that make substantial or some use of mathematics.

For a great many students, however, our mathematics education system produces alienation along with a mediocre level of knowledge and skills. Such students are neither prepared to go on to further levels of mathematics coursework nor are they able to make effective use of the materials covered in the courses they have taken.

My opinion is that our mathematics education system has achieved a local maximum in quality. That is, hundreds of years of efforts in teacher training, materials development, curriculum design, etc. have optimized the system. The optimization that has occurred takes into consideration the amount of school time we devote to mathematics, the capabilities of teachers, the capabilities of students, the support available through homes, and so on. The system is quite stable; it is highly resistant to change.

My conclusion is that if we pursue traditional paths we will see, at best, only very modest progress toward improving our mathematics education system. Indeed, since there are strong counter forces such as television, a change in work ethic, and a change in home environments, we will be lucky to hold our own. The decline in mathematics scores on the SAT over the past years supports my position.

Mathematics educators have long been aware of computers. During the late 1970s there was a considerable push for use of calculators in math education. In the early 1980s the National Council of Teachers of Mathematics produced the Agenda for the 80s, which suggested how NCTM leaders felt mathematics education should proceed during the decade of the 1980s. There was considerable emphasis on computers and computer literacy. The April 1985 issue of the Arithmetic Teacher contains an important article "The Impact of Computing Technology on School Mathematics: Report of an NCTM Conference." This contains more detailed recommendations for the full integration of calculators and computers into the K-12 mathematics curriculum. Interestingly, the same issue of the Arithmetic Teacher contains an article "Eighth-Grade Mathematics in U. S. Schools: A Report from the Second International Mathematics

Study." This compares performance of U. S. eighth-grade students with those from a number of other countries. On average, the U. S. students don't fare too well.

But of course there are now computers. Computers in mathematics education fall into three major categories: computer science, computer-assisted learning, and computer-as-tool.

First, we consider computers (computer science) as a subject matter area—perhaps falling into the domain of the mathematics curriculum, or perhaps being an independent area of study. If considered as part of mathematics, computers use up time currently devoted to other (more "traditional") topics. To the extent that student learning of these traditional topics is correlated positively to instructional time, computer instruction (in lieu of traditional mathematics instruction) may lead to a decrease in learning of traditional mathematics.

A number of computer educators have suggested that time spent in studying computer programming or other aspects of computer science might improve student performance in mathematical problem solving. The research literature is somewhat sparse in this area, however. Few studies have established a solid link between the study of computer programming and improved performance in mathematical problem solving. The evidence is not sufficient to justify using mathematics instruction time to teach computer programming, expecting as a result to increase mathematical problem solving performance.

Second is the use of computers to help deliver instruction. Substantial research now suggests that computer-assisted learning (CAL) can, on average, produce significant gains in rate of learning while maintaining current attitudes and long term knowledge and skills. While much research remains to be done, one might expect that for the bulk of the current precollege mathematics curriculum, substantial use of computer-assisted instruction could lead to a 20 to 30 percent (or more) increase in rate of learning. That is quite encouraging, since both the necessary hardware and the necessary software will likely become readily available during the next ten years. It will be a challenge to mathematics educators to make appropriate use of the potential of computer-assisted instruction. Will the time saved be used to learn current topics better (with increased emphasis on problem solving), or will it be used to add new topics to the mathematics curriculum? Might the time be given over to the study of non-mathematical topics such as art, music, or interpersonal skills?

INDIVIDUAL EXERCISE: Suppose that appropriate use of CAL could free up an average of ten minutes a day from the current mathematics education curriculum. If you had complete control of the school curriculum, how would you use this time? Develop your best arguments to support your position.

TRIAD ACTIVITY: Use active listening, with designated speaker, listener, and observer, to discuss ideas from the above exercise. Active listening is appropriate here, since deep personal feelings on how to use the time may emerge.

WHOLE GROUP DEBRIEF: By a show of hands find out how many people would devote the time to additional mathematics education. See if any other academic discipline receives a number of votes.

Third, we consider computer-as-tool in mathematics. The capabilities of calculators in arithmetic give a glimmer of what we are talking about. Many students spend literally hundreds of hours trying to develop paper and pencil skills that do not rival the calculator skills they can acquire in a few hours.

With a general-purpose computer one can have software to graph, solve equations, and do algebraic symbol manipulation. This sort of computer progress suggests possible changes in mathematics education. Both the calculator and the computer allow an increased separation of algorithmic processes from other aspects of knowing and doing mathematics. Algorithmic processes can be carried out by a machine—generally both more rapidly and more rapidly than by a person assisted by pencil and paper.

It would cost less than $2 per student per year to provide every student with a calculator. (I have seen ads for relatively good quality solar battery calculators at a retail price of $5. These are six-function calculators with memory. Such a calculator can be expected to last several years.) That could easily be done within current budgets. Why haven't we done it? The fact that we haven't could serve as a foundation for a strong attack on our mathematics education system. The current system is so resistant to change that it has not been able to adequately handle the calculator issue. Do we have any indication that our mathematics education system will better handle computers?

I have used the above ideas in many workshops during the past few years. Late in 1985 and early in 1986 I began to run into places where considerable calculator-related change seems to be occurring. For example, Missouri is now going to allow calculators on statewide assessment tests at the sixth grade level. Oregon is experimenting with use of calculators in statewide assessment. The province of Alberta, Canada allows calculators to be used on the tests required of all students graduating from high school.

WHOLE GROUP DISCUSSION: Ask if anyone in the workshop is aware of a school whose mathematics education curriculum has been substantially changed by computer-as-tool or calculator-as-tool. If so, have them share with the whole group. The discussion might also focus on the difficulty of developing appropriate new curriculum and the difficulty of training current teachers to handle such a new curriculum.

The cost of providing every student with a daily hour of computer access for use in mathematics is still high. But it isn't overwhelmingly high. In terms of pure hardware costs, a reasonably decent microcomputer system with a little software now costs about $150 per year. That is based on an eight year life expectancy and not too many maintenance and repair costs. If five students share a machine--each getting an hour of use a day--the cost is $30 per student per year. (The 1984-85 average cost per student for precollege education in the United States was $2,750. Thus, the $30 figure is only about one-percent of the current cost of education.) Moreover, the cost is declining while the value of doing so is increasing. Already a few schools provide such compute access (and the home access of computers may be an order of magnitude greater than the school access). For purposes of long term planning one can take as a “given” that such a high level of computer availability will become commonplace during the next decade or so.

It is difficult to appreciate the potential impact of computer-as-tool on mathematics. Our entire mathematics education system is built around a balance among the capabilities of paper and pencil, book, and human mind. The computer has certain characteristics of each of these. What will it be like to begin one's formal studies of math in kindergarten or the first grade seated in front of a very sophisticated microcomputer? What does it mean to “know” mathematics when this knowing takes full advantage of the capabilities of a computer?

The challenge of computer-as-tool to mathematics education far exceeds the challenge of computer-assisted instruction. If a computer can solve or help solve a particular category of problem, what do we want students to learn to do mentally, assisted by paper and pencil, or assisted by a computer? What does it mean to learn mathematics in an environment that includes ready access to a very powerful computer system? (The topic of artificial intelligence could rear its challenging head here. More and more we will see computer systems that accept as input a statement of a problem and produce as output a solution to the problem.)

My feeling is that the computer is a powerful enough change agent to knock mathematics education out of its current “local maximum” position. The risks are high, since we may stabilize at a new local maximum that is less desirable than the current situation. But the potentials are also high. What a great time to be a mathematics educator! And what a challenge to mathematics educators.

So far I see little evidence that our mathematics education system will meet the challenge in a timely fashion. For example, I am not aware of a single school system that has a K-12 mathematics curriculum designed around the ready availability of calculators and computers. I am not aware of any school system that has a staff adequately familiar with computers-in-mathematics to handle the changes we are discussing. I know of no teacher training institute that has integrated widespread computer usage into the preparation of teachers. The computer challenge is here now--but our mathematics education system has yet to rise to the challenge.

