On the Need for Realistically Scaleable Educational Technology

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Global Issues in Funding Development of Technology-Based Learning Systems
Panel Discussion: The Problem of Scaling-Up Technology to Educate the World

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Introduction

This paper sets the tone for a series of panel presentations and workshops on next generation technology-based education systems. The authors represent a broad spectrum of backgrounds and experiences, and together are able to present a vision for where the future of educational technology seems headed. This document serves as preface to the presentation, posing the kinds of questions that lead to discussion of issues relevant to scaleable and pervasive technologies for education.

Reflections and Considerations

There are times when events change forever the nature of society and our social order. When the Phoneticians developed a phonetic alphabet, the way mankind stored and retrieved information was forever changed. When Gutenberg conceived of moveable type and developed the printing press, the world changed forever. By the early seventeen hundreds we invented the modern school based upon books and libraries. We now live in a time when we are at a major crossroads in the digital world. Already the digital world has invaded many aspects of our lives. Perhaps most importantly it has given us an almost instantaneous access to information worldwide. All new inventions have both positive and negative influences. For example, the internal combustion engine gave us the automobile and freed us from fixed localities. In 1900 most Americans had not been more than fifty miles from where they were born. Today we are defined as the mobile society, but the automobile also brings an annual death toll in the United States of 45,000 people and pollutes the environment.

The challenge to educators is that the digital world cannot be put back into the box. The negative consequences may be like Pandora's Box. We already hear cries from traditionalists that the negative factors out weigh the positive factors. The challenge for educators is how to make the positive influences of these technologies a major factor in future learning and teaching efforts. To do this we must understand the present and how we must make the transition from the present to the potentials of the future. The average child entering school has a speaking vocabulary of 2,500 words, but the range is from 1,000 to 5,000 words. Some children will have had 3,000 hours of pre literacy experiences and others as few as 30 hours when they enter school. New technologies will allow us to narrow this range of experiences and vocabulary. By the time the average high student graduates he or she will have spent about one ninth of their waking hours in school. The home school connection is essential if we are to improve educational achievement in our children. The new digital technologies or the pervasive technology open new and exciting opportunities for all children and all learners throughout their lives. Research tells us that *time on task* is one of the major indicators of success in learning. Current wisdom, without any scientific justification, holds that our American Education System is in shambles. However, we are educating more children than ever and we are educating a more diverse group of children than ever. Examples abound of both successful and failing schools. The United States of America was the first nation in the world to implement the concept of universal education for all children in the late 1800s. However, the battle for inclusion of every child continues on until today. The reform movement begun in 1993 with the report *A Nation At Risk*, [3], is one of the most comprehensive and continuing reform movements ever experienced in the history of American Education. Pervasive technologies will be the next major influence on these changes and they will be affordable.

One of the first changes in the digital revolution is that we now focus on learning and not instruction. Schools are becoming *learner centered* and *performance based*. What the learner does and how well the learner masters challenging academic standards is of major importance in American Education today. In this sense the digital world has already changed some of our thinking. The challenge is to move ahead.

- ✓ Will the school of the future be centered on a digital library?
- ✓ How will pervasive applications of technology change the nature of learning?
- ✓ What to do with widely available digital sources?
- ✓ This is the most fundamental issue. Let's consider various aspects of this issue.
- ✓ What are educationally relevant, digital sources?

We have come to believe that all digital media, such as text, graphics, stored audio, live one-way audio, live two-way audio, stored video, live one-way video, live two-way video, and is relevant to learning in some way.

✓ How do students use digital data directly?
They browse, we think, as they would any library source for writing papers and doing projects.
✓ Is browsing educationally effective, then?
✓ Are digital sources good references for papers and projects?

Sometimes yes, sometimes no. They give students access, and the process of finding them is rewarding to students and could encourage critical thinking.

✓ But, do students know the good data from the bad data, and does glitzy tend to overwhelm truth?
✓ Who else could use these educationally relevant digital sources?
Teachers of course, curriculum designers, instructional designers, parents.
✓ How could they use them?

- As enrichment material for classroom instruction?
- As a resource for distance learning and computerized lessons?
- As a basis for life-long learning?

✓ What do we mean by computerized/digitized lessons?

Media types and various level of interactivity (sometimes called intelligence) combined to create learning experiences.

- ✓ What are these media types?
- ✓ Is this a classic multi-media issue, or, in how many ways can information be presented?

