Developing A Philosophy of Computers in Education


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This I believe:

• Many of our world’s problems can be addressed through better education.
• All of the children of our world deserve the opportunity to gain a high quality education.
• Our educational system can be much better than it currently is.

These three ideas help drive my personal philosophy of education and computers in education.

I am an old timer in the field of computers in education, having spent more than 40 years working in this discipline (Moursund, 2002a; Moursund, n.d.). Over these years, I have gradually developed a personal philosophy that helps guide me in my teaching, writing, consulting, and presentations. I want to share some of my ICT ideas and philosophy with you, and I strongly encourage you to examine your personal philosophy of computers in education.

This article is written specifically for preservice and inservice K-12 teachers. My goal is to help improve the education of teachers and the students that they teach. Of course, other people—such as teachers of teacher—will also benefit by drawing ideas from this document and incorporating them into their own personal philosophies of education.

Introduction

Many years ago, some of my computer in education graduate students told me about a course they were taking, in which they were required to develop a personal philosophy of teaching. They said it was one of the most useful assignments they had ever been asked to do. I remember sort of laughing at the time—who needs to write down a philosophy of teaching?

However, consider two different philosophies of education that I recently encountered while talking to two of my friends. The first said that his philosophy of education is that teaching and learning are personal, human things. The heart of teaching and learning is the face-to-face interaction among students and teachers. (This, from a person who has developed and used instructional video materials throughout his career!)

The second said that computers are an extension to the human brain, and that learning about the capabilities and limitations of one’s brain is a fundamental, unifying theme in education. A human’s brain is naturally curious, driven to satisfy this curiosity, and driven to developing aids to overcome limitations of the mind and body. Reading, writing, arithmetic, telescopes, microscopes, and computers have all resulted from the curiosity and drives.
In retrospect, I now understand that the purpose of the personal philosophy of education assignment was to get students to think deeply, reflect on what they know and are learning about education, and do some planning about their future as a teacher. The process of thinking about and developing a personal philosophy is challenging and rewarding.

Over the years, I have listened to many learned people express their philosophy of computers in education by saying, “Computers are here to stay.” Nowadays I cringe when I hear that statement, because it typically is followed by a quite shallow statement of the person’s insights into computers in education. Have you ever hear a person say, ”My philosophy of mathematics education is that mathematics is here to stay”? How about other statements such as “reading and writing are here to stay, or history is here to stay”?

Surely, we can expect more than such trite statements from education professionals! I hope that you agree with me that such superficial statements are not particularly useful in guiding a teacher in performing everyday tasks of curriculum development, teaching, assessment, interacting with students, parents, and colleagues, and so on. I think of my philosophy of computers in education as being a set of principles, guidelines, priorities, and ways of thinking that help me to make decisions as I carry out my professional work as a computer educator.

Information and Communication Technology (ICT)

So far, I have talked about developing a philosophy of computers in education. However, for me the word computer in this context is merely shorthand for Information and Communication Technology (ICT). ICT includes computers, but it also includes the Internet, the Web, cell phones, digital still and motion cameras, digital devices for storing and playing music and videos, robots, and so on.

I believe that ICT is the most powerful change agent in education since the development of reading, writing, and arithmetic a little over 5,000 years ago. ICT is fueling increasing rapid developments in science and technology throughout the world. It is fostering (should I say fermenting?) societal change throughout the world. I want to help you develop a productive personal philosophy of this change agent in education.

Let me give an example of the challenge you face. Hundreds of millions of knowledge workers throughout the world routinely work while seated at Internet-connected computers. They make routine use of email and the Web as they seek information to help them solve problems and accomplish tasks. They use powerful software tools to help solve the problems and accomplish the tasks. Think about this knowledge worker situation as you ponder the question, “Should I give open ICT system tests in the courses I teach?”

You may think that this is a silly question. Your personal philosophy of education may include the idea that tests should be closed book, and thus, certainly they should be closed ICT. Indeed, you may feel that it is even inappropriate for a student to make use of a computer word processor and spelling checker while taking a test.

However, perhaps you have heard of the ideas of authentic assessment and authentic content? One of the goals of education is to prepare students to be responsible adults who can perform well in the workforce. Knowledge workers in the adult workforce do their work in an open book, open ICT environment. If one of the goals of schools is to prepare students to work effectively in such an environment, then authentic assessment means that we should test students in such a performance environment.
My personal philosophy of education includes authentic content and authentic assessment. This includes a thorough integration of ICT into curriculum content, instruction, and assessment. I hope you will ponder such ideas as you proceed through this document.