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Possible Connections Between Math and Computer Anxiety by Shane Goodwin

[This section was contributed by Shane Goodwin as part of the work in Sharon Yoder's Computer in Education Seminar, University of Oregon, Fall 1988. The High Tech/High Touch book was part of the required readings for the course. All students were given the assignment of writing an addition to the text that they felt would be useful to students taking the course. They were told that some of their writings would be added to subsequent editions of the text, to help produce a living, growing text.]

In recent years, psychologists, researchers, educators, and others have seriously begun to explore the interweavings and similarities that may exist between math anxiety and computer phobia . From the scattered research that is becoming available, it appears that these phobias are indeed related in many aspects and the understanding of one may enlighten the uncertainties of the other. Although the research is far from conclusive and complete, the studies and commentaries by experts may help us understand the possible connections as well as potential remediations.

The common ground between the two anxieties could be classified as follows:

1. Fear of the New (neophobia)

The British researcher, Geoff Simons, authored a book entitled Silicon Shock , which analyzes the tremendous impact computers are making on society. One of the probable factors of computer anxiety that he expounds on is the fear of the new. “The new and strange—whether in the form of environmental features, human strangers, peculiar objects, or freshly contrived artifacts—have always had the capacity to arouse anxiety in people." (Simons, 13)

Perhaps, in addition, to the "newness" of the physical realities of computer hardware, the very language itself contributes to the phobia. Sometimes referred to as "computereeze", the high tech jargon can be unnerving to the uninitiated in perhaps the same way that the language of mathematics has been to millions of people. In Overcoming Math Anxiety , Sheila Tobias indicates that the ambiguities of the language of mathematics have long been a source of frustration for many students. That is, the connotations that many mathematical terms carry over from everyday usage can appear, at times, as difficult contradictions or confusions.

Another similarity between the two anxieties may be tied into the actual symbolism that weaves its way throughout these sciences. In terms of "user-friendliness", a technical computer manual filled with difficult coding and keyboard symbols is not much different from the unchartered waters of mathematical symbols found in a typical mathematics textbook. Oftentimes, in a mathematics textbook, portions of the Greek alphabet are used in a logical and meaningful fashion for the authors or professors yet remain in oblivion to the mathophobic student.

Whether it be the language, symbolism, or even the very way of thinking about problems, mathematics and computer science share certain inherent challenges to the anxious user. The fear of "newness" is a very real factor that has to be dealt with in our remediations of computer and mathematics anxiety.

2. Attitudes and Learning Styles

Student and teacher attitudes as well as styles of learning may play very significant roles in the issue of anxieties. Current research is still scarce in this regard, but it would seem reasonable or at least worthy of investigation. Many educators and specialists have suggested that because of our unique and individual cognitive mappings, current teaching techniques of mathematics or computer science are not flexible enough to accommodate other points of view (Tobias, 1978).

Although the issue of "soft mastery" and "hard mastery" has often been characterized as male-female differences, it is probable that these learning styles are shared by both sexes and may influence to some extent, how we view the computer and our relationship with it (Turkle, 1984). The difficulty our delivery system faces in this regard is that we tend to restrict our teaching of computer science to a rigid, logical, and top-down methodology that makes it challenging at best for those students who are more "soft-mastery" oriented learners. This obviously could be a factor in the negative experiences and attitudes that are evident in the background of computer-anxious students.

Some researchers have hypothesized that since there is a large gap between male and female participation in elective mathematics and since the computer is often viewed as a rigid mathematical machine, that a similar gap has been occurring in our secondary and post-secondary computer courses (Bakon, 1983). Whether that gap has occurred due to the carry-over of a math anxiety attitude is not known for certain, but it has been approached in the literature and research (Gressard and Loyd, 1984). Whatever the case may be, we should continue in our efforts to break down the stereotypes that have been formed over the years and encourage more girls to develop their talents in computer science technology as well as mathematics.

We are just barely receiving a new generation of teachers and administrators that have had, for the first time, exposure to computers since childhood. It would seem that if there indeed has been a correlation between the anxiety of the teacher and that of the student, then a significant decline of the number of computer anxiety cases will be observed in the future. That is, it is probable that the more our educators become comfortable with computer technology, the more our students will as well.

In a similar light, researchers have proposed the "decentralization" of computer activities in order to allow the association of computers to expand outward into other domains besides mathematics (Gressard and Lloyd, 1984). Perhaps as a result of efforts to make computer technology more of a high touch field than ever before, the very concept of computer literacy will evolve and become integrated into other content areas.

3. The Fear of Losing Personal Control

For the "hacker", the very idea of retaining control of the computer through his or her own programs and procedures is a positive stimulus and a factor in the enjoyment of computer science (Turkle, 1985). For a student that enjoys mathematics, the concept of controlling the problems and knowing that either the final answer is right or it is wrong is a source of satisfaction. There is a philosophy of objective mastery and control. Yet, for the computer or math-anxious person, that same feeling of control and understanding is lacking. Frustrated and depressed, the person feels unable to produce some kind of intelligent or satisfying output from either the computer or the mathematical problem. Hence, this need to retain personal control is another factor influencing computer anxiety (Simons, 1985).

People resent not having control over their own destiny and goals. When a computer is regarded as a threat to our control over decision-making processes, financial planning, government, administration, etc. then computer phobia becomes a very real phenomenon. Likewise, if we consider ourselves inferior and incapable of using mathematical tools to control outcomes to problem-solving, then we are threatened with a feeling of loss of control and solidity in our intellectual destinies. Mathophobic students do not need just solace and understanding, but also a sense of mastery and control of the mathematical tools and principles (Tobias, 1978). The same must logically apply therefore to the tools and principles of computer technology and the many facets of its applications.

4. The Fear of Never Catching-Up

Sheila Tobias describes common scenarios of math-anxious people describing the very day or week or lesson that they missed back in grade school when fractions, or perhaps exponents or square roots were discussed, and as a result, all these years they have never been able to "catch-up." It is true that mathematics is a structured discipline of hierarchy and one concept will often be used extensively in the building of another. The challenge then in combating math anxiety, is to realize that it is possible to back up and take another swing at the concept. The trick is to understand that there is no shame in starting over again in order to build a more secure foundation (Tobias, 1978).

Similarly, for adults or even pre-college students that have "missed out" on the full force of the computer technology, it can be nothing but overwhelming and intimidating to confront the very quantity of computer advancements that have been made in a considerably short period of time. To perceive one's self trying to master so much information that has already circulated around the world so quickly and in so many disciplines, understandably leads to stress and anxiety. In addition to the quantity, we might add the quality as well. That is, just as with math anxiety, there is a danger in comparing one's abilities, interests, or quality of understanding and mastery to those of other colleagues, professionals, "hackers", etc.

5. Potential of Mutual Improvement

Finally, in addition to the probable similarities of math anxiety and computer anxiety that exist, there is great potential for the deeper understanding of one field to influence the development of the other. For example, a recent study was made at the high school level to investigate the possibilities of reducing math anxiety via computer-assisted instruction (Harris and Harris, 1987). Several chapters of Seymour Papert's Mindstorms discuss the issue of how computers become discovery tools by which mathematical concepts are indirectly assimilated into the working knowledge bases of children in a very comfortable and uninhibiting way.

It would seem reasonable as well, that by working towards the successful remediation of math anxiety and the gap in female and minority participation, we would see improvements carry over to computer anxiety and participation. Whether or not this really will occur remains to be seen. There must be further research and experimenting in order for our delivery system to reach its true potential in this challenging information age.

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Session 13: Computer-Based Information Systems in Social Studies

Goals

1. To explore effective methods for increasing student and teacher use of Computer-Based Information Systems (CBIS).
2. To explore effective computer-based methods to help students develop the higher-order skills (analysis, synthesis, inquiry, interpretation, evaluation, problem solving) needed to exploit the full potential of CBIS.
3. To gain increased understanding of how progress in hardware, software, and CBIS may affect the social studies curriculum.

Background Information

Alvin Toffler's The Third Wave discusses the agricultural revolution, the industrial revolution, and the informational revolution (Toffler, 1980). We are now well into the third wave, an information age. Fueled by computer-related technology, the information age is bringing changes to our society as large as the changes brought by the agricultural revolution or the industrial revolution.

