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ABSTRACT

This document contains the following invited papers from the SITE (Society for Information Technology & Teacher Education) 2001 conference: (1) "Information and Communications Technology in Education: A Personal Perspective" (David Moursund); (2) "A Model for Creating an Art Museum-University Partnership To Develop Technology-Based Educational Resources" (Bernard Robin, Sara Wilson McKay, Beth Schneider, Sara McNeil, and Donna Odle Smith); and (3) "2001: A Cyberspace Odyssey" (Julie Springer and Phyllis Hecht). A summary of an invited panel, "Nation Technology Leadership Initiative Fellows Panel" (Lynn Bell), is also included. Most papers contain references. (MES)

Invited Papers Invited Panels (SITE 2002 Section)

INVITED PAPERS

**Information and Communications Technology in Education:
A Personal Perspective**

David Moursund
University of Oregon, USA

Abstract

Throughout my professional career I have worked, played, studied, taught, experienced, and learned about Information and Communications Technology (ICT) in Education. I have been an active participant in this field as it has slowly moved from infancy into early childhood. In this presentation, I will share some of the things that I have learned and that I think are particularly important. I will illustrate some of these things with personal stories and reflections. My goal is to help move the field of ICT in Education out of its current early childhood phase.

Introduction

My first experience in the field of Information and Communications Technology (ICT) was in the summer of 1963, shortly after I received my doctorate in mathematics. My area of specialization was numerical analysis, and this involved developing computational methods for solving various types of math problems. In the summer of 1963 (nearly 40 years ago), I helped to teach Talented and Gifted high school students who were learning about computers and computer mathematics. This remains one of my interest areas (Special and Gifted Education).

In the summer of 1965 I taught a course for secondary school teachers in a National Science foundation (NSF) summer institute, and by the summer of 1966 I was running my own NSF summer institute for teachers. All of the summer institutes and other NSF programs that I have run have focused on uses of ICT in precollege education.

My professional career has been one of learning and of sharing my learning. I have been fortunate in having job situations that supported this approach. I have held faculty appointments in Mathematics at the University of Wisconsin, in Engineering and Mathematics at Michigan State University, and in Mathematics, Computer Science, and Education at the University of Oregon. In addition, I started the professional society that eventually became the International Society for Technology in Education, and I headed that organization for 19 years (ISTE).

This document is divided into somewhat isolated pieces, but readers may find that some of the pieces tie together as they work to create meaning from the document. The organization of the document, as well as the messages I am attempting to convey, are fuzzy.

Throughout my professional career I have had an increasingly broad range of interests. These can be thought of in terms of discipline areas such as mathematics, computer science, and education. Significant chunks of my professional career have been spent in each of these three fields.

Or, my interests can be thought of in terms of more general ideas such as teaching, learning, problem solving, and research. The academic positions that I have held have all allowed me considerable time to pursue these general ideas.

In the next few sections of this document I will explore some topics that I would like to share with you. Some of the topics will be illustrated through personal stories. Over the years, I have gradually come to understand that story telling is an important aspect of teaching.

Research

You have all heard the expression, don't reinvent the wheel. This is a profound idea. There are many problems that people want to solve. Some have the characteristic that once one person solves the problem, others need only imitate what the first person did. This is sometimes called the Einstein effect. For example, perhaps it was an "Einstein," living many thousands of years ago, who invented the wheel. (See Figure 1.) Others saw how useful the wheel was, learned to make wheels, and taught still others to make and use wheels.

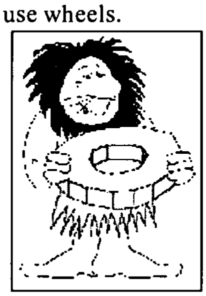

Figure 1. Invention of the wheel.

I view research as solving problems in a manner so that others can build upon the results—so that others do not have to reinvent the wheel. My initial research was in mathematics. As a mathematician I posed and solved some problems, wrote and published some papers, and achieved both promotion and tenure at the Associate Professor level. While at Michigan State University, early in my teaching career, I also did research on the various methods used to teach freshman mathematics at that University.

One of the key ideas in mathematical research is that a problem gets posed and solved. If the statement of the problem and the solution are carefully done, then that problem is solved once and for all. People have been able to depend on the correctness of the Pythagorean Theorem for more than 2,000 years.

Imagine my surprise later in my career when I eventually began to read the research literature in education and ran into the idea of a meta study. In essence, a number of studies are carried out on various versions of an education problem. A meta study analyzes the results, attempting to discern results that others can build upon. However, what one typically finds is that the problem being studied is so complex and involves so many variables that no clear-cut solution emerges. We pose such problems as "What is the best way to teach a child to read?" At the same time that we know that a combination of nature and nurture makes every learner different. Thus, education problems are not solved once and for all. Moreover, changes in technology lead to changes in possible solutions to educational problems.

Thus, my career as a researcher in mathematics and in education feels somewhat schizophrenic. My father was a research mathematician. One of his favorite statements was, "Either it is or it isn't." Fuzzy logic had not yet been invented back in those days. Fuzzy logic is now important in mathematics, engineering, and other fields. It helps to describe our research findings in education.

My career as a researcher is thoroughly intertwined with those of a large number of master's and doctorate students. In 1970, I created this country's second master's degree program in the field of computers in education. In 1971 a student asked me if the University of Oregon offered a doctorate in that field. After a brief discussion with Keith Acheson, a math education colleague in the College of Education, we decided the answer was "yes." I think it was more than ten years before the Dan of the College of Education realized that such a new program had been created and was graduating a large number of students. I have been the major professor or co-major professor of about 75 doctoral students in this field (along with five in mathematics). By and large I have been able to work with whatever area of interest the students have had. Thus, I have had the opportunity to work in a huge number of different aspects of the field of computers in education.

Computer Science

I was one of three people who worked together to create the University of Oregon's Computer and Information Science Department in 1969, and I served as chair of the department for its first six years. In those days I believed strongly in the importance of computer and information science and such topics as computer programming, artificial intelligence, computer graphics, and information retrieval. Although I didn't have any undergraduate or graduate coursework in these areas, I eventually learned enough to teach a variety of such courses.

During those years, a colleague of mine suggested that the single most important ideas that were coming out of computer science in the 20th Century were *effective procedure* and *procedural thinking.* A computer program can be thought of as being an effective procedure, even if it contains bugs and fails to solve the problem it was intended to solve. Procedural thinking is the type of thinking that one uses when developing computer programs and in making use of computer programs to solve problems.

The early master's degree and doctorate computer in education programs at the University of Oregon required a substantial amount of computer and information science coursework. There was a considerable emphasis on the ideas of effective procedure and procedural thinking. I considered that to be one of the strengths of the programs. A number of my doctoral students went on to hold positions in Computer and Information Science Department.