The World is Getting Smaller

Walt Disney’s Magic Kingdom popularized the song *It’s a Small World* written by Richard M. Sherman and Robert B. Sherman. Here is a small piece of the song:

- It's a small world after all
- It's a small world after all
- It's a small world after all
- It's a small, small world

Probably the tune is now going through your head. If not, you can listen to the tune at [http://www.niehs.nih.gov/kids/lyrics/smworld.htm](http://www.niehs.nih.gov/kids/lyrics/smworld.htm). Want to learn more about Disneyland? Short video clips are available at [http://www.gofox.com/vacations/dlexplore.php?explore=Clips](http://www.gofox.com/vacations/dlexplore.php?explore=Clips). Does it seem a little strange to you that a person can be reading an article from a computer screen, click on a piece of the article, and almost immediately be listening to a tune or viewing video clips that help the article to communicate more effectively? Probably not—the Web is now a teenager and has become a routine aid to most secondary school and college students. Most children in the United States (and lots of other children throughout the world) are growing up in this environment.

A catchy tune is a fun way to think about our changing world. However, there are other ways that are more “scholarly-academic” and that may better contribute to your developing a personal philosophy of ICT in education. About 40 years ago, Marshall McLuhan introduced the idea of our world becoming more like a Global Village ([Symes, 1995](#)). More recently, the three-time Pulitzer Prize winning author Thomas Friedman has written a book, *The World is Flat: A Brief History of the Twenty-first Century* ([Friedman, 2005](#)). The book analyzes how ICT is leveling and flattening the playing field of worldwide competition for jobs. At the current time, many tens of thousand people from countries such as India, China, and the former USSR are telecommuting to jobs in the United States and other countries far from their homes. This has become possible because of the Internet and the Web. I will return to this topic later.

I have lived during a time of rapid change in science and technology, and my career has contributed to this change. Every teacher is a change agent. The pace of change is quickening, and so you face a world of even more changes than I have seen ([Moursund, 2005a](#)).

ICT is but one component of science and technology. However, it has had a very high rate of change, and it has helped support rapid change in many other disciplines. Examples of other technological progress include deciphering the human genome, genetic engineering, and cloning. Nanotechnology is now beginning to contribute to major changes in materials science and manufacturing ([Merkle, n.d.](#)).

Thus, you need an educational philosophy that facilitates your personal lifetime of adjusting to change and preparing students who will live in a still more rapidly changing world. Moreover, teachers and other well-educated people are change agents. Thus, you need a vision of the types of change you want to encourage and support, and the types of changes you want to discourage and to work against.
You also need to learn to access and make use of information from organizations that will help you adjust to change. The International Society for Technology in Education (ISTE) is an excellent source of information. The ISTE National Educational Technology Standards for students and for teachers incorporate careful thinking of many hundreds of ICT in education leaders (NETS, n.d.). These standards have been widely adopted, although success in actually preparing students to the levels suggested by the standards vary widely.

**Problem Solving as a Part of Every Discipline**

Successful teachers have the drive and passion to be lifelong learners and to help others to learn. They are willing to face the complex challenges of learning subject matter content and how to teach the content (this is called content-pedagogy) in the disciplines they teach.

Some teachers specialize in teaching just one discipline, while others teach a wide range of disciplines. Each discipline can be defined by its unique combination of:

- The types of problems, tasks, and activities it addresses.
- Its tools, methodologies, and types of evidence and arguments used in solving problems, accomplishing tasks, and recording and sharing accumulated results.
- Its accumulated accomplishments such as results, achievements, products, performances, scope, power, uses, impact on the societies of the world, and so on.
- Its history, culture, language (including notation and special vocabulary), and methods of teaching, learning, and assessment.
- Its particular sense of beauty and wonder. A mathematician’s idea of a “beautiful proof” is quite a bit different than an artist’s idea of a beautiful painting or a musician’s idea of a beautiful piece of music (Moursund, 2006).

Throughout my professional career, I have been particularly interested in how ICT affects various disciplines. This has led me to conclude that every teacher needs to know some ICT content and some ICT content-pedagogy in each discipline they teach. This is a component of my personal philosophy of ICT in education, and it influences my actions in all aspects of my professional career.

Notice that the first two bulleted items listed above both mention problem solving. I use the term problem solving in a very broad sense—as a major component of every discipline—so that it includes:

- Question situations: recognizing, posing, clarifying, and answering questions.
- Problem situations: recognizing, posing, clarifying, and solving problems.
- Task situations: recognizing, posing, clarifying, and accomplishing tasks.
- Decision situation: recognizing, posing, clarifying, and making decisions.
- Using higher-order, critical, creative, and wise thinking to do all of the above. Often the “result” is shared or demonstrated as a product, performance, or presentation.