The information age is based on improvements in technology. We have improved and new methods to store, process, and transmit information. But it is important to realize that we had good methods for the storage, processing and transmission of information long before computers came on the scene. The telephone, for example, was invented in 1876. Still, Computer-Based Information Systems (CBIS) represent a significant change.

It is also important to realize that we still have need for the agricultural age and industrial age products. What has changed is our efficiency at producing the needed food and products. In the United States only about three percent of the work force is needed to raise the agricultural products consumed in this country and made available for export. Less than twenty percent of the work force is now directly involved in industrial manufacturing, down from a peak of nearly sixty percent shortly after World War II. The information age represents a massive change in the nature of the jobs available to people seeking employment.

WHOLE GROUP EXERCISE: The telephone was invented in 1876, and its use and availability have been expanding steadily since then. During the past 40 years the computer, the transistor, microwave transmission systems, earth satellites, fiber optics and cellular telephone have fueled the continued and rapid growth of this field. How have telephones affected our society and our educational system? The purpose of this exercise/discussion is to get workshop participants to begin to think about the transmission of information and how changes in this area affect both our society and our educational system.

One very important idea is that people learn to use a telephone while they are quite young and without benefit of formal schooling. The interface between people and this technology is so “user friendly” and natural that it is easy to learn to use a telephone. Of course, at a professional level there is still more to learn, so formal training is often needed.

Note also how changes in technology have reduced the need for telephone operators. In a real sense, the telephone system is like a gigantic computer with millions of terminals. Every person who uses a telephone is making use of this timeshared computer system.

This session focuses on roles of Computer-Based Information Systems (CBIS) in education. CBIS be divided into two major categories: bibliographic systems and source systems. The contents of a bibliographic retrieval system consist of periodicals, books, and other similar publications, or pointers to such publications. (Often a computerized bibliographic system contains only an index, perhaps also containing short abstracts, rather than entire articles and books.) Generally speaking, when one is searching a bibliographic retrieval system, one doesn't know what (if anything) will be retrieved. On the other hand, a source system contains specific information organized in a specified fashion. Examples include major league baseball statistics for the years 1900 to 1980, stock market data (high, low, last, volume for each stock traded so far today), airline reservation information (information on each flight, such as seats sold and remaining to be sold), and an FBI file of stolen cars. Thus, in using a source system one knows (in general) what will be retrieved. This two-way classification does not fit all situations, and a particular CBIS may have characteristics of both.

It is estimated that by the year 1990 there will be one billion telephone numbers in service worldwide, roughly one per every five people on earth, and almost all will be able to communicate with the others. We are rapidly moving toward the time when a significant part of the earth's population will have easy access to huge databanks, more massive than the largest university research libraries.

WHOLE GROUP EXERCISE: Introspect for a minute on how your education was slanted toward being a productive member of an industrial age society. What changes might be necessary to prepare a person for life in an information age society? Specifically, how might rapidly improving access to more and more information lead to changes in what constitutes a good education?

The nature of our school year, with a long summer vacation, clearly ties in with the needs of an agrarian society. But differences between needs of an industrial society and an information society are more subtle. In an information society, more time and energy is spent processing information. People who work with information (knowledge workers) are provided with sophisticated equipment to aid in information processing. Training and experience in using a computer to process information is of increasing importance.

Knowledge workers need good higher-order skills. They need to be able to formulate the right questions, and then make use of the accumulated knowledge of the human race as they work to answer the questions. They need good hypothesis formulation and testing skills.

Use of CBIS in a Social Studies Course

Suppose, for example, a student wants to investigate deaths in automobile accidents and how they might relate to alcohol consumption. A computer could be used to retrieve statistical data such as deaths per billion miles driven and per capita alcohol consumption over a number of years. A computer could be used to scale and graph both sets of statistics on the same axes. Then the student could examine the graphs, looking for relationships. The student could argue a particular viewpoint based upon such data.

Once such an inquiry process is initiated, the student could formulate other conjectures and test these conjectures. For example, it might occur to the student to investigate whether the initial drinking age, such as age 18 in some states and age 21 in others, seems to relate to automobile traffic deaths. Or, the student might note that some states adhere to the 55 MPH speed limit much better than others. How does this affect traffic deaths?

Notice that while high tech is used to retrieve and present the information, the issues concern people. They are high-touch issues. Moreover, investigation of these issues requires good higher-order skills.

TRIAD GROUP EXERCISE: Begin by working as individuals. Make up an example of a social studies problem that could be investigated by appropriate access to CBIS. What sorts of questions might the student pose and explore? What characteristics and capabilities would the CBIS need to have? Share your example with the members of your triad. In discussing each other's examples, look for specific benefits of CBIS over non-computer access to information.

What Changes Might Occur Due to CBIS?

TRIAD GROUP EXERCISE: By ten years from now it could well be that an inexpensive microcomputer will contain several 16-megabit memory chips, make use of a 32-bit CPU, and have circuitry that is ten times faster than today's microcomputers. What difference will these hardware improvements (raw computer power) make in the world from a social studies curriculum point of view? Discuss in your triad. Be as specific as possible, and keep the discussion to issues involving raw computer power.

This is a challenging exercise. Most computer educators have not thought about what difference computers might make in social studies education. Certainly, most have given little thought as to how rapid decreases in the cost of raw computer power might affect social studies education.

Suppose, for example, that this raw computer power is used to provide each student with a portable computer/CBIS. In a package no larger than a typical history book, a student might carry the equivalent of a number of books, software to access and process the information, a word processor, and other application programs. This improved access to information might decrease the need for memorization of facts and increase the value of higher-order processes.

Raw computer power is only part of the picture. A second part is software. A lead article in a recent issue of The Wall Street Journal is on “Expert” systems. These very complex computer programs are designed to exhibit “artificial intelligence.” The article notes that about 50 such systems are in commercial use and that another 1,000 systems are being designed (Davis, 1985). The article indicated that it currently costs about $500,000 to develop an expert system of medium capability. Many of the systems under development will cost much more. Such expert systems capture part of the knowledge of a human expert or team of experts in a particular field. The final product may even out perform the human experts on whom it is modeled. The educational and social ramifications of such systems have not yet been seriously explored.

Of course, much simpler software to process information is already available. Examples include statistical, equation-solving and graphics packages. Such software is routinely used by large numbers of students and workers. One can think of such software as having a low level of artificial intelligence, since it contains some of the knowledge of how to help solve a broad range of problems. Such software can be viewed as an intelligence amplifier.

The hardware progress discussed earlier will greatly add to the software available on microcomputers. That is because the 32-bit CPU microcomputers with large memories will be able to run the software that currently runs only on larger computers. For example, imagine a microcomputer able to run the entire IBM program library! We are already seeing signs of this. IBM recently announced that they have developed a CPU chip that executes the 360/370 instruction set. Many graduate students and other educational researchers are familiar with the SPSS statistical package. In the past it was only available on mainframe computer systems. Now it is available on an IBM microcomputer system.

TRIAD GROUP EXERCISE: Consider the software progress that is likely over the next ten years. How should this affect the social studies curriculum? Discuss in your triad, being as specific as possible, but concentrate on the software issue.

A third part of the picture is improving access to the accumulated knowledge of the human race. More and more of this information is being stored in computer-based information retrieval systems. IBM recently announced they were beginning mass production of a magnetic disk storage system with a capacity of 5 billion characters (the equivalent of 5,000 very long novels). A number of companies are now producing laser videodisc storage systems designed to store 500 million to 2 billion characters. A 500 million character videodisc is 4.72 inches in diameter and the thickness of a phonograph record. (Remember, 500 million characters is the equivalent of 500 long novels!)

Laser videodiscs are ideally designed for the storage of databases and will break a cost bottleneck that schools face as they move toward increased use of CBIS. Currently, CBIS is too costly for most precollege educational settings because of telephone line charges and mainframe computer access charges. But the actual cost of producing multiple copies of a laser videodisc is about a dollar or two each. A laser videodisc reader and interface to a microcomputer will is priced at less than a thousand dollars.