To a large extent, this emphasis on computer science has disappeared from both the University of Oregon programs and from computer in education programs throughout the country. We are producing ICT master's and doctorate students who tend to have very little knowledge in the field of computer and information science. This saddens me.

Science of Teaching and Learning (SoTL)

In recent years I have become quite interested in the Science of Teaching and Learning (SoTL). Branford et al. (1999) and Bruer (1993) provide excellent summaries of this field. Bruer's 1993 book contains an example that resonates with me and helps to illustrate what SoTL means.

One of my earliest memories is of my parents doing some gardening in our backyard, and my father asking me a question somewhat like "What is 9 plus 14?" I had no idea what the answer might be, or how to solve such a problem. A few minutes later, however, I happened to walk past our picket fence, and it occurred to me that I could answer the question by counting pickets. I "discovered" *counting on* as a way to solve such a problem. I was so excited that I ran to find my father to tell him my answer.

Bruer's book contains an example of research suggesting that perhaps one-third of first graders have not discovered or been taught counting on prior to entering the first grade. This is a significant barrier to learning the arithmetic in the typical first grade curriculum. The SoTL intervention was to develop a short unit about the number line and counting on that could be taught to first grade students. Less that an hour of instructional time was required to make a significant difference in the math education of many students who had not previously discovered or been taught these ideas.

This research result and educational intervention illustrates a very important idea. Think for a moment about whether each first grade teacher is able to determine which, if any, of his/her students would benefit by such an intervention and has the knowledge and skills to implement the intervention. We immediately see a major problem in our efforts to improve education. How can we "bring to scale" our educational research findings? How can we translate good research results into widespread practice?

For the most part, we are not successful in doing so. The difficulty is that teacher knowledge and skill cannot be mass produced and mass distributed. Over the years I have does lots of staff development, written books and articles on staff development, and taught both courses and workshops on staff development. It is clear to me that staff development is a critical component of improving our education system.

However, we need better ways to turn educational research into practice. ICT is a powerful aid to doing so. In addition, computers and computerized equipment are contributing significantly to progress in Brain Science. This helps explain my current interests in Brain Science, SoTL, and ICT in math education (Moursund, 2002).

Intelligence

Howard Gardner's 1983 book on Multiple Intelligences had a significant impact on my thinking about teaching and learning. Both my father and mother taught in the Mathematics Department at the University of Oregon, and my father served as head of the department for about 30 years. It is clear that my father raised me to be a mathematician. My report card from early in the first grade indicated: "Now that we have hit numeration, David really shines." It turned out that the combination of nature and nurture facilitated my getting a doctorate in mathematics and achieving some level of success as a research mathematician.

I have a reasonably high level of logical/mathematical intelligence from Howard Gardner's Multiple Intelligences point of view. However, my spatial intelligence is below average. Spatial intelligence is considered to be very important for success in mathematics. But, my other talents, supported by our formal and informal educational systems along with intrinsic and extrinsic motivation, allowed me to achieve success as a mathematician. I find this particularly interesting as our educational system continues to label children and pigeonhole them. The tests that I State of Oregon vocational tests that I took during my senior year of high school indicated that I should not seek a career in mathematics.

Of course, I heard about the idea of IQ long before I graduated from high school. But it was only when I ran into Howard Gardner's first book on Multiple Intelligences that I began to take a serious interest in this topic. The following definition appears in Moursund (1996, 2001) and is synthesized from the work of Howard Gardner, David Perkins, and Robert Sternberg.

Intelligence is a combination of the ability to:

1. learn. This includes all kinds of informal and formal learning via any combination of experience, education, and training.
2. pose problems. This includes recognizing problem situations and transforming them into more clearly defined problems.
3. solve problems. This includes solving problems, accomplishing tasks, and fashioning products. It involves creativity and higher-order thinking skills.

I find that this definition works well both in being a teacher and in being a computer-using educator. For example, ICT is a powerful aid to solving problems. Thus, part 3 of the definition allows me to argue that computers make us more intelligent. In addition, ICT contributes SoTL.

Problem Solving

In this document, I use the term problem solving in a very broad sense. Thus, it includes activities such as accomplishing a task, making a decision, answering questions, and solving a problem.

Problem solving has been a unifying theme of my professional work (Moursund, 1970). In my teaching and writing I make frequent use of the diagram of Figure 2.

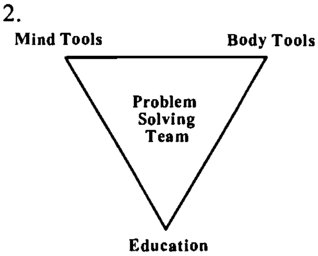

Figure 2. Aids to problem solving.

The central focus in Figure 2 is a 1-person or a multi-person team that wants to solve a problem. This team is assisted by Mind Tools, Body Tools, and the formal and informal education of the team members. This education includes learning to make effective use of the Mind and Body Tools as well as the (human) members of the team. Thus, we have a clear representation of three areas for focus in improving the capabilities of a Problem Solving Team.

ICT provides us with improved Mind Tools, Body Tools, and Education. Moreover, ICT is an aid to integrating these three aspects of problem solving. For example, a Mind Tool or a Body Tool can contain Intelligent Computer-Assisted Learning (ICAL) that "just in time" can help members of the Problem Solving Team learn to use the tools. If the ICAL is sufficiently intelligent, the instruction can take into consideration the specific problem to be solved. We see this in contextual help being built into software applications.

One of the key ideas in problem solving is building on the previous work of others and the previous work of oneself. Throughout my professional career I have studied, written, and taught about problem solving. One of the points that I stress is that ICT provides a new way to build upon previous work. Some types of previous work can be stored in a "The ICT system can do it for you." form. ICT has allowed us to accumulate a huge number of computerized procedures and automated machines that can automatically solve certain types of problems.

Our educational system is severely challenged by the pace of progress in these aspects of ICT. Much of our formal education still focuses on having people learn to do things that ICT systems can do much better than people. Some of this teaching and learning effort should be moved into domains in which people far outperform computers. I often use Figure 3 in discussing this idea in my teaching and writing.

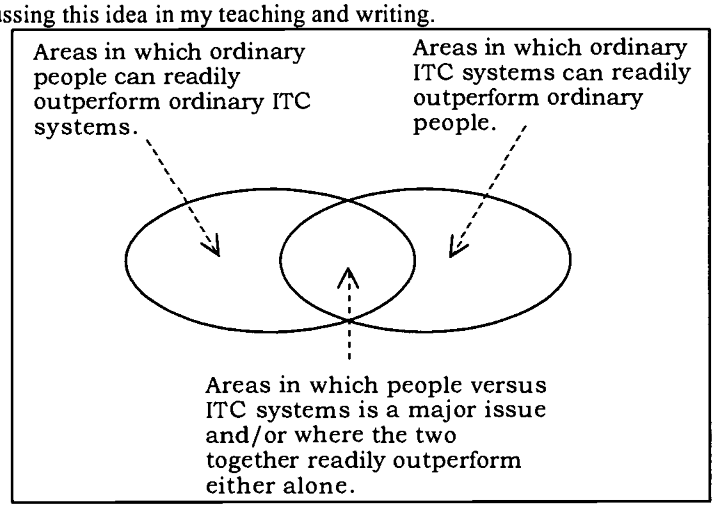

Figure 3. ICT versus people in solving problems.