My personal philosophy of ICT in education is rooted in the idea that ICT is a powerful aid to teaching, learning, and problem solving in every discipline that is taught in our schools. I tend to think of education as a system designed to help students increase their levels of expertise in
areas deemed important by our society and/or by students. The book Moursund (2004a) is a free book for teachers, designed to provide an introduction to the general field of problem solving and to roles of ICT in problem solving.

**Expertise**

I have given a great deal of thought as to what it means to have a high level of expertise in a discipline. Some of this thought is summarized in Figure 1. The basic ideas of Figure 1 come from the discipline of mathematics (Moursund, 2005b). Math educators distinguish between a student’s level of knowledge of mathematics and a student’s level of mathematical maturity. Mathematical maturity is a type of understanding and ability to think like a mathematician in using one’s mathematical knowledge to represent and solve math problems. I believe that the concept of discipline-specific maturity is useful in each discipline that people study.

![Figure 1. Expertise is a combination of knowledge and maturity.](image)

I find it helpful to think about content knowledge and maturity in each discipline that I teach and study. I have found that my content knowledge in an area declines over time if I don’t use it and continually renew it. However, I find that my maturity in a discipline tends to remain—and indeed, grows over time through transfer of learning from the current disciplines I am using and studying, and as I gain in overall wisdom.

These insights have helped me to better understand the major flaws of a “memorize, regurgitate, and forget” approach to education that is so common in our schools. When it comes to memorization, computers are far superior to people. When it comes to understanding and use of one’s understanding, people are far superior to computers.

**Three Questions to Ask Yourself**

As you work on developing your own personal philosophy of ICT in education, ask yourself three questions. From your point of view:

1. What things can appropriately-educated people do a lot better than ICT systems?
2. What things can ICT systems do a lot better than appropriately-educated people?
3. What things can appropriately-educated people and ICT systems working together do a lot better than either alone?

You can make up our own definitions of “appropriately educated” and “a lot better.” You should pay particular attention to things within the disciplines that you teach or are preparing to teach. Likely your answers to these questions will change over time, as you learn more about ICT in education. Perhaps your answers will change as ICT itself continues along its path of very rapid change.

My personal philosophy of ICT in education is strongly shaped by my answers to these three questions. I think of ICT as an aid to both my physical and my mental capabilities. One of my favorite examples is the Web, a digital global library. I make quite frequent use of this library, drawing from Websites located throughout the world. This overcomes some of my physical limitations and saves me a lot of time, since I am not “faster than a speeding bullet” and able to physically visit the information sources in a timely fashion. The Web extends my mental capabilities, as I can draw upon a huge amount of accumulated information (I can build on the work of others) as I do my professional work. The Web also facilitates my dissemination of the writing work that I do.

Some History

For many years, I have been somewhat of a futurist, teaching, presenting workshops, and writing books on possible futures of ICT in education (Moursund, 2005a). This section presents some historical events and trends that help shape my ICT in education philosophy. Some of these ideas may help you as you work to develop your personal philosophy of ICT in education.

Four Eras and the Beginnings of the Knowledge Era

I assume that you are familiar with the first four eras—hunter-gatherer, agricultural, industrial, information—in the list given below. For the sake of discussion, I have added a fifth era that I believe is now beginning.

1. Hunter-gatherer. During this time people lived in small bands or tribes. For the most part, they were constantly on the move, seeking food.

2. Agricultural. Up until about 11,000 years ago, all people on earth lived in hunter-gatherer societies. Then people in the Tigris-Euphrates Valley (roughly where Iraq is now) began the Agriculture Age. At that time, the total human population on earth was perhaps 12 million—much less than some current cities. Eventually, over a period of thousands of years, agriculture spread from this initial location and was independently developed in several other locations.

3. Industrial. The Industrial Revolution—fueled by steam power—began in Great Britain in the late 1700s. The following is quoted from the October 1845 issue of Scientific American:

   “It is estimated that the power of steam in Great Britain is equal to the labor of 170,000,000 men, in a population of only 28,000,000.”

The quote indicated that about 50 years into this Industrial Revolution, the installed base of steam power in Great Britain was equivalent (in terms of pure physical power) to about six times the physical power of the entire population of Great Britain. A somewhat different way of representing this information is that the total steam power amounted to
a little more than one horsepower per person. That is, one horsepower is about the same as five or six "person power." Think about that statistic the next time you push down the gas pedal on the 200 horsepower gasoline engine in a car!

4. Information. This “officially” began in the United States in 1956, when the number of white-collar workers first exceeded the number of blue-collar workers. This was still quite early in the time of mass production of computers.