One could speculate on the possibility of a wire service, a newspaper chain, or a publisher of a chain of magazines producing such laser videodiscs for sale to schools. For example, this could be done by the New York Times, which already indexes and stores in a computer database a large number of periodicals. A school might have a subscription, paying perhaps $120 to $180 per year to receive a laser videodisc each month. One videodisc a month would represent a major addition to a library's reference collection—the equivalent of perhaps 5,000 books a year. In fact, several business and stock market information service companies are currently taking such an approach for the sale of databases to their customers. Moreover, several news services are beginning to distribute databases to education via floppy disks.

TRIAD GROUP EXERCISE: Consider only the improved access to information that seems likely to occur during the next ten years. How should this affect the social studies curriculum? Discuss in your triad group, being as specific as possible.

The Role of Social Studies Courses

Computers can provide much improved access to the accumulated knowledge of the human race as well as providing automated methods for processing it. Increasingly, this information includes detailed step-by-step sets of directions on how to solve various categories of problems. Often the directions are designed to be carried out by a computer, a robot, or an automated piece of factory equipment.

Most of our current secondary school curriculum was designed without attention to information-age technology. Even now, after years of substantial school movement toward computer literacy, the accessing of databases is just beginning to receive serious attention (Hunter, 1985). Thus, the curriculum in most school systems does not provide a mechanism for students to learn to make use of Computer-Based Information Systems. Most students do not learn to use computers to solve the types of problems that can be solved most easily by computer.

One of the primary places where students learn to access and use reference materials is the social studies curriculum. For example, the Eugene, Oregon 4J School District has twelve social studies program goals that include:

> XI. Students [will] possess skills in locating, gathering, interpreting, analyzing and evaluating social studies data.
>
> XII. Students [will] apply critical thinking and problem solving skills to social issues (Eugene School District, 1981).

Throughout our country all students take a number of social studies courses, and these program goals seem equally applicable to them. The Eugene 4J School District materials further explain program goal XII: "Students will identify an issue, select an appropriate problem solving process, and apply the process to the issue." and "Students will ask appropriate and searching questions." Inquiry is a key idea in the social studies curriculum.

Secondary school social studies courses can be divided into two major categories. First, there are the history courses, such as U.S. History, World History, and History of Western Civilization. Most school districts require students to take two or three of these courses. Second, there are the non-history courses such as General Social Studies, Current Events, Social Problems, Geography, Government, Civics, Modern Problems, Economics, etc. Secondary school students generally take about two years of these types of courses.

TRIAD GROUP DISCUSSION: Of the two major categories of social studies courses, which is apt to be more receptive to CBIS? Why? Discuss in your triad group.

Traditional history courses are more resistant to the types of changes we are proposing (Robbat, 1984). History courses are "book-based" and typically seek to cover the content of a specified book. Robbat's study investigated fifty history teachers, half on the east coast and half on the west coast. All understood inquiry methods and 25 had received training in use of computers. However, only one used a computer in his teaching, and that use was for relatively mundane drill and practice. Thus, it could well be that the line of least resistance to CBIS in social studies is the non-history courses.

The Problem

The problem facing the social studies curriculum is based on two observations. First, very few social studies teachers currently make use of Computer-Based Information Systems or help their students learn to use such systems (Robbat, 1984). Second, the balance between teaching lower-order skills and higher-order skills in social studies and other courses currently is over weighted in the direction of lower-order skills (Brown, 1982). This imbalance exists throughout our school curriculum; it is a major theme in many of the recent school reform reports (summarized in Felt 1985). Also, many educators are arguing that students need increased higher-order skills and they are suggesting ways to help students improve these skills (ERIC, 1984).

These two observations support our contention that students, on average, are receiving social studies instruction that focuses quite heavily on lower-order skills and that virtually ignores modern aids to information retrieval and information processing. An education focusing on lower-order skills and ignoring CBIS does not adequately prepare students to function independently in the information age. Inquiry and problem solving are essential components of a high quality education.

Inquiry has a long history in the social studies. The goal is to have students learn to pose questions or formulate hypotheses, collect or access data, analyze the data, and interpret the results (Sinatra and Annacone, 1984; Steinbrink, 1985). Each of these recent studies suggests models for teaching inquiry methods. The models identify lower-order skills (answering questions of fact posed by the teacher); middle-order skills (answering open ended questions or questions involving careful reasoning posed by the teacher); and higher-order skills (students both pose and answer difficult and open ended questions). Note that neither of these studies specifically discusses students making use of online retrieval systems or computer aids to the creation of databases.

TRIAD GROUP EXERCISE: The inquiry methods of the social scientist are somewhat analogous to the use of “scientific method” by scientists. In your triad group, discuss this analogy, looking for strengths and weaknesses of the analogy. Your discussion should bring out major differences between social sciences and sciences, as well as similarities. Why do so few social studies teachers place major emphasis on inquiry in their courses?

In discussing the capabilities of people, sometimes people are divided into categories based on a quantitative vs. non-quantitative (that is, qualitative) dichotomy. This approach is perhaps based on the observation that relatively few people develop strong skills in both the quantitative (math, the physical sciences) and the less quantitative (social sciences, humanities) areas. One might conjecture that the typical social studies teacher falls into the non-quantitative category.

But now we are suggesting that the social studies curriculum should make increased use of computers. Computers have the appearance of a quantitative aid/device. Once again we are into the high tech/high touch issue. It is not obvious that computer technology will have a significant impact on social studies education in the next decade. Both the nature of the fields to be studied and the nature of the aids to learning (teachers, books, established curriculum) would seem to resist rapid change.

Summing Up

A few pioneering projects have experimented in training secondary school students to use CBIS (Carver and Ounanian, 1984; Wozny, 1982). The Carver and Ounanian study involved 34 college-bound high school students. They successfully learned to use an online bibliographic retrieval system and to formulate their own search strategies. The Wozny study involved ninth grade honors students. They received training in use of both online and conventional (non-computerized) information retrieval systems. The students were successful in learning to use a variety of databases and other sources of information. These studies suggest that secondary school students can learn to make effective use of online retrieval systems.

Ann Lathrop (1988) surveyed librarians at a number of secondary schools where online searching was being done. Her research suggests that it is feasible to provide online facilities in the secondary schools and that they would make a useful contribution to education. We appear to just be beginning a period of rapid growth in the availability of such services in secondary schools.

The remainder of this section discusses changes that have occurred and are continuing to occur in our society due to Computer-Based Information Systems. These changes represent part of the core of the information age. They form the major justification for computer education leaders to place heavy emphasis on the use of CBIS.

The initial impact of CBIS has been strongest in business and industry. It is now difficult to imagine how our airlines could function without the computerized passenger reservation system. These databanks allow ticket agencies throughout the world to know the status of available seats on scheduled airlines up to a year in advance. CBIS has made it possible for volume of stock trading on the New York stock exchange to go up by a factor of more than thirty over the past thirty years. Very sophisticated computer information systems are used to make stock information available throughout the country. Other huge database systems include state and national law enforcement databases, credit bureau files, insurance company files, medical information systems, chemistry information, and so on. In many states the largest online computer systems are the state lottery systems.

Starting more than twenty years ago, many companies and academic disciplines began to build bibliographic information retrieval systems. The ERIC system, which contains bibliographic educational information, is typical. Initially such systems were designed to meet the needs of high-level researchers, and they were both difficult and expensive to use. But the number and size of these information systems has grown rapidly. At the same time, they are becoming easier to use and less expensive to use. Now "ordinary" college students often make use of such systems. The breakthrough being provided by laser videodiscs and other new technology will rapidly bring access to such databases into secondary schools. In turn, school staff will have to train students in the skills needed to use such systems. Students will routinely use these skills if they are appropriately trained and the information systems are available.

Computer-based information systems are now being installed in some public libraries. For example, the Library of Congress has replaced its card catalogue by an online index system, and the city of Houston, Texas has installed such a system. Many patrons of city libraries experience difficulty in using online catalogues. It takes considerable training and experience to develop a reasonable level of skill in using such systems.