In the simple sense, the computer presents some fixed digital material in some fixed order and the student uses it. At the ultimate level, based on student performance, the computer generates response data (while using some fixed material) in an adaptive sequence or dialogue. This requires interactivity, therefore:

- ✓ How does the computer interact with students?
- ✓ And, what is typical interactivity?

Interactivity itself has two dimensions:

1. Presentation sequence, and
2. level of material fixedness.

- ✓ What are the problems with using instructionally relevant digitized sources in this way?

    - Cost, good quality interactive multimedia costs a lot, and schools don't have the money.
    - Most authoring systems are too hard/time consuming for teachers and curriculum designers to use.
    - Most authoring systems produced fixed sequence lessons or very simple sequence interactivity.
    - Almost no authoring systems produce dialogue.

What do we know to be educationally effective using digital sources?

On the other fundamental issue, consider next the known premises. If you want students to learn something, you have to let them practice it. Sometimes, people learn more effectively by practicing parts, and by understanding and integrating concepts. Increasing the number of practice trials produces increased learning. Reward affects willingness to practice and therefore the number of practice trials. Individual practice trials that are associated with rewards produce more learning per trial than do those that are not associated with rewards. Being able to exercise control rewards people. People are rewarded by success. Succeeding at something considered important is more rewarding than succeeding at something unimportant.

Punishment tends to stamp out unwanted behavior, but excessive punishment tends to retard learning. Failure is punishment and continuous failure is excessive punishment that leads to giving up. A skilled teacher in a classroom with a desirable student-teacher ratio and no ongoing distractions can implement the elements that we know to be educationally effective. A significant portion of these elements can be implemented by means of an intelligent tutor, [4]. In typical computer based instruction, the computer presents existing, instructional material in a fixed order; the student consumes it, and then is tested. This has the advantage of being easy to do, but the disadvantage of not being able to maximize training effectiveness by tailoring itself to individual student's performance, nor by being able to hold the student's interest over time. Advanced computer based instruction attempts to solve these problems through the use of intelligent tutors.

The phrase *intelligent tutor* is used to describe some form of computer-based instruction that interacts with and adapts to individual students during a lesson. *Interactivity* describes the type of interchange that takes place between the student and the tutor, even when the tutor is a computer. The typical type of *interactive intelligent tutor* is only to present material to be learned and then ask questions about that material. The student answers the questions, and based on those answers, the tutor engages in some kind of adaptation. However, other forms of interactivity are possible. The tutor can answer questions from the student taking the role of a domain expert. The tutor can engage the student in a kind of dialogue in which it and the student can both ask and answer each other's questions. This is called mixed initiative dialogue. The tutor can behave like another person with whom the student has to interact and allow practice. The material can be presented as part of a game-like microworld, which holds the student's interest and increases practice time. In all these cases, an intelligent tutor should be able to adjust to the student's performance strengths and weaknesses. Such adaptation takes place in one of two levels-the ability to alter the sequence of presenting existing instructional material or dialogue and the ability actually to create new material or dialogue.

Intelligent tutors are neither browsers nor page-turners. Thus, implementation is difficult and computationally intensive. The materials they produce and/or the sequence in which it is provided to the student is not known in advance, as is the case of a page-turner. It is generated in response to the individual student's interactions. That is the very essence of the strength of intelligent tutors. That is what makes intelligent tutors more effective than simply browsing the Internet in some fashion. Unfortunately, if one does not know in advance what material is to be presented to a student, one cannot broadcast that material in the manner described in parts of this paper. The ability to broadcast material in that way precludes the ability of a tutor to adapt to individual students in a meaningful way.

Accessing computationally intensive, intelligent tutors requires either downloading them into reasonably advanced personal computers from a network or satellite, or being able remotely to access a computer that has an intelligent tutor resident. In the long run, this apparent problem calls for development of a system that allows full access to such computationally intensive tutors without access to a "wired" Internet. In the short run, it calls for a logical division of function in which classrooms that don't have access to a wired or cable-based Internet have access to a broadcast system and to some stand-alone computers with intelligent tutor capabilities until the long run solution is implemented.

Solid predictions

There are no simple or isolated answers to any of these questions. However, we know that some technologies become part of our everyday life, thus they become vehicles for learning. We adopt their use and they in turn are made to adapt to our need for information and to our modes of learning. Televisions, the telephone and many home appliances fall in this category. Until now, that has not been the case with computer technology. While microchips and microprocessors are built into many tools and appliances, as well as into computing devices, computing is not yet a lifestyle activity. The human need for information and services, supported by pervasive computing, will change that.