At the current time, there are still a few people on earth living in hunter-gatherer tribes. There are a very large number of people living agricultural societies, industrial societies, and information societies. The United States is an information society. Approximately 2% of the United States’ workforce works on farms, approximately 15% have industrial manufacturing jobs, and most of the rest have white-collar (service) types of jobs.

5. Knowledge. There are now hundreds of millions of knowledge workers throughout the world whose work is highly dependent on their knowledge, understanding, and problem-solving skills (see Figure 2). All teachers fall into this category. I believe that sometime in the future, people will look back to our current time and say that was the beginning of the Knowledge Era. Robert Logan (2000) mentions the Knowledge Era idea repeatedly in his book The Sixth Language.

<table>
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<tr>
<th>Data</th>
<th>Information</th>
<th>Knowledge</th>
<th>Wisdom</th>
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Moving toward increased understanding.

**Data:** Raw, unprocessed facts and/or figures, often obtained via use of measurement instruments.

**Information:** Data that has been processed and structured, adding context and increased meaning.

**Knowledge:** The ability to use information tactically and strategically to achieve specified objectives.

**Wisdom:** The ability to select objectives that are consistent with and supportive of a general set of values, such as human values.

Figure 2. Data, information, knowledge, and wisdom.

The remainder of this section discusses the Information and Knowledge eras. Initially, computers were thought of as rather dumb, data processing machines. By the mid 1970s, however, it was clear that computers were both data processing machines and information processing machines. Indeed, the standardly used definition of computer came to be that a **computer is a machine for the input, storage, processing, and output of information**. Now, it is becoming clear that ICT systems are can also be knowledge processing systems (SIG KDD.
Moreover, some ICT systems make use of their data, information, and knowledge to direct or carry out a wide variety problem-solving activities. Thus, it is now appropriate to think of a computer as a machine designed **for the input, storage, processing, use, and output of data, information, and knowledge**.

The list of eras given earlier and the diagram of Figure 2 have strong educational implications. During the past few decades, researchers and practitioners have demonstrated that ICT systems can be developed that have certain types of knowledge, understanding, and intelligence. There are some people who believe that eventually such ICT system capabilities will eventually surpass that of humans—and indeed, that this may well occur in the current century. If this topic interests you, look at the work of **Ray Kurzweil** (n.d.).

For me, this means that we need an education system that places considerably less focus on helping students learn to do (by hand) what computers can do quite well, and that places considerably more emphasis on students learning to do things that are uniquely human and that computers do not do well. Our educational system should help students learn to work with ICT systems, rather than learn to compete with ICT systems. This is an important component of my philosophy of ICT in education.

**Six Languages**

This section is based on the ideas of **Robert Logan** presented in his book, *The Sixth Language* (Logan, 2000). Logan’s work builds on and extends the work of Marshall McLuhan. According to Logan’s theory, the six languages are:

1. Natural language.
2. Written language (first invented by the Sumerians, about 5,100 years ago).
3. Mathematics (invented by the Sumerians at the same time as written language).
4. Science (invented by the Greeks about 2,500 years ago; the Hippocratic Oath is about 2,500 years old).
5. Computing—electronic digital computers, computer programming, and computer tools that aid in problem solving (invented beginning in the 1940s).
6. The Internet (invented about 40 years ago) and the Web (invented about 16 years ago).

One can argue that there are other languages, such as written music notation. However, I agree with Logan’s general analysis. Perhaps my beliefs are clouded by the fact that both my father and my mother were faculty members in the Department of Mathematics at the University of Oregon. In any case, my informal and formal education helped me to develop a relatively high level of literacy in written and spoken English and the other five languages in Logan’s list.

My personal philosophy of ICT in education places a high value on all six of the languages in Logan’s list. You will have to decide for yourself what levels of literacy you should aim at in these various areas. I hope that your decision will take into consideration the fact that our K-12 educational system is now working to help all students gain a reasonable level of literacy in all of these six languages.

Currently, however, most precollege students are gaining only a superficial level of fluency in the languages of computing, Internet, and Web (**Moursund, 1997; Moursund, 2002b**). This superficial level of fluency is useful, but it is a sign that our educational system is not doing
nearly as well as it could be. Your personal philosophy of ICT in education needs to take into consideration your thoughts and feelings about computer fluency and Internet/Web fluency.

The list of languages probably presents a challenge or dilemma to many readers of this document. Suppose that you know very little about computer programming and are essentially illiterate in this language area. Do you then decide that since you are getting along just fine with out any skills as a computer programmer, the same will hold true for your students?