I am particularly interested in identifying teaching/learning situations in which an ITC system can readily outperform a teacher. A simple example is the contextual help that is built into a computer application. A teacher with a classroom of students—each using different components of a computer application and/or different applications—cannot compete with this steadily improving computer capability.

I will close this section with a story from my graduate school days. I was taking a course in Complex Variable, and we were using a text written by the course instructor. However, the professor kept giving us really hard homework problems that were not in his book. Finally, a student got up the courage to ask where these problems were coming from. The answer was that these were research problems from papers published about 30 years earlier.

A little thinking about this helped me decide to do my dissertation work in Numerical Analysis. The recent advent of computers made it possible to pose and address new problems. At the same time, it made it possible to solve old problems in new ways. In some sense, I could skip over much of what had been done in the past, moving directly to the frontiers.

This idea, of course, applies to all areas of human intellectual endeavor in which an ICT system is a powerful aid to representing and solving problems. It helps explain why many young people—often without advanced college degrees—have been so successful in the ICT field. They used their brainpower and the new tools to solve new problems, rather than spending so much time and effort learning to solve problems that had already been solved. Readers of this document may want to do some introspection about their own lines of scholarly activity!

Cost/Benefit Analysis

Figure 4 portrays the balance between some of the obvious costs and benefits of making use of ICT in one's professional and non-professional activities.

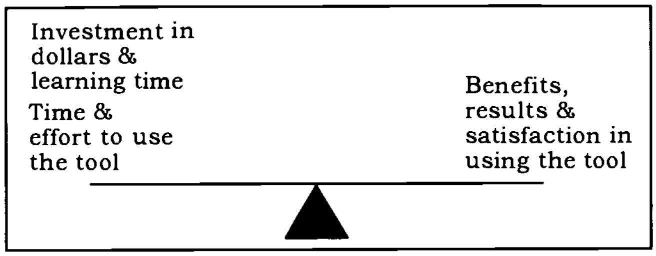

Figure 4. Cost/benefit balance.

At a conscious or subconscious level people make decisions all of the time about how to use their personal resources such as money and time. This simple diagram helps explain why many teachers are not making significant use of ICT in their classrooms and in their other professional work. They face a severe shortage of time. Their perceptions of potential benefits to themselves and their students are not sufficient to tip the scale to the right.

I can think of numerous personal examples in which I have made conscious or subconscious decisions that might be analyzed from a cost/benefit point of view. For example, I know that I am relatively inept in dealing with computer hardware and software problems. The time and effort to gain the needed knowledge and skills is not forthcoming. Fortunately for me, my wife is highly skilled in this aspect of ICT.

Thinking along these lines led me to write about Compelling Applications (Moursund, October 2000) of ICT in education. These are applications that are so intrinsically motivating and intrinsically valuable to a teacher (or to someone else faced by the cost/benefit decision) that the scale is heavily tipped to the right. Most teachers are not finding many Compelling Applications.

Learning and Learning Theories

I have no recollection of every having heard about transfer of learning or about any learning theory other than behaviorism during my K-20 education and early years as a university faculty member. In retrospect, this makes a strong statement about our education system. What do we know about learning and learning to learn? Why don't we place more emphasis on this topic in each course that students take? I would think that a math teacher would know quite a bit about how to learn mathematics and would share this knowledge with his/her students. But, I don't recall ever receiving any explicit instruction in this area.

I recall being rather impressed when I first learned about Near Transfer and Far Transfer. But, this "theory" doesn't seem to be very useful in teaching and learning. I was far more impressed when one of my doctoral students worked on Low Road and High Road transfer. This theory seems relevant to teaching and learning. It helps explain why rote memory approaches to education don't work very well, and why teaching a computer application such as a word processor at a keystroke level is not a good approach to facilitating learning that transfers.

In more recent years, one of my doctoral students did his dissertation on cognitive learning theories. I have learned that Constructivism and Situated Learning are all quite important in the field of ICT in education, and that there are many other learning theories (Cognitive Science: Online).

Figure 5 is a model of how a typical person learns to use a Mind Tool or a Body Tool. It is a "learn by doing" model. This model is supported by Constructivism and by Situated Learning. Our formal educational system does only a modest job of following this model. People learning ICT on their own or on the job typically follow this model.

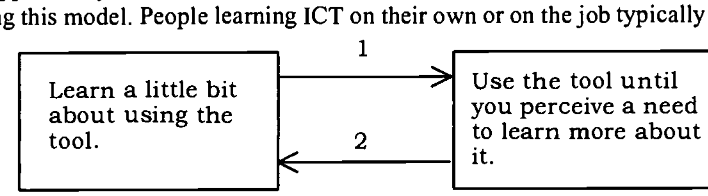

Figure 5. Learning to use a Mind or Body Tool.

The teaching/learning model in Figure 5 is highly dependent on the individual learner obtaining feedback on when more learning may be needed. This feedback may come from self, peers, teachers, the tools being used, and so on. As more instructional intelligence is built into ICT systems, more feedback—as well as more contextual, just in time instruction—will occur. In ICT, aids to learning include peers, teachers, oneself, ICT systems, books, reference manuals, and so on. Learning from one's colleagues and fellow students is quite common.

Intelligent Computer-Assisted Learning

When I first encountered the Computer-Assisted Learning (CAL) work being done by Pat Suppes in the 1960s, I couldn't help but laugh. Very expensive computer systems were being used to teach students to do paper and pencil arithmetic. The computer system "knew" how to solve the problems that it was helping students learn to solve. Moreover, even in those days the computer was thousands as times as fast as students, as well as more accurate, at doing arithmetic. Handheld calculators were beginning to be reasonably priced.

However, over the years my attitudes about and approach to CAL have changed. Here are a few reasons for my changing attitude:

- Research on individual tutoring, small class size, and individual education plan (IEP) points to potential changes that could greatly improve the effectiveness of our educational system.
- Studies, metastudies, and a metameta study on CAL suggest that in a wide variety of settings, even CAI of modest quality can produce better learning gains than typical whole class instruction.
- Microworlds, computer simulations, and virtual realities have moved CAI well beyond the behaviorist drill and practice approach to learning.
- Significant progress is occurring in Intelligent CAL (ICAL). This entails increased machine understanding both of the materials to be learned and of the learner. We are beginning to see a significant number of examples of ICAI systems that can out perform a classroom teacher working in a whole class setting. Indeed, some can out perform an individual tutor. See, for example, Fast ForWord's use with sever speech delayed children and with people receiving cochlear implants (Scientific Learning Corporation).
- The cost effectiveness of CAL and ICAL continues to improve both because of research and because of continued rapid decreases in the cost of computation and telecommunication.