But, beyond and after the PC, what will become the elements of scaleable education systems? And, what reasonable limits will be imposed on scalability? We believe that today scaleable means nothing less than *universal scalability*. That is access that is adaptable to all life-styles, dependable, and abundant, in technical terms: *pervasive*. Education systems built on top of pervasive technologies hold the most promise for scalability, and therefore, for equity. We believe that a wide range of devices will enable universal scalability. These "information appliances" will become affordable consumer products. Cost and ease of use will contribute to *universal scalability* and *equity of access*.

Pervasive technologies will offer opportunities for building truly scaleable education systems. New models for globally scaleable education systems are possible. The first new model to impact education will be based on the use of one class of computing that is not available yet, but that promises to become extremely pervasive in the near future: *the digital set-top box* (DSTB). Until now these devices have proven too expensive for the general public, and the services that would be provided over the new infrastructure have not been ready for use. The integration of communications technologies, that is, cable, wires and satellite; and, service providers offering combinations of consumer services make the dynamics of pervasive computing more realistic. The expectation is that a single DSTB will be able to provide Internet and interactive television over the same kind of communications and user-end device, and within the same level of use complexity that consumers are today comfortable and familiar with.

How will such technology work?

New infrastructures for pervasive computing will connect many types of devices to many servers. Servers that we now know of as supporting only the Internet and PCs will support networked devices having many new user interface characteristics, for example, mini-small screens, mathematical and multilingual keypads, voice activated, physical identifiers (i.e., finger and voice prints), etc. The networks themselves will be hybrid and accommodating, supporting different levels of connectivity, for example, high latency, low bandwidth, variable performance, selection menu reliability, etc. Pervasive system must enable content and application developers to provide services on behalf of multiple device types in a personal choice driven and manageable way.

First, the system must be adaptable to cost and usage level factors. Tailored or *portal entry* opportunities must also be supported. For example, members of the educational community will want to have content marked for educational value and applicability, all content on the networks, not just educational clearinghouses content. In order to supports this vast array of information access options, less common software technologies called middleware, like transcoding, data synchronization, and queuing will become more important, enabling tailored delivery of these applications and services to this broad range of device types. Finally, in order to ensure ease-of-use, to the diversity of the users, the need for centralized client-oriented middlemen services and management must be eliminated. The new *information environments* must be able to tune in to their users if they are to become part of their life-styles.

Current global market trends are heavily focused on the emergence of networked, or *commerce economies*. By observation of changes already underway in industry, we believe that indeed only globally scaleable solutions will find a receptive market place. Education systems, built on top of these new computing life-styles, will target the global market place. More specifically new business designs and next generation companies will want to be competitive worldwide. Therefore, the educational needs of the entire world must be taken into consideration.

Why will that be so?

Pervasive computing and e-commerce are not the only forces operating on the future of education systems. Social and economic requirements for life-long learning in the digital world drive the need for end-to-end education systems. That means that the same kind of technologies that will provide staff development for teachers and bring real-life experiences to school children will also support universities, commercial and industrial training. Intellectual property, automatic capture of information, interactive delivery, and all of the technologies that are now called Digital Library, will enable life-long learning via pervasive computing, creating a single education infrastructure.

It makes business and technical sense to find a least common denominator solution, because we cannot afford to build 3 or 4, and we cannot continue to support disparate solutions while the world becomes closely connected. A single, highly adaptable education framework makes eminent economic sense. More than 4% of the GPD in the US is dedicated to K-12 education expenditures. Of that, 54% is spent on Instructional Expenses (IE) for teachers, benefits, books, supplies, instructional services, etc. That translates into $3800/year/student on IE. To higher education the US dedicates 2.3% of the GDP, with 50% expenditures on IE, [1].

Redirecting to Technology Expenses (TE) without affecting IE?

Even in the US access to the Internet is not prevalent. In 1997, 78% of public schools were connected, but only 27% of classroom. With only 14% of poor and minority classrooms connected (1) we can see that the real connection is to economics and public policies. But even for those classrooms that are connected, additional inequities are created by lower speed connectivity, lower than in some homes, in academia, in the office. Life-long learning takes a performance hit because there are no universal education access standards [6].