Let me share a personal example. I had to pass reading tests in French and German to get my doctorate in mathematics. In the process, I found that I am not very good at learning “foreign” languages. However, my personal philosophy of education includes the idea that all children should be gaining fluency in one or more languages beyond their first language. I am especially proud of two of my grandchildren who are growing up bilingual.

**Human and Artificial Intelligence**

Throughout my professional career, I have been interested in both human intelligence and machine intelligence. In the United States, machine intelligence is called Artificial Intelligence, or AI. I can trace this interest back to the science fiction reading I did as a teenager, and that continues to give me great enjoyment. Nowadays, I spend a lot of time reading about brain/mind science, and artificial intelligence.

Howard Gardner, Robert Sternberg, and David Perkins are my three favorite authors in the area of human intelligence. Gardner is well known for his theory of multiple intelligences (Gardner, n.d.). Sternberg is well known for this triarchic (three component) theory of human intelligence (Sternberg, n.d.). Perkins is well known for his book Outsmarting IQ (Perkins, 1995). In brief summary, intelligence is a combination of the abilities 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 includes critical thinking and making effective use of one’s overall knowledge and skills.

The first item in the list seems simple, but it isn’t. For example, suppose that I am learning about the countries of the world. What should I memorize, and what should I learn to look up? Before I could possibly memorize *The World Factbook* (CIA, 2006), major changes would have occurred in this collection of data and information. Moreover, the rote memorization is of little practical value unless it is accompanied with a good understanding of the meaning and some uses of what has been memorized.

Notice how the second and third items in the list fit in with my definition of problem solving. I want to help students get better at problem solving. Thus, I want an educational system that is designed to increase and bring out a student’s intelligence, and that helps a student to make effective use of his or her intelligence.

Here is a question to ponder about item 3 in the above list. If a student learns to make effective use of ICT to solve problems, does this, in effect, make the student more intelligent?
Do you think of intelligence as something fixed at or before birth, or do you think intelligence is changed through formal and informal education? Current research strongly supports the latter position!

Artificial intelligence (AI) is a branch of the field of computer and information science. It focuses on developing hardware and software systems to solve problems and accomplish tasks that—if accomplished by humans—would be considered a display of intelligence. The field of AI includes studying and developing machines such as robots, automatic pilots for airplanes and space ships, and “smart” military weapons (Moursund, 2005c).

A word processor with a spelling and grammar checker makes considerable use of AI. The development of such technology has proven very useful to me in my writing career.

The theory and practice of AI is leading to the development of a wide range of artificially intelligent tools. These tools, sometimes working under the guidance of a human and sometimes without external guidance, are able to solve or help solve a steadily increasing range of problems. Over the past 50 years, AI has produced a number of results that are important to students, teachers, our overall educational system, and to our society.

One way to think about AI is that this discipline is producing aids to human capabilities and productivity. Another way to think about it is that AI is producing competition for humans seeking employment. Of course, these same two ways of analyzing the situation can equally well be applied to industrialization and the automation of industrial manufacturing processes.

My point is that AI is a powerful aid to increased productivity and a powerful change agent. My personal philosophy of ICT in education includes a strong belief that precollege students need to understand capabilities and limitations of AI, and to have an education that prepares them to live in a world that includes more and more artificially intelligent ICT systems. That is the reason why I wrote a book on AI for educators and make it available free on my Website (Moursund, 2005c).

As you work to develop your own personal philosophy of ICT in education, think about how AI is affecting the content you teach as well as your teaching of this content. If you don’t know much about roles of AI in teaching and learning, you might want to do a Web search of Highly Interactive Intelligent Computer-Assisted Learning. My recent use of Google produced 112,000 hits. A Google search for Intelligent Tutoring Systems produced 525,000 hits.

Remember the trite statement given earlier in this document, that computers are here to stay? Well, think about the idea that ICT-based intelligent tutoring systems are here to stay. Think about the fact that AI is here to stay, and that ICT systems making use of AI are being steadily improved. How do these facts fit in with your personal philosophy of ICT in education?

**Increasing Productivity in Agriculture and Manufacturing**

Peter Drucker was perhaps the leading business management consultant and business futurist of the 20th century. The following short quote from Peter Drucker is from a presentation to some members of the US Congress in the winter of 1992 (Drucker, 1992).

“Productivity [in manufacturing and agriculture in the United States] has increased 50-fold in the last century ... and is growing as fast as ever. [Now] both sectors together employ fewer than one-sixth of the labor force.
Knowledge has become the central resource. [But] the productivity of knowledge workers is incredibly low. Does anybody here believe that the teacher of 1991 is more productive than the teacher of 1900?"