During all of the years since first encountering the work of Pat Suppes, I have held onto my amusement about using a computer to teach a person to compete with a computer. In many cases it makes far more sense for a person to learn to use the ICT tools, and then for the person and ICT tools to work together (see Figure 3).

Here is an example of what I mean. Handheld ICT systems (including cell phones, calculators, palmtop computers, etc.) are now small enough, cheap enough, rugged enough, and useful enough so that many people find them and their applications to be compelling. Such devices have had a significant impact on the world. And, of course, the ICT systems need not be handheld. Wearable ICT systems and implanted systems are alternatives. But, they have had minimal impact on education (Center for Highly Interactive Computing).

Distance Education

Over the past two years I have served on the Oregon Department of Education's K-12 and K-20 Distance Education Committees. In addition, I currently have a student doing her dissertation on Distance Education. My experience in this field goes back about 50 years. My parents ran the math education correspondence courses for the University of Oregon. I began grading correspondence course lessons about the time I finished the ninth grade. In more recent years I created some Distance Education courses for the International society for Technology in Education and made use of them in the UO master's and doctorate programs.

Last year it occurred to me that all education is distance education and all learning takes part in a person's head. From a teaching point of view, the issue is how distant the education is, and how interactive it is. A hardcopy library may be both distant and is not very interactive. A large lecture course is rather distant and not very interactive. A small seminar is better than a large lecture both because of the smallness and because it allows a high level of interactivity. A contextual help feature in a computer application is not very distant and may be highly interactive. (Note that much of the interaction may be trial and error on the part of the learner, with feedback coming from the machine and the learner.)

We all agree that one of the goals of education is to help students to gain expertise in being an independent, self sufficient, intrinsically motivated, lifelong learner. This was true well before ICT came on the scene. But, ICT adds Some new dimensions. I see this in my own life. For all practical purposes, I cannot read email without also being on the Web. Many of the messages I receive lead me to looking up stuff on the Web so that I will have a better understanding of the messages received and of the responses I want to send.

Moreover, I find the build in dictionary and thesaurus in my word processor to be excellent examples of Distance Education. They provide me with just in time instruction.

The point I am trying to make is that that most people nowadays think of Distance Education in terms of entire course being delivered over the Internet, over a two-way video network, over TV, or via video tapes and disks. But, the size of the desired unit of instruction is often much smaller than a course—it might well be instruction on the definition or spelling of a word. ICT can help move our educational system toward Distance Education being an integral, every minute component of teaching and learning. As we move our education system in this direction, we can place significantly increased emphasis on the learner becoming increasingly responsible for their own learning.

Computational Science, Social Science, Etc.

I first encountered Computer Algebra Systems while I was still in graduate school. In the 1960s and 1970s quite a bit of work occurred on developing artificially intelligent computer systems that could solve a huge range of math problems. In essence, discipline-specific knowledge and skills is built into the ICT system.

In the 1980s and continuing to the present such work has blossomed. For example, the 1998 Nobel Prize in Chemistry went to a pair of Computational Chemists for work they had done during the previous 15 years or so.

The change in the sciences is clear-cut. We now have Computational Biology, Computational Chemistry, Computational Mathematics, Computational Physics, and so on. Scientists now tend to be classified as experimental, theoretical, and computational. In all fields of science, Computational Scientists are helping to push the frontiers.

But, this pheromone is not limited to research in the sciences. We have seen major changes in the Mechanical Drawing and Graphic Arts curriculum due to ICT. We have also seen major changes in certain parts of the business curriculum. We have seen scientific and graphing calculators become commonplace in math and science courses. Indeed, students are now allowed to use calculators on some state and national tests.

Still, we have a very long way to go. Take a look at Figure 6. I use this figure in discussing educating in a variety of disciplines. For example, our current K-12 math curriculum appears to place about 75% of its time and effort on students learning to do Step 2. This is, of course, the step that ICT systems do best. If we merely cut this component of math education to 50% of the curriculum, that would allow a doubling of the time spent on problem posing, problem representation, mathematical modeling, meaning making, interpreting the results, and other higher-order processes in math education.

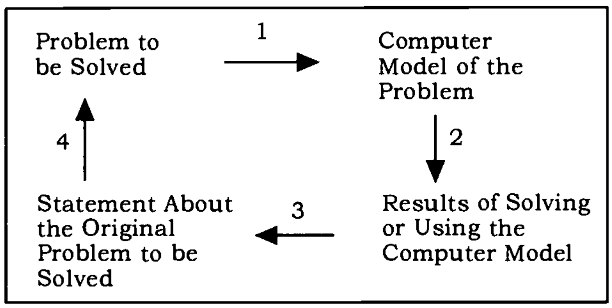

Figure 6. Using Computer Model /Simulation to solve a problem.

I like to think about "profound" issues such as allowing students to use a full range of ICT facilities when learning, doing seatwork and homework, and taking tests. Of course, this topic has been addressed in a variety of science fiction stories that I have read. Indeed, I have found that science fiction has provided me with many interesting ideas. Recently I read Kingsbury (2001), a novel that extends ideas from Isaac Asimov's "Foundations" books, and includes a major focus on people having external computers wired into their brains. I have begun to think of some of my Websites as being parts of my auxiliary brain.

Closely related to this is my contention that each researcher should be developing a Website in which they share their steadily growing expertise with the world. I think of this as an expanded or extended Professional Vita designed to help oneself and others.

Project-Based Learning and Other Books

Earlier I have indicated that "Don't reinvent the wheel." Is one of the most important ideas in problem solving. At the same time I have suggested that in certain cases one might skip over or touch upon quite lightly what is already known in a field. These two ideas seem somewhat contradictory. But, they shed some light on one of the major activities of my professional career.

I write books. This began with my initial teaching at Michigan State University when I repeatedly taught an introductory numerical analysis course for juniors in Engineering. I did not find a book that reflected my newly-learned ideas in this field—ideas that assumed that students would have good access to powerful computers and would learn how to write programs in FORTRAN. So, I enlisted the help of two of my colleagues and we wrote an introductory numerical analysis book (Moursund and Duris, 1967).

Since then I have written a lot of books, some individually and some with coauthors. In most cases what I did was to write a book for a course I was teaching. I would find that the existing books did not adequately reflect my thinking about and approach to the course. I would prepare extensive handout materials during the course, polish them into a draft book, use it the next time I taught the course, and eventually end up with a publishable book.

Perhaps the key to all of this was my feeling that I was "ahead of the curve." That is, I felt that my ICT knowledge and skills in education were at the frontiers. Thus, I believed that whatever I taught should be put into book form, published, and shared with others.