Can IE allocations be redirected to TE? Developing countries may in the end define the standards. With 80% of the world in various stages of development, TE is not yet a priority worldwide. Only 35% of public schools in Mexico, for instance, have telephones; only 3% of the population in African countries has telephones, [2]. In contrast, the connection of education to economic development is well made, worldwide. IE is supported as the key to economic development, the double helix, but not TE. Viewed as a business opportunity, however, TE could drive IE and thus universal connectivity to life-long learning and continuous economic development. In this case, developing countries and fast growing minority communities in developed economies may tip the scales and define the standards.

For example, assume that only 2% of GDP devoted to IE, and 1% of that devoted to a Digital Learning Network, the following global market is created:

	GDP ($T)	**IE (%)**	**IE ($B)**	**Devoted Yearly ($B)**
US	7	2	140	1.4
World Wide	36	2	720	7.2

What is the promise for education?

One of the greater challenges in the application of computing technology to education has been *equity of access* to the technologies. That is particularly true in the case of the Internet. We know that today access is still a privilege. But even when access exists, the ability to make use of the technologies is limited by the level of sophistication required of the users. Scaling up access is, therefore, a function of two problems: *connectivity and ease of use*. And we must consider these two requirements as one. Connectivity alone is not enough. Pervasive computing cannot only address the access and cost factor issues, but also the know-how problem. Only when computing devices become as easy to use as household appliances will equity of access becomes a realistic goal.

Popular broadcast technologies coupled to computing appliances will become pervasive solutions, not only because of the access factor, but also because of the ease of use factor. Such solutions have worldwide and life-long learning potential. The following illustrates what will drive needed solutions.

Countries	**K-12**	**Higher Ed.**	**Workforce Preparation**
Highly Developed	Internet, Broadcast	Internet II, High Speed Internet, Internet	Internet II, Internet
Medium	Internet, Broadcast	Internet	Internet. Broadcast
Developing	Broadcast, Internet	Internet	---
Under-developed	Broadcast, Internet	---	---

These solutions will be further modulated by ease of access, government policies and services availability.

How to prepare now for this new wave of technology?

We have never really planned for technology, rather the pace of change has been so incredibly fast that we have been caught, time and time again, off balance and racing to catch up. The catching up is constantly defined as having a certain number of computers to students or types of computers or technology coordinators.

We seldom stop to ponder the significance of the following types of questions:

- ✓ What types of technology for what sorts of students?
- ✓ Where should we make the investments in software?
- ✓ For individualized enrichment as supplementary, complementing the curriculum rather than replacing it, or as general practice for the entire class?
- ✓ Is content knowledge or skills reinforcement best practiced in classroom or home settings, and why?
- ✓ What is the role of the Internet, research?

- Email communication?
- Content and skills enrichment?

- ✓ How do we use technology for assessment?
- ✓ For professional development?
- ✓ What do we know about the ways these applications can work?
- ✓ How do they relate to improving student achievement?
- ✓ What type of professional development is necessary to fully capitalize on their potential?

What will educational systems be like in these environments?

Adopting new education models will mean using the same strategies that industry uses to remain competitive and up to date in technology. In the business model, new equipment and services markets will create opportunities for new education businesses and technologies in a more unified information sector where content, communications, and information technology becomes a bundle of services. A single industry or a consortium of service providers will provide these services. The business potential will be unbounded by time or geography. But as technologists have endeavored to move education toward the "anytime, anywhere" paradigm, so have educational services moved to the *e-frontier* with specific social consequences.

The digital world cannot be put back in the box. Social orders will be changed or have been changed. But perhaps the direction of change can be affected with knowledge, planning and effective policies. We must, as a community, become (simultaneous) technically, politically and commercially involved as follows:

- ✓ Developing global and universal solutions [5], based on a common architecture and technology approach for the 3 major market segments in life-long learning.
- ✓ Developing and installing pilot projects that technically validate the approach taken.
- ✓ Modifying public policies in profound ways.
- ✓ Defining a business case in each key market segment and each country.
- ✓ And we must, also as a community, be able to first anticipate the outcomes of such activities and make sure that the solutions are driven by our role in:
- ✓ Defining the killer applications
- ✓ Defending the importance of evaluation
- ✓ Building professional development as part of product development
- ✓ Establishing expert panels to prevent random uncoordinated investments

What can we do to alter a seemingly inevitable course?