How has it been possible to increase agricultural and manufacturing productivity by a factor of 50? In essence, one can answer the question by looking at how scientific research and technological progress have been combined in agriculture and in manufacturing.

For example, think about a farmer plowing a field using a horse or ox, and then planting and harvesting using similar low tech tools. Compare this situation with a farmer using a 300 horsepower air-conditioned tractor and other machinery for plowing, applying appropriate amounts of fertilizer, planting, cultivating, and harvesting. It is easy to see how the productivity of a farm worker increased by a factor of 50.

A similar analysis can be done for industrial manufacturing. The increase in agricultural and manufacturing productivity substantially raised the average standard of living. At the same time, it substantially changed employment. At the time of the 1776 American Revolution, about 90% of the people worked on farms and the Industrial Revolution had not yet reached the US. During the Industrial Revolution, agricultural employment steadily decreased steadily, and is now less than 3% of employment in the US. Industrial employment eventually grew to somewhat over half of all employment. During the past 55 years, this has declined to less that 15% of all employment in the United States.

The 1992 quotation from Peter Drucker includes the statement, “Knowledge has become the central resource. [But] the productivity of knowledge workers is incredibly low.” Both teachers and their students are knowledge workers. How can ICT increase the productivity of these two large classes of knowledge workers? This is still a poignant and very challenging problem.

My personal philosophy of ICT in education includes the idea of using ICT to empower both students and their teachers. Let’s look at this situation from a student point of view. Right now, we have an Industrial Era form of education. It is a top down model, driven by high-level policy makers, politicians, high stakes testing, and other forces beyond the student. Largely, students are organized into classroom-sized groups and “processed” in a somewhat uniform manner according to relatively fixed time schedules. This is frequently referred to as a “factory model” of education.

Interestingly, this model of education continues at a time when a person can completely specify details of a car or a computer that he or she wants to buy, and then have it manufactured to meet those specifications. Our factory system has learned to mass-produce individualized products, but our education system is still struggling with this concept.

Our educational system has a lot of experience in the development and implementation of Individual Education Plans (IEP) for special education students. Thus, we know how to individualize the education of a large number of students—the five to six million students who qualify for an IEP. Research has convinced us that this is a good way to help educate these students.

I believe that with the help of ICT, we could individualize the education of all students. The details of how to do this in a cost effective manner are beyond the scope of this document. However, the foundations for such an idea lie in highly interactive intelligent computer-assisted learning, distance learning, and a more authentic curriculum—one that thoroughly integrates
students learning to make effective use of ICT as an aid to problem solving in each discipline they study.

Such curriculum, instruction, and assessment should be aimed both at helping students to learn to learn and to helping students become intrinsically motivated, self-sufficient, lifelong learners. Here, our current educational system is good at talking the talk, but it is not good at walking the walk. Suppose that beginning in the earliest years of schooling, students were given significantly increased power to select what it is they want to learn and how they want to demonstrate their learning. The required (factory model, uniform content) might gradually decrease as students move into the upper elementary grades, and continue to decrease as they move on into secondary school.

We see some aspects of this individualization paradigm in high school and in college, where students are offered an increasing range of courses to select from. However, few high schools and colleges offer something akin to an IEP for each individual student.

**Me, a Course of Study**

I enjoy writing scenarios that represent possible futures of education. Recently developed a scenario for the year 2004 titled *Me, A Course of Study* (Moursund, 2004b). In this scenario a high school senior reflects on her informal and formal education to-date as an assignment in a required course, Me, A Course of Study. The purpose of the course is to help students learn more about themselves and what has led to them being the way they are.

I believe that from the very earliest grades, one of the goals of education should be to help students learn about themselves. One aspect of this is learning one’s strengths, weaknesses, likes, and dislikes as a learner. Learn one’s most effective learning styles and preferences in the study of different disciplines. Learn to take an increasing level of responsibility for one’s own learning. Learn to take advantage of the very wide range of different types of aids to learning that are available on the Web and in other resources.

A key aspect of learning to take responsibility for one’s own learning is to learn to self assess one’s learning efforts, knowledge, and skills. Our educational system has widely adopted the idea of using rubrics in assessment. By and large, however, rubrics are not written so that students can use them to assess their own work. I feel that this is a major weakness in our current educational system. From early on, students should be learning how to assess the quality of their learning and learning efforts.

Joseph Renzulli is best known for his work in the field of Talented and Gifted students. His 1998 article, *The Total Talent Portfolio: A plan for identifying and developing gifts and talents*, explores the idea of each student (with young students being substantially aided by their teachers) doing a careful study of their talents and learning preferences. I strongly agree with the ideas in this article. When applied specifically to ICT, this means that I believe that students of all ages (including preservice teachers) should be learning their ICT-in-education strengths and weaknesses.