An Example: ICT-Assisted Project-Based Learning

Project-Based Learning (PBL) has a long history, going back to Dewey and earlier. Research supports this as an effective mode of instruction. I can still recall some of the projects that I did in high school.

But, ICT brings some new dimensions to PBL. Thus, it seems "a natural" that in recent years I have written a book in this area, developed courses and workshops in this area, and had supervised a doctoral dissertation in this area.

One of my key thrusts in ICT-Assisted PBL came from a professor in Architecture who was an outside member for a student of mine who did a dissertation on problem solving. At the dissertation defense the Architecture professor asked if I understood the principle of AND. I hemmed and hawed, trying to think about what A. N. D. might stand for that was related to problem solving. Finally the professor explained that Architects solve many problems simultaneously, and often added new problems as they proceeded in solving a problem. For example, designing a fountain for the City of Springfield included addressing the idea that the name of the town came from the fact that there were springs in a nearby field. AND, this region was a center of logging, so the fountain should capture this idea. AND, this was one of the early towns in Oregon, so the fountain should capture a pioneering spirit. And...

Now, apply the idea of AND to anything that you teach. As you become more skilled in a course area, you find more and more ideas that you can weave into the course. This helps you move up the expertise scale (see Figure 7). I use such an expertise scale in discussing roles of ICT in teaching and learning. ICT is a powerful aid to helping a person move up the expertise scale in areas of personal interest.

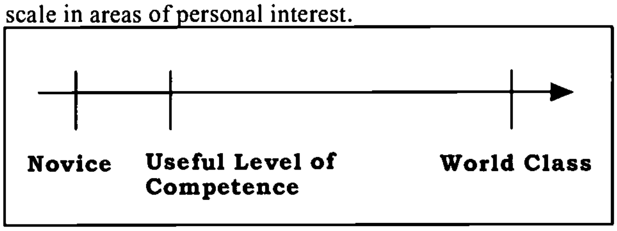

Figure 7. A general-purpose expertise scale.

Now, think about PBL and ICT. It is possible to use PBL in essentially any course. AND, at the same time, students can be learning and using ICT. AND, at the same time students can be gaining skill in cooperative learning, self assessment, peer assessment, problem posing, and so on. AND, a teacher employing ICT-Assisted PBL can be learning ICT, authentic assessment, a wide variety of subject areas, and so on.

A year ago I was asked to do a workshop on ICT-Assisted PBL. This was to be done in a hands on environment, making use of a wireless network. Wow! An opportunity to develop a new type of workshop, and hence a new book. This time, however, I decide that the book should be interactive and made available on the Web. This was my first endeavor in writing a "never ending" book. When the muse hits me, I add to and revise the book. Whenever I do a workshop on the topic, I tend to make significant additions to the book (Moursund, 2001).

Current Project: Math, Brain, and ICT

This past summer I did a workshop with two of my long time colleagues. The workshop was for inservice provides who provide workshops and courses for the Math Learning Center, a non-profit organization located in Portland, Oregon (MLC). I have served on the Board of this organization since its inception in 1976, and I have been Chair of the Board from time to time. The 1.5 day workshop was done by:

- Dr. Gene Maier, who focused on his lifetime learning in math education, with special emphasis on Visual Math.
- Dr. Bob Sylwester, who focused on recent finding in Brain Science and their education implications.
- Dr. Dave Moursund, who focused on roles of ICT in math education.

After the workshop was completed, I reflected about what it had covered and its overall success. It soon dawned on me that the workshop provided a good starting point for my next project. Thus, I am now working in the area of Math, Brain, and ICT (Moursund, 2002). I applied to do workshops on this topic at three different conferences, and I began work on a Website to support my studies and workshops. The workshop, as well as the overall combination of topics, provides a great environment to practice AND.

Final Remarks

Some of you may have heard the foul rumor that I am moving toward retirement. The University of Oregon allows a faculty member to work one-third time for five years as a phase in to full retirement. My current intent is to begin this five year plan starting this next fall.

Meanwhile, I am trying to develop hobbies and other activities that will help to keep me active and involved over the next decade or so. I hope to continue to come to conferences such as this, doing presentations and workshops. I hope to continue to do consulting, lending my advice even when it is not asked for.

AND, I have made a major commitment to a new non-profit organization, the Oregon Technology in Education Council (OTEC, 2002)). Currently I am serving in the volunteer positions of being Chair of the Board and the Web Master. This environment requires me to read widely and communicate with a lot of people. It also allows me to write almost anything that I want to write, and to have an immediate audience. I believe that you and some of your students will find this Website to be quite helpful to your work and learning.

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A Model for Creating an Art Museum-University Partnership to Develop Technology-Based Educational Resources

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Abstract The Museum of Fine Arts, Houston (MFAH) and the University of Houston (UH) have collaborated on the design and development of multi-faceted web sites related to both permanent and traveling exhibitions at the museum. Stakeholders from the museum and the university describe the web sites and their various educational resources, including multimedia games and activities for K-12 students. The authors discuss the collaborative efforts from their individual perspectives, including the UH Instructional Technology program, the UH Art Education program and the MFAH education department. The paper also includes an examination of the development of online educational resources for K-12 teachers and students and describes how students and instructors in two graduate IT courses participated in this partnership. The paper includes an overview of the role of technology in art education in general and in art museums specifically to suggest the importance of context in the development of art educational materials.

The University Perspective–Part I: Creating a New Kind of Instructional Technology Course

In the fall of 1997, faculty from the University of Houston (UH) met with representatives of the Museum of Fine Arts, Houston (MFAH) to discuss how the museum could take a small amount of grant funding and develop innovative uses of new technologies that would enhance public access to the arts. Since Instructional Technology (IT) faculty members at the university were searching for authentic and meaningful projects that students could work on as part of their course of study, it was decided that the museum would provide the content that students would use in a web design course. Project-Based Web Design and Development is the name of a graduate IT course which is offered twice a year in the UH College of Education. In this course, students work in small collaborative teams to design and develop online educational resources that the museum wants to make available to a larger audience. Students are challenged to explore authentic investigation techniques and, working with museum staff members, they attempt different creative approaches to presenting museum content online.

The first museum/university collaborative project in which students used content from the museum was the development of a web site for Bayou Bend, the American decorative arts wing of the MFAH. In this project, student designers created the overall appearance and layout of the site. Students worked with museum content experts to develop site navigation, page design, and educational resources to showcase Bayou Bend and its collection. Student teams created searchable databases, produced virtual room tours, and integrated streaming media content into the site. In addition, several students conducted research to evaluate the effectiveness of these technological components as educational resources. The Bayou Bend project is described in greater detail in the paper, *A Museum-University Partnership to Develop Web-Based Educational Resources* (Robin, Jenkins, Howze, & O'Connor, 2001).