Computer-base information systems are also slowly creeping into the home. A number of companies are experimenting with various combinations of broadcast television, cable television, and telephone to provide access to information. Some regional telephone companies are experimenting with "computerized yellow pages" and complete replacement of the telephone directory. A recent ad in a national newspaper tells readers how to subscribe to a computer service offering access to all seven million entries found in the yellow pages of telephone directories in this country.

The triple combination of CBIS expansion and use—at work, in school, at home—provides strong support for having students receive specific instruction and practice in using CBIS. For secondary school students, the interaction between "at school" and "at home" use of computers is particularly important. There are substantially more computers in homes than there are in schools.

The next two years will likely see continued rapid growth in the availability and use of Computer-Based Information Systems. The same time span should also see a doubling in the number of computer work stations available in our precollege educational system. This will bring average computer availability in secondary schools to the level of about one work station per classroom plus a computer lab or two for use by whole classes. CBIS can function quite well in an environment with a limited number of computers, and we can expect most secondary schools will provide CBIS as reasonable collections of information become available on compact disks.

The next few years will also likely see rapid increases in the availability of CBIS to the general public. The technology seems poised for a major breakthrough in this area. Thus, by 3-5 years from now it is evident that there will be greatly increased access to computers for CBIS and other applications. Likely the increased access to appropriate computer systems will be accompanied by increased awareness of the value of having all students learn to make effective use of such systems. School systems will be called upon to meet this challenge.

A second major consideration should be the interdisciplinary aspects of CBIS and use of computers to process information. General ideas of CBIS can be taught in any specific course, and the social studies courses provide a natural place for initial instruction. But each discipline has its own information collection, organized in a manner specific to the discipline. Effective access to these databanks requires specific knowledge of the discipline as well as substantial practice.

Within each discipline there are problems that can be solved by computer. Eventually each discipline will include the study of which of its problems can be solved by computer and how to use a computer for this purpose. Mathematics provides a good example. One goal in mathematics education is to help students learn to solve certain categories of problems. Most of the general categories of problems studied at the precollege level can be solved by computer. That is, many problems can be solved by use of CBIS to retrieve a program designed to solve the problem, and then providing the necessary detailed description of the problem to the computer program. Thus, there will be increasing pressure on our school system to provide students access to these types of computer software and to incorporate such computer use into the mathematics curriculum. However, the effects of information upon individuals and society will remain the province of the social studies.

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Session 14: Stress and Burnout

Goals

1. Learn to recognize stress and stressors in yourself and others.
2. Learn to more effectively deal with stress and stressors in yourself and others.
3. To discuss stress as being part of functioning in a computer education leadership position.

Stress Reduction Exercises

This session is on stress (the reaction of the body to stressful situations). Being an educator is stressful. Being a computer leader or computer coordinator is stressful. Indeed, life is stressful. In this session we will learn a little about stress and what you can do about it. We will examine the issue of burnout (job-related stress that becomes overwhelming), and things you can do to help prevent burnout.

We begin with a progressive relaxation exercise designed to combat stress. It can be done almost anywhere and any time, and it takes only a few minutes. A good reference is a book by Dr. Edmond Jacobson called Progressive Relaxation. It contains a large number of relaxation exercises.

PROGRESSIVE RELAXATION EXERCISE: (Five to fifteen minutes). The idea is to work through various muscle groups with about seven seconds of tension and twenty seconds of relaxation for each muscle group. Begin with the muscles of your left foot. Tighten all of the muscles of your left foot. Hold them tight for a slow count of seven (about seven seconds). Then relax your left foot for a slow count of twenty. Next do the same thing for the calf muscles of your left leg, and then the thigh muscles of your left leg, etc. Then work up your right foot and leg. Then start with a hand (a fist) and work up your left arm, and then right arm. Then do it for your head. In each case, work from the ends of your limbs towards your trunk. Continue until you have worked through the major muscle groups of your body.

Depending on how finely you divide up your muscle groups, this progressive relaxation exercise may take fifteen minutes or more. If you don't have that much time, you can do a very quick version of the exercise. You could do all of the muscles in a limb at one time. Or, you could apply it to all of your muscles at one time. That is, tighten everything! Hold everything as tight as possible for a slow count of seven. Then relax everything for a slow count of twenty. The whole exercise takes only about a half minute. For many people it is quite effective.

The mind is a wonderful thing. Your mind can remember and/or create sights, sounds, kinesthetic feelings, smells and tastes. The purpose of the next exercise, a guided fantasy, is to experience your mind creating a safe, relaxing, stress-reducing place. Since this mind-place is your own creation, you can recreate it and visit it in the future when you feel the need to do so.

SAFE PLACE FANTASY TRIP: (Ten minutes). The following guided fantasy is presented in a slow, calm, soothing voice with relatively long pauses between paragraphs.

> Get yourself seated in a comfortable fashion and so that you will not fall out of the chair if you relax. Begin to prepare yourself to relax. We will start with the six breaths exercise.

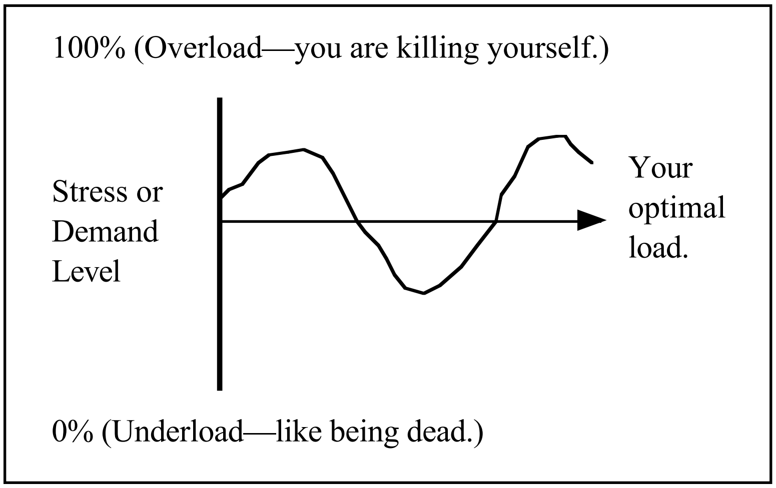
> Take a very deep breath ... hold it ... hold it ... and slowly exhale ... Now take a very deep breath ... hold it ... hold it ... and slowly exhale. Next take a medium deep breath ... hold it ... and slowly exhale. Repeat the medium deep breath. Now take a normal breath and exhale in a normal fashion. Repeat the normal breath.
>
> As you continue to breath fully and comfortable, you may be aware of your hands touching each other or resting on your lap. You may sense the presence of others in the room, and you may hear their breathing. If you haven't already done so you may want to close your eyes. (Note: Some participants may not want to close their eyes. That is okay. Give your instructions in a manner that allows all participants to succeed in following them.)
>
> Now I want you to imagine that you are going to go to your favorite place ... a place where you can be comfortable and relaxed. Decide where you will go. See yourself making the necessary preparations.
>
> Now you are on the way. Perhaps it is a very short trip, such as to a favorite room in your house. Perhaps you are traveling to the mountains, to a mountain cabin and lake. Perhaps you are traveling to the ocean, to a beach house.
>
> You have arrived at your favorite place. Look around you, taking in the sights. Hear the sounds. Smell the air. Be there. Enjoy. Notice that you are relaxed, alert, and secure.
>
> What do you do at your favorite place? See yourself performing these activities. Hear the sounds you make. Feel your body in motion. Continue to breath in a way that is comfortable to you. (A pause of a half-minute to a minute is appropriate here.)
>
> And now it is time to return from your favorite place. Say your good-byes, knowing that you can come back again and again. See yourself leaving, returning to this workshop room.
>
> Continue to breath slowly and comfortably. And now, as you are ready, be with us here in this workshop.

TRIAD GROUP ACTIVITY: (Ten minutes) What was the experience like for you? Use active listening techniques. Each person is to share experiences and reactions for about two minutes.

