National Strategies for Educational Technology:

Building Africa's capacity for leadership and training in education and the economy.

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As the 21st century begins to unfold, it is clear that education and technology are key to a nation's future. The world is in an era of vast changes in communications and commerce that some have called "The Knowledge Revolution." One of a nation's most important goals therefore must be to produce citizens adequately prepared for life and work in that knowledge-based and technology-driven world. Thus, national strategies for educational technology are needed to create a highly educated and skilled work force that can think, solve problems and communicate effectively using technology. I propose that increasing a nation's capacity in educational technology is a key strategy for economic and cultural development.

Why do I say "cultural" as well as economic development? Because the changes taking place are revolutionizing our relationships, symbols and beliefs as much as they are changing the way we think about commerce and knowledge. Consider what it means today to be a member of a company with a design division in Tokyo and Los Angeles, a financial division in New York and Cape Town, and manufacturing divisions in South America and Germany. You may be the company's one employee who lives in a small town in Canada and works at home. Your pay arrives as an electronic transfer to a bank whose offices you have never visited. For products and services you need in your personal life - things like books, clothing, food, and music - you electronically locate and interact with companies and individuals that you will never meet face to face. The products and services themselves, you will never touch until they arrive at your doorstep. You will further your education with a learning team from several nations, seeking solutions and creating new knowledge at unprecedented distances and pace.

How do societies deal with this kind of economic and cultural revolution? How will we assimilate new telecommunications and computer technologies as they transform our lives? They will likely follow the same path that past technologies and cultural shifts have taken. To illustrate this anthropological perspective, Tom Carroll (2000), a leader in U.S. educational technology, compares the introduction of information technology to the introduction of the steam engine in the days of wind-powered sailing ships.

At first there was period of innovation. The tall ship didn't simply take down its sails and begin to steam across the oceans. Pioneer risk-takers created small experimental designs and tested them on smaller bodies of water like rivers and lakes. The canoe paddle was refitted to a wheel on the sides or back of the boat. A few extra paddles were left loose in the boat for when the engine failed, which it often did.

In a second stage, hybrids were formed as new technologies were pasted onto old delivery systems. Ships were launched that had both sails and steam engines. If engines failed, which they still did, the winds could still be used. The hulls were still made of wood and designed for sailing not steaming through the waters. But shipping times between ports began to shrink, and as they did, more and more people saw the benefits of the new technology. The technology became ubiquitous, and that brought a complete transformation in shipping.

Finally, a fully transformed vessel emerged. The hull was first coated with and then later made completely of steel and the design accommodated higher speeds. The

sails were gone completely. The fuel had changed completely from coal and wood to oil, and today, in certain specialized vessels, electric and nuclear. The engine itself changed completely from steam to the internal combustion engine. And that evolution caused an even greater transformation. Transportation across the oceans shifted completely out of the water - to the air!

These three phases - innovation, hybridization, and transformation - characterize the infusion of advanced technologies into education and the economy. Companies, organizations and governments will find themselves at several places at once along this continuum. A transformed company will be ahead of its competitors operating in a town or city with a hybrid infrastructure for communication, employing people who have been educated in institutions that have not yet begun to innovate. At the same time, a transformed educational institution in another location will educate people who find that they need to leave their region or country to find work appropriate to their level of training and preparation because an infrastructure remains to be built. Organizations conducting the same kinds of business will themselves be at different levels along the continuum of transformation, with the competitive advantage going to those who are further along the road of change. It is clear that organizations of all kinds - family businesses, large corporations, and even nations - need to facilitate the evolution from innovation to transformation of technology in society.

This paper will attempt to address three broad questions about that evolution in education.

1. What major strategies might a nation consider for building an infrastructure of technology materials, resources and practices for the transformation of education?
2. What are the most important roles for a government to play?
3. What are some examples of proven and promising uses of technology in transformational education and training programs?

The paper will draw on several sources of experience and writing and in the U.S. including:

- A report from the RAND Corporation on fostering the use of educational technology in education, (Glennan & Melmed, 1996)
- Standards from the International Society for Technology in Education (ISTE, 2000), and
- Our work with systemic reform initiatives and technology innovation projects in education (The Vermont Institute for Science, Mathematics and Technology; The WEB Project; and The National Institute for Community Innovations)

National Strategies

The following five guiding principles based on a RAND study (Glennan & Melmed, 1996) and our own experience, provide a starting point for the discussion of national strategies to increase the use of technology in education.

1. **Relate the use of technology to a larger educational reform agenda.** Without this strategy in place, technology remains in a stage of perpetual small local innovations. A few pioneers will experiment and get out ahead of others, but the masses will be left behind. The larger agenda helps create the conditions for ubiquitous technology leading to the complete transformation of the system.

2. **Integrate the costs of educational technology into the regular costs of education.** Categorical, one-time expenditures that treat technology like a capital expense rather than an ongoing cost of business and service, will not get the long-term job done. This principle does not negate the importance of making crucial one-time investments, but those funds should be part of long-term funding strategies to sustain the evolution from innovation to a transformed system.