Over the last three years, the structure of the course has undergone significant changes and revisions as the partnership between UH and the MFAH has evolved. First, because the web projects that students create are complex and multi-faceted, they cannot be completed in a single semester. Consequently, the course is now offered in both fall and spring semesters to enable work to continue throughout the school year. This poses a considerable challenge as each new semester brings a fresh group of students into the course that must first investigate the work done in the previous classes and then devise strategies for building upon that work. We have dealt with this transition from one semester to the next by employing course facilitators who work with each new group of students. The facilitators come from a variety of sources, including graduate students who previously took the course and want to continue working on the project, other faculty members who are interested in the content, and museum staff members. Facilitators are in charge of different components of the web project and they provide guidance and continuity to the new student teams that continue the work that previous students began. One of the interesting effects of working with the museum is that students participate in a cross-disciplinary exploration of such topics as history, geography, religion, economics, politics, and other cultural influences associated with works of art and artifacts, not the typical type of exploration normally found in a web design course.

Another modification to the course is that students from outside the IT program are encouraged to enroll and participate in these museum-based projects. So far, students from both the College of Education's Art Education program and the university's Art Department have enrolled in the course. These students have been extremely helpful to the success of the project and the course. Even though they often do not possess the same level of technical skill as the IT students, their knowledge of art and art education nicely complements the technology expertise of the other students. In future semesters, it is hoped that students from additional programs, such as history and social studies education, will also enroll in the course.

The Museum Perspective

The MFAH has moved slowly into cyberspace. Developed as a pilot project funded by a small grant from the National Endowment for the Arts, the Bayou Bend web site was the first effort of the partnership between the MFAH and the UH Instructional Technology program. Brochures on Bayou Bend's collection, founder, and gardens, and the newly published catalogue *American Decorative Arts and Paintings in the Bayou Bend Collection* provided important information and images. Also, with access to the Bayou Bend director and curator, UH students and faculty had a wealth of information about Bayou Bend and produced an innovative web site that featured a rich assortment of information and educational resources.

The success of the Bayou Bend project led to discussions between the IT faculty and the MFAH education director about future projects. In all aspects of its programming, the MFAH education department forms collaborations with a wide range of community organizations including libraries, schools, the city parks department and housing authority, colleges and universities, hospitals, and community centers. The education staff recognized the need for a greater web presence and was eager to collaborate with the team of professors and students at the University of Houston.

The next project the collaborators undertook was to develop a comprehensive web site for an exhibition, *The Grandeur of Viceregal Mexico: Treasures from the Museo Franz Mayer* (http://www.fm.coe.uh.edu). This exhibition from the Museo Franz Mayer in Mexico City consists of approximately 130 works that will travel to the MFAH and two other American venues and present the rich artistic heritage of colonial Mexico during the Viceregal period (1521-1821). The museum education team and faculty from the university mapped out the following components as the focus students would work on over four semesters:

1. A thematic exhibition introduction;
2. Resources for teachers;
3. Interactive multimedia games;
4. A comparison of colonial art from Mexico and the U.S., including a comparison of Bayou Bend and the Museo Franz Mayer and their collections;
5. An historical and cultural timeline;
6. Documentation of a cultural exchange between art students in Houston and in Mexico City;
7. Web-casts of exhibition lectures and symposia.

This latest project presented a major challenge–a lack of readily accessible information about the Franz Mayer collections and few images of the works of art in the exhibition. Museum staff members know that images and texts relating to exhibitions often are not available far in advance. However, the students, who began working on this project in the fall of 2000, and newer classes of students who continued this work, needed images and content in order to design and develop the basic structure of the web site as well as the content pages and educational resources. At the beginning of the project, the exhibition curator gave presentations to all classes and discussed a small number of works of art for which the museum had slides. The education director was responsible for providing as much information as was available and researching additional background information. Late in the spring semester of 2001, students had access to catalogue essays and entries and a complete set of exhibition images which greatly facilitated the project.

For the museum, this collaboration has built stronger ties between the university and the museum; introduced students to the museum as a resource for learning; provided web site design services; and supported the museum's commitment to education. The potential of the web site to provide information about the exhibition to a very large audience is of great importance to the museum. The collaboration with the university has further enabled the education department to put its teacher resource center catalogue online, to work with middle school students on a pilot museum web site for kids, and to be a partner in a major grant-funded project developed by UH focusing on teaching American history.

The strength of the partnership, its educational focus, was also its major drawback. Students who worked on the project, with a new class arriving each semester, were a very diverse group with little or no background in art or art history. Progress was often slow and frustrating from the museum's point of view, although necessary for the students' learning. In the educational setting of a graduate course, students need to learn to assess their own work and try several approaches before reaching a solution. The museum is both client and teacher, which sometimes becomes a conflicting role. But overall, the project has been a success, as measured by the quality of the web site and the eagerness of students to enroll in the course. In the future, it will probably make sense to focus the partnership on the museum's own collection for which images, publications, and research materials are readily available and deadlines are not as critical.

The University Perspective–Part II: Creating Multimedia Educational Resources

In the second series of IT courses, Collaborative Design & Development of Multimedia, students also worked in collaborative teams, but these students designed and developed multimedia resources using Macromedia Authorware™. Students enrolled in two courses sequentially (fall and spring) that focused on instructional design principles, the application of technology to multimedia design and the use of teams to develop effective instructional initiatives. The challenge for the student teams was to develop a learning module that could be incorporated into the museum web site and presented on a kiosk at the museum.

At the start of the course, students completed an initial assessment of computer skills, multimedia skills and team strategies. In addition, this survey also asked students to rate their multimedia project experience in such areas as designing navigational structures. Students were presented with brief descriptions of projects by the clients and were asked to rank their first, second, and third choices. The second week of class, students were assigned to different teams based on a combination of factors: the skill assessments, the instructor's knowledge of each individual's background, and student preference. Teams were given the job of visualizing, designing, and developing a module to meet the requirements of their client. The team that worked on the MFAH project consisted of five members, each with a variety of backgrounds and experiences ranging from K-12 teaching to corporate training.

The fall semester focused on team building and developing competencies in the authoring software that would allow students to complete the project. The team developed ideas and prototypes for the project and presented these to a representative of the MFAH. It took the team several weeks of meetings to develop a plan and direction for their project, and students soon realized that working in a team and trying to develop a piece of software is an intensive process that requires a multitude of skills. By the end of fall semester, the team had decided to integrate all information in short game-like activities. Based on the previous findings of museum visitor attention spans, and of visitor preference for self-directed learning, the activities were designed to be short in duration, with a menu of individual activities so they could be accessible by choice, and in any order.

During the spring semester, six activities were developed along with a finished menu interface with links to all activities. In the Paper Dolls game, for example, users may select any combination of dress and hair taken from portraits from the Franz Mayer and Bayou Bend collections, and drag those components onto a face on the computer screen. When finished, the program displays the visitors' combination, along with an image of the face in its original portrait for comparison. The Concentration game differs from the original in that the matched pairs are not identical but are conceptual. For example, the cocoa cup from the Franz Mayer collection is a match for a teapot from the Bayou Bend collection, because both beverages were extremely important in social gatherings in their respective countries.