WHOLE GROUP DISCUSSION: (Ten minutes) The mind is indeed a wonderful thing. You can learn to use your mind to calm yourself, to relax yourself, to restore yourself to an even keel when you are stressed. Many people learn to do this through some type of meditation technique. Everybody can do it. How many of you experienced some success in at least one of the relaxation exercises above? (Show of hands.) How many of you meditate at least three times a week? (Show of hands.) If several people indicate they meditate regularly, ask one to share “why” with the group.

Stress

Consider the “stress graph” given below. Be aware that the Optimal Load represented by the horizontal axis depends on the particular individual under consideration. We don't all have the same stressors, nor do we all react the same to any particular stressor. However, stress under load and stress overload can exist for all of us. Generally we fluctuate between these extremes, staying within a safe range.



Stress is a normal part of life. Each person deals with stress and stressors in their own way. Something might be quite stressful to one person and hardly at all stressful to another. But some stressors tend to be nearly universal. Examples include death of a family member, divorce, and being fired or laid off from a job. Major stressors such as these may combine with the more "ordinary" stressors of everyday life, leading to serious physical and/or mental illness. There is increasing evidence that a high percentage of illness is due to stress. It is almost as if the body is saying "If you don't treat me better I am going to be sick--and then you will have to treat me better."

Here it would be appropriate to have a brief discussion of "western" medicine versus "eastern" medicine. In a simple sense, the former focuses on external aids (drugs, for example) to treat illnesses, while the later emphasizes the powers that are within each of us to treat our illnesses. We all have some insights into this—for example, we understand the placebo effect. The body has tremendous capabilities to monitor its performance and well being, and to take actions to improve its well-being.

TRIAD GROUP ACTIVITY: (Five minutes to write; ten minutes to debrief in triads.) Make short written lists of the following:

1. Ways you can recognize when you are being stressed. How does your body tell you that you are over stressing yourself?
2. Ways that you stress yourself.

In presenting this exercise, the workshop leader may wish to illustrate with several personal items from each list. I can recognize when I am over stressing myself because I have trouble sleeping, I forget where I have put things, I become short tempered, and I get a back ache. I stress myself by taking on more and more work and by creating situations in which I will have to work very hard to meet commitments I have made.

WHOLE GROUP DEBRIEF. Ask people to share some of their stress symptoms. Write them on the overhead projector. For each stress symptom suggested by a participant, ask for a show of hands as to how many other participants listed the same symptom. Common symptoms include head ache, neck or shoulder ache, shortness of temper, over eating, and tiredness. It is interesting to see how much alike people are.

A potential stressor in computer education is provided by the combined areas of ethics and equity. Once one becomes aware of the issue of software piracy and/or the issue of equity, one may feel some desire or obligation to "do something" about it. The awareness, combined with the feeling one ought to or must do something about it, is a stressor. For some, it can be a continuing stress. The following exercise illustrates this.

INDIVIDUAL EXERCISE: Spend a minute or so getting in to a calm, relaxed but alert state of mind, perhaps by use of the six breaths exercise illustrated earlier in this workshop. Then let come into your mind a scene of your walking in upon a pair of students in a schools' computer lab. The students are making copies of commercial software that carries a copyright notice; they are talking about their large collections of pirated software. Now sense your reactions--is this a stressful situation for you? How would you deal with the situation?

DEBRIEF: Debrief in triads or in the whole group. Note how the same stressor produces differing levels of stress for different workshop members. Perhaps some workshop participants have already experienced this stressful situation. Is it less stressful the second time?

Recently I received an ad, addressed personally to me, from a company located outside the United States. The ad contained an extensive list of IBM PC software and offered to sell them for $15 each. Some of the pieces listed retail for over $500! It was interesting to note my reactions. I became angry. I wanted to do something about it. I felt frustrated. I talked to several people about the letter, and I even asked a lawyer for advice. Clearly the whole situation was stressful to me.

Interestingly, I ran into a somewhat similar situation when I was a graduate student in mathematics. I became aware that some of my fellow students had copies of books that appeared to be printed on very thin paper and had strange bindings. It turned out that copies of many of the very expensive textbooks and reference books could be purchased from a source outside the United States, at perhaps 25% of the regular price. I wasn't particularly bothered by this at the time.

The above examples indicate clearly that stress is in the mind/body of the person being stressed, rather than in the stressor. A stressor might affect one person quite strongly, and another person not at all.

Some General or Common Sources of Stress

If one likes, there are a variety of places one can look for stressors—some categories into which one can place them. Five general areas/categories are:

1. Body and mind limitations (handicaps, illnesses, limited or blocked capacities).
2. Personal relationships (with colleagues, with boss, with spouse or lover, with one's children or in-laws, etc.).
3. Risks and responsibilities (at home, at work, at play).
4. Fulfillment, values and spiritual life (self image, sense of purpose, sense of belonging, ethical and equity concerns).
5. Environmental settings (at home, work or play; air pollution, noise pollution).

INDIVIDUAL ACTIVITY: (Five minutes) Look through the above list. Make some notes to yourself about your stressors. List your most common stressors, and place them into the five general categories. See if you can detect any patterns. Do some of your stressors not fit any category?

Although no particular stressor is equally perceived by all people, there are some potential stressors that affect large numbers of people. I am going to name six potential stressors. Many people "learn" or "acquire" these stressors when they are relatively young. See if any of them are stressors for you.

1a. Be strong. (Don't show how you actually feel. Don't ask for help. Don't accept help. Don't cry—be brave.)

1b. Be weak. (Let your feelings hang out all the time. Be helpless. Be physically weak.)

2. Hurry up. (Work faster. Play faster. There isn't enough time. Don't be late.)

3. Please others. (You must always try to please other people. Real pleasure only comes when you are doing things to make other people happy. "You make mommy and daddy so happy when you ...")

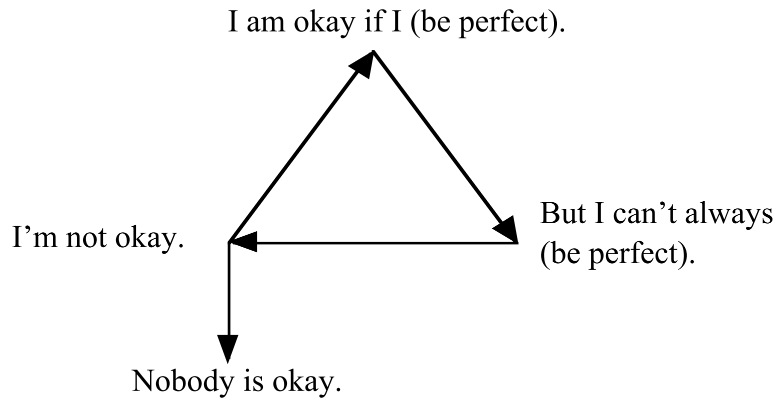
4. Try hard(er). (No matter how hard you try, you can still try harder. It is the process of trying—not the process of succeeding—that is important.)

5. Be perfect. (Do it better. You can do better than you are doing. No matter how well you do something, you could have done better.)

These are called "drivers." They tend to drive people—to control their lives. In that sense they are stressors. "No matter how well I do, a voice inside me says to try harder, hurry up, and do it better." A person with strong drivers has fewer options, less opportunity to assess a given situation and make a decision based upon that particular situation. At a subconscious level, decisions are often made following these drivers.

By a show of hands, see how many people acknowledge at least three of the drivers as especially relevant to their everyday lives. The "be strong" and "be weak" drivers are often male-related/female-related in our society. The "be perfect" driver is often associated with quite intelligent, high achieving people. Hurry up—there is not enough time—is common with computer coordinators.

One way to understand the drivers is via the triangle given below. One starts at the top with the stance "I am only okay if I (driver)." One moves down the right side of the triangle to the realization that "But I can't always (driver)." This causes one to move along the bottom of the triangle, to the "I'm not okay." position. From there one of two things typically happens. Either one moves into the "Not only am I not okay, but nobody else is okay either." position, or one jumps back to the top of the triangle to begin the whole process over again. This can quickly become a manic/depressive situation.