**Talented and Gifted Education**

In essence, Joseph Renzulli believes that every student has some of the characteristics of being talented and gifted. He strives to implement his ideas through schoolwide programs, project-based learning for all, and easy entry/easy exit into TAG-like learning opportunities.
Perhaps you have heard of Benjamin Bloom. He is well know for Bloom’s Taxonomy, but he also made other major contributions to education. His research on learning provides solid evidence of the benefits of individual tutoring. According to Bloom, a student at the 50th percentile level can achieve at the level of a student at the 98th percentile level through individual tutoring.

This tells us that our educational system could be much more successful—but, we don’t have the money to provide each student with an individual tutor. Or, perhaps we do. The cost of ICT has declined to the level that we can afford to provide every student with a personal computer. Thus, the missing component is having high quality computer-assisted learning materials that can function like an individual tutor. While some progress is occurring in this area, relatively little federal research and development money is being invested in this endeavor.

Part of my vision of the future is a large-scale implementation of highly interactive intelligent computer-assisted learning systems designed to fit the individual learning needs of each student. I believe that all teachers should gain some knowledge about possible futures of ICT in education. What roles will teachers play in education as a steadily increasing part of the rather mundane components of instruction and assessment are provided by teachers? If this topic interests you, you can read more about it in my free book (Moursund, 2005a) that I have written for teachers.

Change

This section briefly describes some key ideas of change that are part of my philosophy of ICT in education.

Paradigm Shift

A paradigm is an example that serves as a pattern or model for something, especially one that forms the basis of a methodology or theory. A change from one paradigm to another within a specific area is called a paradigm shift. The invention of reading and writing led to a paradigm shift from an oral tradition to a written tradition. Our current concept of science and scientific method are a paradigm shift from our knowledge and belief system of a few thousands ago.

Over the past 5,000 years, our formal educational system has adjusted to (accommodated to, implemented) a large number of paradigm shifts. Here are a few examples in the United States:

1. Free public education is available to all students, and many years of schooling are required. This is a huge change from 200 years ago.
2. Scientific method is now a routine component of science education, and science is a required component of the curriculum.
3. The 1975 Education for All Handicapped Children Act (Public Law 94-142) led to a major paradigm shift in the education of students with the handicapping conditions specified in the law.
4. Schools now make routine use of overhead projectors and/or video projectors, broadcast radio and television, and video and audio recordings.
5. Four-function calculators and much more powerful equation solving and graphing calculators have come into routine use in the math and science curriculum, and their use is now allowed in many regional and national student test.
6. Card catalogs have largely disappeared from libraries, and access to the Web has become a common addition to or replacement of physical libraries.

**Upper Limit Theory**

Figure 3 illustrates an incremental, “continual improvement” model for improving education. This diagram also illustrates the idea of Upper Limit Theory (Branson, n.d.). Beginning in the mid 1980s, Robert Branson has argued that the teaching centered model of education that prevails in the United States and many other countries is bumping into its upper limits. Now, nearly 20 years later, we can look back over nearly 40 years of national data on K-12 education and see that little progress is occurring in the overall quality of student performance in areas such as reading, writing, science, and math. Branson argues that on average, our educational system was performing at approximately the 95% level of possible performance by the mid 1960s. All of our efforts to improve our educational system since then have had little effect on performance in reading, writing, science, and math.

![Upper Limit Theory Diagram]

Figure 3. Continual improvement model and upper limit theory.

As the continual improvement model begins to bump into upper limits, paradigm shifts often occur that open up new, higher level upper limits. Figures 4 helps to illustrate the idea of a successful paradigm shift.

![Paradigm Shift Diagram]

Figure 4. Paradigm shift, opening room for more incremental change.

Here is an ICT-related examples. Before the invention of the transistor, vacuum tubes were an essential component of electronic equipment. Vacuum tubes—much like incandescent light bulbs—are relatively large, fragile, with a short life, and produce a lot of heat. Thus, considerable efforts were made to make smaller, less fragile tubes that had a longer life and produced less heat. Beginning after the invention of the transistor in 1947, vacuum tubes gave way to transistors. It may well be that you own a laptop or desktop microcomputer that contains more than a billion transistors. Try to imagine such a machine containing a billion vacuum tubes, each the size of your thumb and each giving off 25 watts of heat!
In his writings, Robert Branson argues that distance learning and computer-assisted learning are the keys to a new paradigm that will move our educational system well above its current student performance levels.