Glancing at the research literature will reveal that not much is known about any of these questions, certainly not enough to direct public policy. The lack of specifics on how particular applications effect student achievement are proving to be a barrier among many lawmakers to expanding funding for technology and thus to get at persistent issues that surround questions of access and equity.

In order to prepare for the inevitable, near future, several things, we believe, need to be done (again) now, but with added determination:

- ✓ Identify (no more than) three key educational applications for pervasive computing.

✓ Adopt a variety of rigorous evaluation methods to test the effectiveness of these new applications as far as improving student learning.
✓ Develop concomitantly with the technology, professional development packages that can be delivered in conjunction with the technology, in the same way that other information service packages are now bundled with the software, hardware and access that is sold in the consumer market place.
✓ Establish groups of experts and experienced practitioners and technology consumers to guide the development of funding for this new generation of information computing.
✓ And, principally, affect public policy.

The advent of pervasive computing will not change the basic dimensions of the debate. Certain features of the new pervasive computing technology, particularly those with some potential to grab the imagination such as the uses for interactive television to conduct surveys or to give feedback on a test, may be snapped up immediately by an education industry often hungry for novelty rather than substance. But the longer view may be that we don't end up with much more for our billions of dollars of investment than we did under the Apple 11 regime. Our lack of research and development knowledge, a lack that would choke any other industry, threatens to make pervasive computing just another chapter in the long saga of failed educational experiments.

We cannot fail this time because a failed pervasive technology in education is more dangerous than all the combined failed technology experiments driven by commercial opportunities. The new pervasive information environments of the near future must be made to work for education with equal effectiveness, as they will be made to work for e-commerce. And, public policy must be directed to ensure that goal. And, lawmakers must be made to understand educational technology, or elected for that quality. Only then can education systems harness technology the way in which industry does to succeed in the digital world. In the end, for everybody's (digital) world to succeed, educational enablement must become its first priority.

Concluding Remarks

Interactive intelligent tutoring and other learning methods that are based on digital technologies hold the promise of quality education in the inevitable future. The direction, in which Internet connectivity is going, towards high bandwidth Internet-2, will support those methods. The problem is how to make digital education equitable. While broadcast technologies and *digital television* already offer the possibilities of CD quality video and sound, multicasting to multiply the content that can be made available, the use of residual space to transmit data, and even wireless interactivity, the educational quality of the resulting environments will at least not support interactive intelligent tutoring.

The conflicting paradigms are *quality and equity*. With the advent of pervasive computing that will invade all social spaces, we cannot afford to settle for one or the other. *Inclusiveness and achievements* must be the goals of our future digital learning environments. The challenge is to advance research that will provide both quality and equity. We do not have a proposal for that combination of goals. We have presented issues and ideas in support of research that will produce the desired results, assuming that we are not going to find in our hearts justice in doing less.

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About the authors

Daniel Abensour is the co-founder of CMI and its Chief Executive Officer. Dr. Abensour is an internationally recognized expert in high-speed communications and also specializes in Multimedia Applications and Network Management. From May 1996 to August 1998, Dr. Abensour was Vice President of Technology, Corporate Architecture and External Engineering for the Racal Data Group. Dr. Abensour also was in charge of the Racal Research laboratory in Sunrise, Florida. Prior to joining Racal, Dr. Abensour spent a number of years with IBM. Most recently, he was strategist for the IBM Networking Hardware Division reporting directly to the Division President. Previously he was Program Director of ATM market development. In this position, he defined the switching strategy for IBM and, in 1995; he developed and announced SVN (Switched Virtual Networking). Prior to that he was the IBM ATM Systems Manager where he was responsible for the definition of the ATM strategy for IBM and for the worldwide coordination of the related engineering developments across several laboratories in the US and in Europe. Dr. Abensour held several senior manager positions with IBM in Research and in Development Engineering and Programming in different laboratories: Research Triangle Park, North Carolina; Boca Raton, Florida; T.J. Watson Research Center in Yorktown Heights, NY; La Gaude Development Laboratory, France. Dr. Abensour is a graduate of the Ecole Nationale Supérieure des Telecommunications in Paris, and holds a Doctorate des Sciences in Computer Sciences from the University of Toulouse, France. Dr. Abensour was a member of the IBM Academy of Technology and a Senior Technical Staff Member in IBM. He is an IEEE Senior Member, holds several patents, has published over 30 technical papers and has delivered several keynote addresses and presentations at industry conferences around the world.