Triangle illustrating effect of having a strong drive.

If one or more of these drivers are helping to stress you, be aware that for each driver there is an "allower." It is all right for a person to "be weak" by showing emotions and being compassionate. These are important aspects of being human. There is enough time—there is all of the time in the world. Etc. Each person can determine their own allowers, but sometimes help from a professional therapist is needed. As an example, consider the "be perfect" driver. Some people handle this by noting that only God is perfect. Others use "logic" to decide that it is impossible to be perfect.

INDIVIDUAL EXERCISE: Take some time now to write down an allower (for yourself) for each of the above drivers that is stressful in your life. Note that identifying such allowers is a useful step in decreasing the stress of the drivers. But actually believing and making use of the allowers is not easy. Professional psychotherapy help may be necessary. Many of one's drivers are deeply rooted in early childhood and are highly resistant to change.

Stress in Others

One important reason for people in leadership positions to know about stressors and stress is to improve their ability to work with others. You can learn to detect when a person working with or under you is particularly stressed. You can learn to recognize when what you are doing adds to the stress.

INDIVIDUAL ACTIVITY: Pick a person you know well. For this person make two short lists.

1. How you can recognize when that person is over stressed.
2. Things that tend to stress that person.

Discuss your observations in your triad. Note that leaders need to recognize stress in the people they lead and avoid over stressing these people.

Some people are very good at recognizing stress in others and in effectively helping the person who is stressed. Oftentimes a few kind words, or a close/intimate conversation, can help.

Burnout

Computer education leaders face the possibility of burnout. Burnout is a situation where the general stress of the job gradually overcomes one's ability to cope. The job becomes an overwhelming stressor. Eventually one falls apart and/or in some manner must take drastic action. Drastic action may be quitting teaching, substantial withdrawal or cutting back in what one is doing, or becoming seriously ill. Sometimes such stress leads to the inability to function well on the job—no matter how hard one tries, one does poorly.

A computer coordinator is particularly susceptible to burnout. It is a subtle thing. As one functions as a computer coordinator, one receives positive strokes. People acknowledge your knowledge, compliment you on your good work, and thank you for answering their questions. They then offer you still additional opportunities to do even more work and to gain even more strokes. You get the opportunity to keep the computer lab open extra hours each day, run a computer club, do an inservice, or have a parents' night. You get the chance to prepare and teach new courses, serve on district committees, develop school and district computer education plans, select and purchase hardware and software, etc. You must do all of these things without release time or extra pay, however. Needless to say, burnout is a distinct possibility.

There are obvious solutions to the type of job-related stress that can lead to burnout. The very best one is to learn to say "NO!" You, all by yourself, cannot solve all of the problems of the computer education world. You have no obligation to the world to say "yes" every time someone asks you to do something that requires you to do more work. Indeed, you have an obligation to say "NO!" in a manner that will avoid burnout for you and will allow you to continue to function successfully as a computer education leader.

INDIVIDUAL EXERCISE: Reflect on your work life and work style. Have you ever come close to burnout? When was the last time you said "yes" when you would rather have said "NO!" to a request to do more work?

WHOLE GROUP ACTIVITY: How many of you have seen symptoms of burnout in yourself or in others? (Show of hands.) Share what you have learned in this area through your previous experiences.

In conclusion, learn to recognize stress in yourself. Learn some immediate actions to take such as the six breaths exercise, progressive relaxation, and fantasy trip to a safe spot. Learn other things to do, such as exercising, taking time for a relaxed cup of (decaffeinated) coffee or tea, or conversation with a friend. Give careful consideration to restructuring your lifestyle so that it is less stressful. Learn to treat yourself better—you are important!

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Session 15: Keeping Up, Final Questions, Closure

Goals

1. To encourage you to have and to follow a plan for personal growth.
2. To answer questions that may have occurred earlier in the workshop and not yet been answered.
3. To bring closure to the workshop.

What and How Much Do You Read?

To get started, ask if anybody has read an interesting computer-related book lately. For example, has anybody read The Fifth Generation by Edward Feigenbaum and Pamela McCorduck, The Third Wave by Alvin Toffler, Megatrends by John Naisbitt, or The Soul of a New Machine by Tracy Kidder? Have people share some of their reading experiences. Be aware that some people read considerably more than others, and that some people use their reading time to read materials that are relevant to their professional careers while others read "escape" literature.

WHOLE GROUP EXERCISE: By a show of hands, see how many people have read one or more "professionally-oriented" books in the past three months. All of the above books are acceptable examples. Then have people share examples of books that they have found to be particularly relevant to their careers as computer education leaders.

My personal recommendation is Frames of Mind: The Theory of Multiple Intelligences by Howard Gardner. It is published by Basic Books and is now available in paperback for $11.95. A number of ideas from that book have been discussed earlier in this workshop.

The general idea we are addressing by this initial exercise is how much time and effort one puts into professional keeping up and growth. Reading professionally-oriented books is an excellent way to gain information relevant to one's career as a professional educator.

WHOLE GROUP EXERCISE: (Five minutes) Make a list of the periodicals that you read regularly. Include newspapers, magazines, journals, etc. Use your own definition as to the meaning of "read regularly." By a show of hands, see how many people fall into categories 1-3, 4-6, 7-9, 10-12, or more periodicals read regularly. Now think about the total amount of time per week you spend reading/studying academic-oriented materials (books, journals, magazines, term papers) which may contribute to your overall expertise as a professional educator. By a show of hands, group people into 1-3 hours, 4-6 hours, etc.

One of the computer coordinators I interviewed for The Computer Coordinator book reads 25 periodicals regularly, and skims the table of contents of another 25! The bulk of computer coordinators at the school district level fall into the 10-12 and 13-15 categories. How do you compare to this? If you fall much below the middle, perhaps you are in the wrong field! A computer education leader must remain current. Periodicals provide one of the best sources of current information.

Some people have job settings that help make extensive reading more possible. A university professor in a research-oriented university may be in front of classes only 6-8 hours per week, or less. A teacher in a non-research college may have a teaching load of 12-14 hours per week. The teaching load in a community college may be up to 16 hours per week. But a precollege teacher is with students far more hours per week. It is easy to see why many teachers feel that they cannot keep up with their professional reading.

Part of “keeping up” is to have a systematic plan for reading, studying, taking courses, and carrying on high level intellectual discussions with one's colleagues. One makes a decision that reading and /or skimming a particular set of periodicals is essential. Time for this is budgeted, just as is time to prepare for teaching one's class, etc.

TRIAD GROUP EXERCISE: (Ten minutes) Discuss with the members of your group the types of periodicals you read that help you remain professionally competent and add to your professional competence. Make a recommendation to the members of your triad.

WHOLE GROUP DISCUSSION AND COMMENTS: Most computer educators at the precollege level do not have a strong formal education in the computer field. Thus, they must work to build a background suited to their position and at the same time work to keep up. This is a double burden. Many computer educators are not even aware of some of the more useful periodicals.

I have found the Business Week magazine to be very useful. Each issue contains several articles on technology. It presents them from a business oriented, rather practical point of view. I highly recommend this magazine for computer education leaders. More generally, I recommend that computer education leaders gain a good understanding of business and industry. These are the driving forces behind the computer field.

Half-Life of an Education

People sometimes talk about the half-life of one's education. This is an idea discussed in The Computerized Society, a 1970 “computer literacy” text by James Martin and Adrian Norman. (Note that in 1970 the phrase computer literacy had not yet been coined. However, a number of computer literacy texts were already on the market.) The idea of the half-life of an education is interesting, even if the concept is not well defined. Roughly speaking, the idea is to assume that one is educated to the level of being fully competent in a discipline, and then ceases to learn any new material. How long will it be before one has only half of the knowledge needed to be fully competent?

Medicine is a rapidly changing field, and it could well be that the half-life for a medical education is five years or less. The half-life of an education to be a sixteenth century French literature specialist may be 40 years. The sixteenth century itself is no longer changing, and relatively few people are making contributions to the French literature of that period.