My personal opinion is that he is partly correct. However, the very heart of ICT is its aids to solving problems and accomplishing tasks in all academic areas. Thus, my personal ICT in education philosophy includes support of a paradigm shift to integration of ICT throughout curriculum, instruction, and assessment. It involves helping students to learn to work with ICT as an aid to solving problems and accomplishing tasks. It involves having students become independent, life-long learners who can adjust to the rapid pace of technological change that will occur during their lifetimes. This learning will occur in an environment of highly interactive intelligent computer-assisted learning delivered over computer networks and embedded in the computer applications one uses. I believe there is a global need for this paradigm shift.

**Flat World—An Increasingly Level Competitive Playing Field**

As noted at the beginning of this document, many people have made the observation that in some sense the world in getting smaller. Thomas Friedman’s 2005 book uses the metaphor of the world becoming flatter. By this, he means that it has become much easier for countries and people throughout the world to compete for business and jobs throughout the world. His book provides a large number of changes, using terms such as outsourcing, off-shoring, and supply chaining. One of the ways he illustrates these ideas is to analyze how many dozens of companies located throughout the world built computer components that are shipped to an assembly plant in Malaysia. His individually specified laptop computer was one of 25,000 assembled in this plant during one week in 2004, flown to the United States, and then delivered by UPS to their purchasers located throughout the country.

Steady improvements in transportation and communication have gradually moved a significant amount of manufacturing to low wage regions of the world. Now, the Internet and the Web are doing the same thing for many knowledge jobs. The cost of long distance communication is now so low that it is possible to base Call Centers in India or China, and have them serve customers throughout the world. Already, many tens of thousands of knowledge jobs that were formally being performed by people in the United States and now being performed by people in India and other countries. While many of these jobs are relatively low level (booking reservations for a cruise line, tracing airline lost luggage), many others are quite technical, requiring a high level of education, knowledge, and skill in the science, engineering, and ICT. A number of companies, including IBM, Intel, and Microsoft, have established large research centers outside the United States.

For educators, consider the possibility of US students making use of individual tutors that happen to live in low wage countries. This might be particularly helpful for students attempting to learn a second or third language that is native to the low wage country.

The educational implications of flat world are immense. Friedman discusses four categories of workers whose workers are difficult to outsource or offshore. He calls these:

- Special workers, such as famous sports stars and entertainers.
- Highly specialized workers, such as certain accountants, brain surgeons, lawyers, and researchers.
• Anchored workers, such as barbers, buildings and grounds maintenance personnel, doctors, nurses, plumbers, police personnel, and restaurant waiters and waitresses.
• Really adaptable, versatile workers who are quick to adjust to changing demands of jobs requiring a wide range of people skills and knowledge-based skills.

Perhaps you have noticed that teachers tend to fall into both the third and fourth categories. Even teachers, however, face competition for their jobs. For example, high quality, highly interactive intelligent computer-assisted learning materials can be developed any place in the world, and then delivered to individual students located any place in the world. Native speakers who live in the culture they are helping students to learn might well supply foreign language instruction and tutoring.

My conclusions from this are reflected in the title of a book I wrote nearly 20 years ago: High Tech/High Touch: A Computer Education Leadership Development Workshop (Moursund, 1986). With an appropriate combination of people skills and technical knowledge and skills, one can fill a wide range of the anchored worker jobs and the jobs that require adaptability and versatility. It helps to be an intrinsically motivated lifetime learner, learning well in both informal and formal settings. It helps to be a people person, well skilled at interacting with other people in one-on-one and group environments.

Final Remarks
Nicholas Negroponte is a professor of media technology at the Massachusetts Institute of Technology and founding chairman of MIT's Media Laboratory. Negroponte’s writings and the work of the MIT Media Laboratory are good sources of forecasts for the Information Age (MIT Media Lab). Quoting from Negroponte’s book Being Digital (Negroponte 1995, pp11-12):

“The best way to appreciate the merits and consequences of being digital is to reflect on the difference between bits and atoms. While we are undoubtedly in an information age, most information is delivered to us in the form of atoms: newspapers, magazines, and books (like this one). Our economy may be moving toward an information economy, but we measure trade and we write our balance sheets with atoms in mind.

…

The information superhighway is about the global movement of weightless bits at the speed of light. As one industry after another looks at itself in the mirror and asks about its future in a digital world, that future is driven almost 100 percent by the ability of that company's product or services to be rendered in digital form.”

Every year, our world grows more and more digital. As a preservice or inservice teacher, you live in this world that is changing relatively rapidly. As a teacher, you are helping to educate your students to live in a world that will be even more digital. I encourage you to thoroughly integrate this idea into your educational philosophy.

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