At the end of spring semester, seventh graders in a local school district evaluated the six activities using a survey that included questions that might indicate student engagement as well as the efficacy of these activities for conveying museum content. Student endorsement of the interactive multimedia activities was high and indicated that these users preferred this type of activity to merely reading for content. The highest rated activities, Make a Vase and Paper Dolls, were coincidentally the two activities that allowed the participants the highest measure of individual choice and control. Although the formative evaluation testing was carried out in a classroom setting as opposed to a genuine museum setting, the student responses to the interactive multimedia activities seems to align with the literature about visitor studies regarding interactive experiences in museums. The students expected to learn, but they were also interested in playing computer games to reveal the content and enjoyed the delivery method. This experience appears to parallel the literature indicating that museum visitors come to the museum expecting both to learn and to have an enjoyable experience while there.

These prototypes were developed by the team in anticipation of an increasing presence of interactive multimedia incorporated into museum exhibits. The MFAH is still developing new concepts toward inclusion of projects like these in museum education. The team hopes that these activities will lay a foundation toward on-site testing and evaluation and that we will see a continued development toward capitalizing on the growing strength of technology inside museum exhibits.

The Art Education Perspective: How these Projects Fit into Art Education Pedagogy

The Art Education program at the University of Houston has only recently become a formal component of the fruitful collaboration between the MFAH and the IT program at UH. While a few students from the Art Education program have enrolled in the project-based web design course and have been involved in constructing the exhibition web site, the possibilities for further contributions from the field of art education generally and from considerations of technology in art education specifically are yet to be realized. In light of this, this section will:

- detail some of the early involvement of Art Education program students and faculty in the collaborative project;
- discuss briefly recent pedagogical trends in art education and how the museum collaboration reflects these ideas;
- position the technological development of art-related educational resources within recent thoughts on technology use in art education; and
- propose the strength of broadening the university part of the collaborative structure to include content areas.

An art educator was involved in the museum/university collaboration from the beginning in that an Art Education Professor Emeritus became involved in the collaboration by serving as a team facilitator in the early days of the project. Art Education graduate students then participated in the IT course and served as team members under the direction of the Art Education Professor Emeritus. Additionally, the Art Education program at UH, like the IT program, has made a commitment to focus on real-world projects within its course structures, and students in the program have suggested that their learning is increased because of the authentic nature of the intellectual endeavors. Knowing that the research the students conduct and the lessons they develop will be utilized by area arts organizations and teachers creates a level of motivation that is unmatched by class group projects or other assignments.

In keeping with its commitment to real-world projects, the Art Education program at UH also has a commitment to working with real works of art which further enhances the outcomes for all stakeholders in the museum/university partnership. Because the UH Art Education program subscribes to Discipline-Based Art Education (DBAE) as its theoretical base for learning in the visual arts, working directly with and through works of art in the museum's exhibition coincides with students' pedagogical expectations of sound art education. DBAE is an art teaching methodology that considers a holistic approach to the study of art including its four disciplines: art history, art production, art criticism, and aesthetics (Wilson, 1997). Works of art figure prominently in this methodology asking students and teachers to engage with a work of art in a variety of ways prompted by the strands of DBAE. For example, students expect to consider the art historical provenance of an 18th century portrait and also ask aesthetic questions about the difference between oil paintings and photographs. Art Education students well-versed in these kinds of pedagogical ideas bring depth of content and multiple layers of experience to the courses and the collaboration.

One of the best ways to address the always expanding depth of content and the forever bifurcating layers of experience within the visual arts is through the appropriate use of technology. Art education has embraced technology as both an important art medium and an important forum for considering art virtually. Digital imagery in the art classroom is a 21st century venue for seeing and discussing art. New communication technologies and digital media are changing the practices of making, understanding, and responding to art (Bruce, 2000). The computer age has created a shift from the textual to the visual. Pedagogy of visual pragmatism acknowledges the informal curricula of the World Wide Web and values individualized learning recognizing that the education audience is larger than K-12 teachers and students (Stafford, 1998). The Electronic Media Interest Group of the National Art Education Association has as its expressed goal to promote informed and responsible applications of media and technology in art education, and over 50 sessions at this year's national convention of art educators have a technological focus ranging from using basic technology in the elementary art classroom to considering the museum as a hypertextual narrative.

Conclusion

In extending the museum/university partnership beyond the IT component to include Art Education faculty and students, the collaboration grows in depth through the various layers that the different content areas and viewpoints add to the partnership. Expansion of new projects and the addition of even more content area experts and students will also increase the number of beneficiaries of this endeavor. The partnership has not been without its share of problems and frustrations, it seems almost inevitable that differences of opinion will result with this many creative stakeholders involved. But this model for creating a museum/university partnership has been worthwhile for the museum educators who are learning to harness the power of the web, for the students who are learning to create real-world technology projects while working with actual clients, and for the faculty who are learning to transform their courses into exciting new learning environments that are more challenging and more educationally meaningful than ever before.

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2001: A Cyberspace Odyssey

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Abstract: This paper reviews the first stage of a technology initiative to assist K-12 teachers in developing Web projects that integrate K-12 curriculum content and the collections of the National Gallery of Art. A select number of these projects will be made available on the Gallery's Web site (*www.nga.gov*). While the Gallery has offered education resources through the Web site since its inception in 1997, this program marks the first significant effort to provide online teaching resources designed by K-12 educators. The program's goals, design, and evaluation objectives are summarized by the two staff members primarily responsible for its conception and planning.

Program Goals

As an art museum with a national mandate, the Gallery has produced distance learning materials since opening its doors to the public in 1941. Films, slide programs, teaching packets, CD-ROMS, and videodiscs have long been available to teachers and other adult audiences on a free-loan basis. The establishment of the Gallery's Web site in 1997 brought more immediate, versatile, and dynamic means through which to foster awareness of the visual arts and make the Gallery's collections widely accessible. Exhibition literature, teaching packets, lessons and activities, and interactive virtual tours are among the many educational resources available through the Gallery's site (*www.nga.gov*).