In discussing the half-life of an education, Martin and Norman do not include a “forgetting” factor. Most people find that unless they use a particular skill or collection of knowledge, they gradually forget how to do so. This is particularly true of the types of material one studies in more advanced courses in college and graduate school. The combination of half-life and forgetting factor suggests that most people need to work quite hard to maintain their professional competence—especially if they are in a high-tech, rapidly changing field.

We all know educators who have “died on the vine"—that is, who have not kept up and are no longer adequately academically productive and proficient. It is easy to be critical of such people. But it is important to ask yourself “How do I know that this won't happen to me?"

WHOLE GROUP EXERCISE: What do you think is the half-life of your current level of computer education knowledge? By a show of hands, have people vote for 3 years or less, 4-6 years, 7-9 years, longer.

Typical results in this type of vote are that about half of the group vote for three years or less, while most of the rest vote for 4-6 years. Note how stressful it is to lay such a “trip” upon oneself. People voting for the 1-3 year category are essentially suggesting they need to double their current computer education knowledge in the next 1-3 years in order to keep up. Presumably they expect to do this while simultaneously working more than full time in a computer coordinator or other computer education leadership position. Needless to say, this is stressful!

WHOLE GROUP EXERCISE: What do you think is the half-life of a solid and modern master's degree in computer education? By show of hands have people vote for under 3 years, 4-6 years, 7-9 years, etc.

When I do the above two exercises in workshops, I always get a longer half-life estimate for the second situation. The workshop participants feel that having a solid background would make it easier to keep up.

The idea of a half-life of a formal education and the difficulties of remaining professionally competent are very interesting. For most professionals, the question is addressed from a framework of an initial professional level of training. If one begins with a solid foundation (such as a master's degree in computer science education) this formal education may last for many years. Only some rapidly changing details need to be periodically filled in to keep up to date.

For example, suppose that one has learned to program quite well in BASIC, Logo, and Pascal. Then when a new language comes along, such as LogoWriter or Modula-2, learning the new language is relatively easy. But if one has never learned to program well, then one has little chance to acquire a good working knowledge of a new programming language while still holding down a full time computer education leadership job.

Of course, the whole issue of keeping up depends somewhat upon one's own definition of keeping up. Do I need to know the details of every machine at the level of the hackers who spend hundreds or even thousands of hours on a particular machine? What constitutes a really new idea? Is the development of a new super computer, ten times as fast as the older super computers, a really new idea? Is parallel processing a really new idea? How about microcomputers—are they a really new idea? What sort of progress in artificial intelligence would be a really new idea that would be hard to learn—hard to add to my solid foundation of knowledge?

WHOLE GROUP EXERCISE: Think of something “new” that has occurred in the computer education field in the last year. That is, suppose that a computer education leader were fully competent a year ago, and then spent the last year in complete isolation. Assume the person maintained original skills and knowledge. What would the person have to learn to again be fully competent?

One point to these questions is that there are now many people who are in master's degree programs in computer science education. There eventually will be many people entering teaching who have been using computers since their elementary school or junior high school days. The discipline of computer science education will gradually mature. Today's leaders in this field will have to work very hard to maintain their leadership qualifications relative to the newcomers.

WHOLE GROUP EXERCISE: Ask how many people in the workshop are currently taking at least one formal university-level course in computer science or computer science education per year. How many are in a formal master's degree or doctorate program? Debrief in triads, with group members sharing what they consider to be particularly useful in their coursework or degree programs.

Support Groups

The concept of a support group is important. A support group means different things to different people. For a building-level computer coordinator it may be a monthly meeting of building-level computer coordinators from throughout the city. It may mean a weekly meeting of a computer club of students trained as computer aides. It may mean regular meetings with a group of parents who are computer professionals.

For a district-level computer coordinator it may be a periodic meeting of computer coordinators from one's region of the state. For almost anyone it may be a group of people who get together regularly to work on personal growth, human potential, fellowship and learning.

WHOLE GROUP EXERCISE: By a show of hands, see how many participants are involved in some sort of work-related or personal growth-related support group. If the answer is small, extend the question to "have ever been involved?" Note that along with high tech and the information age has come the personal growth movement. Lots of people have participated. Debrief in triads, with individuals sharing their experiences.

The International Council for Computers in Education has started a number of Special Interest Groups. One of the largest is for Computer Coordinators, and the expectation is that it will eventually have a number of local chapters. ICCE encourages you to join SIG Computer Coordinator, and to participate in a local chapter.

A SIG for Teachers of Educators was established in March 1985, while one for computer science teachers was chartered in February 1986. SIGLogo has existed for about a year and published the Logo Exchange nine times a year. A SIG for Telecommunications will be established during 1989.

Personal Involvement and Sharing

One of the ways I keep up in computer education is by attending meetings, giving talks, and presenting workshops. Personal contacts with computer education leaders are both stimulating and a good source of information. And, of course, I am literally surrounded by bright graduate students at the University of Oregon who are working for master's degrees and doctorates in various aspects of computers-in-education. This intellectually rich work environment helps me keep up in the computer-in-education field.

WHOLE GROUP DISCUSSION: Do you give talks at meetings? Do you write papers for your regional newsletter or for journals and magazines? Do you communicate freely and easily both orally and in writing? By a show of hands, solicit input on these topics.

The idea is to increase awareness of the levels of participation by members of the workshop. Many teachers (especially elementary teachers) are frightened at the idea of doing a presentation to a large group of educators. The great majority of educators are unwilling or unable to write for possible publication. For many it may be a psychological block.

Are you currently taking a computer education-related course? Have you taken such a course in the past year? Do you intend to take a course during the next year? What else are you doing to keep up and to improve yourself as a leader in computer education? Invite people to share ideas. Allow time for each person to jot down ideas of their personal plan for keeping up and for improving skills as a computer education leader.

My personal plan for keeping up and continued personal growth includes continued participation as a leader in growth groups (that is, in the human potential movement). Many of the ideas and exercises in this workshop came from my past involvements in the human potential movement.

Final Questions and Closure

Each workshop session should provide ample time for questions. Right here is the last chance for participants to bring their questions before the whole group.

WHOLE GROUP EXERCISE: Make a list of the most important ideas that you have gained by participating in this workshop. As you do this, make a list of key questions that you feel the workshop should have addressed, but hasn't yet addressed. (Note: If the workshop is to make use of a formal evaluation process, here is a good place to do the evaluation.)

Share your lists with members of your triad. Then, as time permits, share your most important questions with the whole workshop. Be aware that many aspects of the workshop were designed to help you learn to answer your own questions. You are a well-educated, competent, professional educator. You are quite capable of answering most of the questions you might ask.

Closing Exercise

This closing exercise is related to the Clear a Space exercise used in the initial session of the workshop. It is a communication with the participants' conscious and subconscious minds.

> And now, once again, I want you to move into a comfortable position. Begin to focus on your breathing. Be aware of your body, its contact with the floor and with the chair you are sitting on. Sense the presence of others in the room. Take pleasure in knowing these people. You have made some good friends.
>
> Continue to breath comfortably as you let your mind move once again over the workshop. Move over the workshop schedule, stopping as an important idea comes to mind. Hold on to an idea, viewing it from different directions; sense its size and power; listen once again to our discussion of the idea. And then continue to move through the workshop.
>
> As you approach the end of the workshop, be aware of the many ideas that you have encountered. Perhaps you see how some of these ideas will be useful to you. Perhaps you can hear yourself sharing these ideas with others. Perhaps you can feel yourself making use of these ideas as you return to your job.
>
> Be aware that throughout this workshop both your conscious and subconscious minds have been active. While your conscious mind has sometimes been overwhelmed by all of the new ideas, your subconscious mind has been taking them all in. In the future you will be pleasantly surprised as your subconscious mind makes some of these ideas available to your conscious mind. You have a wealth of good ideas. You know how to use them.
>
> It is now time to bring this workshop to a close. But be aware that this end is also a beginning. It is the beginning of the rest of your life. The ideas from this workshop will be with you for the rest of your life.
>
> Continue to breath comfortably. Now, as you are ready, return to this room. Go forth, and make appropriate use of your new ideas and knowledge.

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