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Miriam Masullo is a Research Staff Member in the Systems Laboratory at the IBM T. J. Watson Research Center. She came to IBM Research in 1985, with long held personal interest in education and 16 years of experience in both systems analysis and network engineering from the telecommunications industry. At T.J. Watson she has made significant contributions to the areas of Artificial Intelligence, System Management, Policy Management, and Object Oriented Systems. Dr. Masullo received her bachelor's degree from The City College of New York, a Master of Science in Computer Science from the City College of New York, a Master of Philosophy, and a Ph.D. in Computer Science from the City University of New York. Her interdisciplinary thesis with the Departments of Computer Science and Educational Psychology first defined the concept of a national networked education infrastructure built on digital libraries. Dr. Masullo has worked extensively in educational technology projects with several universities, the American Association for the Advancement of Science, the North Central Regional Educational Laboratory, UNESCO and many schools around the world. She has given numerous national and international keynote seminars and workshops and published widely on the subject of technology infrastructure for education. She conducted the first workshop on digital libraries in K-12 education and has participated in NRC initiatives and publications in that area. She led pioneering pilot projects of such technologies as networked multimedia, video on-demand and digital libraries for k-l2 education. She is coeditor of the widely circulated EduPort Newsletter, which has since 1996 provided information on advanced technology infrastructure and digital libraries for in education. Dr. Masullo currently serves on faculty loan from IBM as Director, Educational Technologies for the National Action Council for Minorities in Engineering (NACME). She is a member of the Mathematical Sciences Education Board of the NRC and of the Advisory Board of City College School of Engineering Board.

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Antonio Ruiz received the B.E. degree in Electrical Engineering from the City College of New York, the Master of Science degree in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology, and the Ph.D. degree in Electrical Engineering from Stanford University. He joined IBM in 1978 to work in digital signal processing applications at the T. J. Watson Research Center, and moved to the Almaden Research Center in 1981, to work in multimedia subsystems for workstations. Dr. Ruiz returned to T. J. Watson in 1989 as Senior Manager of the Communications Systems Department. He was also Director of Video Technology in the telecommunications and media industry solutions unit of IBM. He has over 30 publications in leading technical journals, conferences and workshops, and over 25 invention disclosures in the areas of data communications, multimedia, networking, telecommunications, technology and applications. From 1996 to August 1999, Dr. Ruiz was General Manager of Communications Technology for the Racal Data Group in Sunrise Florida. He is now the President and co-founder of CMI.

Laurence Peters is currently Deputy Director of the U.S. Department of Education's Empowerment Zone and Enterprise Community Taskforce. Dr. Peter's was born in the UK and graduated the University of Sussex with an honors degree in English. He gained a teacher's postgraduate teaching degree at the University of Bristol and a Master's Degree in English and Education while at the University of London's Institute of Education. After teaching for three years at a British Sixth form college, he took a teaching fellowship at the University of Michigan, Ann Arbor and studied for his doctorate in English and Education. After moving to Washington D.C. he grew interested in educational policy issues and studied for a J.D. degree at the University of Maryland. After completing his J.D. he was appointed counsel to the U.S. House of Representatives Subcommittee on Select Education and Civil Rights and remained counsel for six years. He specialized in educational research issues and helped design the reauthorized Office of Educational Research and Improvement. In 1994 he joined the Clinton administration to become a Senior Policy Advisor for the Assistant Secretary for the Office of Educational Research and Improvement and in 1998 gained his current position. Dr. Peters has written many articles in the area of educational technology, urban education and curriculum reform.

Frank Withrow is a Ph.D. in Audiology from Washington University, St. Louis. His research has included immediate visual memory spans in children, electrophysiological measurement of hearing in infants, and paired associate learning. He has been a preschool teacher, elementary supervisor and college teacher. He has held the positions of Director of Research and Clinical Services in the Department of Children and Family Services at the Illinois School for the Deaf for the State of Illinois, Executive Secretary for the President's Committee on the Handicapped, Technology Policy person for the Counsel of Chief St ate School Officers, and Education Program Director for the NASA Classroom of the Future. Dr. Withrow served thirty years as the senior technologist in education for DHEW and USED, was a Battelle Memorial Fellow and currently serves on several national boards and committees. He was recently named one of the first twenty U. S. Pioneers in learning technology by NECC.