This two-year technology initiative (2001–2002) was conceived as creative way of extending our distance learning resources and thus continuing to serve those educators without firsthand access to the Gallery's collections. It was also conceived as meeting teachers needs in the following ways:

- pertinent resources: by having the teachers develop these online projects, they would better match K-12 curriculum content and the more practical considerations of classroom instruction or independent research

- learner-driven models: with their potential for interactivity, online projects would be viable in a school setting favoring learner-driven or constructivist education models

- enhancement of skills: charged with conceptualizing and building their own Web-based curriculum projects, teachers would enhance their skills and encourage the use of online technologies

Instructional Design and Resources

Twelve three-member teams were selected from approximately seventy applications, based on the strength of proposed curriculum projects. (Successful team applicants were those with creative topics that could be taught using works of art in the Gallery's collections). Six teams came to the Gallery for a week-long seminar in July 2001; the other six received the same instruction in August 2001. During the program, teams worked with education and computer technology specialists to begin developing the content and storyboards for their Web resources. Instructors were Gallery staff and outside experts in art, education, and instructional technologies. The course of instruction was sequenced to help teachers explore the potential richness of online resources, analyze and critique select sites focused on art and education, and establish criteria for high-quality Web-site content and design before beginning to build their own projects. Toward this end, teams were asked to prepare for their week in Washington by studying and critiquing a preselected list of Web sites and by reading two books pertaining to online curriculum design. One book (Harris, 1998) was chosen to provide a general introduction to the different types of online projects that might be designed, depending on content objectives and desired outcomes. The other publication (Williams and Tollett, 2000) addressed design issues. This preparatory work allowed participants to arrive at the Gallery with shared knowledge and a framework for group discussion.

During the seminar, teachers were offered training in HTML and Dreamweaver, and were given packages of software with which to develop their projects (Adobe Photoshop 6.0; Macromedia Dreamweaver 4 with Fireworks 4 Studio; and Inspiration 6). Teams also learned more about the Gallery's permanent collections and which objects might best support the content of their online curriculum project—be it related to math, music, Renaissance history, or autobiographical writing—to name just a few of the subject areas chosen. At the end of the week, teams gave brief presentations on the direction of their projects. Each team had a clearer focus for their work, with a better selection of possible works of art and resources to support their theme.

Upon leaving Washington, teams were charged with continuing their collaboration through the completion of their Web projects in April 2002. To support their work in the interim, each team was assigned two mentors with whom to consult about either the content or the technological development of their projects. A listserve was established to facilitate communication with, and among, the groups. In addition, teachers had access to a password-protected Web site that offered easy reference to project guidelines and deadlines, links to educational resources, mentors' and colleagues' names and email addresses, and separate work folders for submitting the individual stages of their projects (Fig. 1).

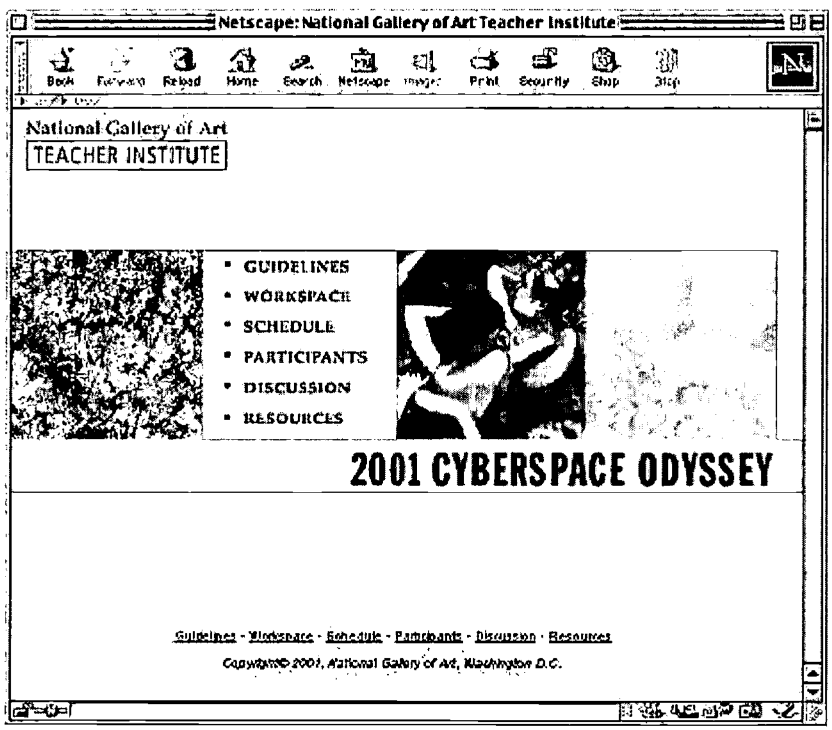

Figure 1: Home page of the password-protected Web site designed to support teachers during the design and construction of their online curriculum projects.

Team Commitment and Application Process

Educators were asked to apply in teams of three and to submit a joint statement outlining their collective qualifications and the Web project they would develop if selected to participate. They were not required to be from the same school, but had to agree to collaborate with their teammates for the eight months needed to conceptualize, build, field-test, and finalize the project. It was recommended that team members possess different areas of expertise, each of which contributed to their particular curriculum topic. Individuals selected to participate received a stipend of $1,000 with an additional $500 payable on completion of their team's online project.

The successful teams were those demonstrating sophisticated computer and Internet skills, experience with curriculum development, and commitment to teaching through online technologies. Priority was given to creative topics that made meaningful use of the Gallery's collections and targeted a specific grade (or age group), subject area(s), and national standards for K-12 curricula. (Information and an application for the 2002 program can be found at *www.nga.gov/education/cyberworkshop.htm.*)

Evaluation

Evaluation of the 2001 and 2002 programs will seek to measure achievement of two objectives: 1) providing useful Web resources for K-12 educators, and 2) increasing Institute participants' skills and comfort levels using online technologies. Useful Web resources are defined as those published and used on the Gallery's Web site, and those remaining unpublished but actively used in the classroom by their creators. Evaluation will assess both content quality and usability of sites. Methods employed will include direct observation of site use (by either teachers or students, depending on the intended audience), and interview sampling techniques designed to gauge user reaction to content and navigability.

Questionnaires will also be used to solicit participants' affective, or attitudinal, responses to the program and the process of building the Web projects. The first of these, available online at the password-protected Web site, asked participants to evaluate the instructional design of the week-long summer seminar and how well it prepared them for the task of conceptualizing and building their curriculum projects. Participant response to this initial survey was 40 percent.

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INVITED PANELS

National Technology Leadership Initiative Fellows Panel

Lynn Bell, UVa, US

NTLI Fellows

As part of a larger initiative to facilitate interactions among teacher education faculty from different content areas and disciplines, SITE and the teacher educator associations from the core content areas have established the National Technology Leadership Initiative (NTLI) fellowships. The Association of Mathematics Teacher Educators, Association for the Education of Teachers of Science, the Conference of English Educators and the National Council for the Social Studies College and University Faculty Assembly have joined SITE in sponsorship of a technology leader from each content area. The NTLI presentations at this year's SITE conference will feature an exemplary paper in each content area – science education, mathematics education, English education and social studies education.

CITE Journal Editors Panel

Editors from each of the sections of the online journal, *Contemporary Issues in Technology and Teacher Education*, will discuss the goals of the journal and recommendations for publication of articles. Journal sections represented include mathematics education, science education, social studies education, English education, and educational technology. Editors will consult with prospective authors.