3. **Provide public access to the national information infrastructure.** Commercial interests and incentives dominate in shaping the technological infrastructure. National strategies must remain mindful of the impacts of regulatory and market forces on under-financed public institutions like schools, social service organizations, libraries and museums. Special efforts are called for to bring leaders from education and social services into the planning and implementation of the national infrastructure.

4. **Monitor and improve the equality of access to the benefits of educational technology.** A "digital divide" exists between those who have and those who do not have access to technology. That divide also exists between schools within a community and between communities within a region. Nations must remain vigilant in their awareness and reactions to the inequalities in order to work to bring the benefits of an improved training and education system to all people.

5. **Scale-up and sustain the best practices from the pioneers.** The pioneers and pilot projects from the innovation stage have lessons to teach others that will save time, money and frustration. As new sites take on these best practices, the national strategies must allow a wide berth for local adaptation and not stifle local creativity with burdensome regulations. The most effective policies are those that inspire and support people with models, incentives and guidance.

Roles for National Governments

With the stakes for success as high as they are - after all, our choices are irreversible and impact our children and our communities in their next steps toward the future - there are crucial roles for governmental leaders to play in fostering the use of technology in education.

1. **Emphasize and demonstrate the importance of technology for improving student learning.** Reforms of education and economy that do not place technology in a central position will miss the greatest opportunity of the 21st century. National leaders can do much to show people why the evolution toward transformed institutions of education and economy is inevitable and desirable.

2. **Create and make available high quality information about educational technology.** People need concrete models and examples of what a transformed school or college looks like. The standards and benchmarks of progress must be visible to all, creating an atmosphere of challenge and shared accountability by all the stakeholders of education and the economy. Examples and challenges help people see what, how and when they can help shape the evolution toward an advanced technological society.

3. **Develop regional and national technical assistance capacities**. New centers of expertise and leadership are needed to help schools and colleges evolve from pioneers, into hybrid institutions and eventually into completely transformed organizations. Programs of leadership development must be integrated into the full continuum of preparation and support of the teaching profession.

4. **Sustain a vigorous, relevant program of research and development of new educational technology ideas, applications and approaches.** While there are many ideas that the system of education and training can adapt from the business community, research support from national governments is needed to explore and develop pioneering new applications that business does not need for its purposes. There is special value in demonstrations that point the way to the new kinds of learning environments that are possible and much needed in the transformed society.

An example of a national policy that embodies many of these principles is the U.S. Educational Excellence for All Children Act of 1999. (USDOE, 1999) The legislation provides incentives to do the following:

· Stimulate the development and use of innovative technologies **to create engaging teaching and learning environments** while expanding our knowledge about effective uses of educational technology.

· Continue support for expanding **access to challenging course work and educational resources** by encouraging new approaches to distance learning and interactive information exchange.

· **Encourage partnerships** among school districts, colleges and universities, community- based organizations, and businesses **to spark innovation** and new forms of technology.

- **Prepare teachers to effectively integrate technology into their classrooms** to help students master high academic standards.

- **Narrow the technology gap** by targeting high need districts and increasing their capacity to use education technology to prepare all students to achieve to high academic standards.

- **Increase access to job networks, training, and student tutoring** through community technology centers.

- **Disseminate information, promising practices, and teaching strategies** through the Regional Technology in Education Consortia.

It is probably clear that national governments have an important role to apply in carrying out broad strategies aimed at building the technology infrastructure and increasing the technological literacy of a society. It is also apparent that the role can be highly aligned with the strategies' intents and purposes. Now, it is important to examine the vision of the desired transformation so that a government, in playing its role and implementing its strategies, will use every available policy and resource opportunity to create its desired future. To stay on target, this vision provides a constant source of focus for the incentives and the monitoring moves of leaders.

High Expectations for All Students

How can leaders know whether a technology application will help them achieve their goals for 21st century learners and learning organizations? To be able to judge, leaders need to come to agreement on what students should know and be able to do, what teachers should know and be able to do, and what a transformed educational system looks like that can help them achieve their goal.

The International Society for Technology in Education (ISTE, 2000) provides part of an answer. In their recent publication of national educational technology standards for students, ISTE shows examples of teaching practices that connect curriculum and technology. They point out that traditional educational practices no longer provide students with all the necessary skills for survival in today's workplace. "Students today must apply strategies for solving problems using appropriate tools for learning, collaborating, and communicating." (ISTE, 2000, p.5) The following table lists characteristics of traditional approaches and the corresponding new strategies associated with a transformed educational system.

Traditional learning environments	-->	New learning environments
Teacher-centered instruction	-->	Student-centered instruction

Single-sense stimulation	-->	Multisensory stimulation
Single-path progression	-->	Multipath progression
Single media	-->	Multimedia
Isolated work	-->	Collaborative work
Information delivery	-->	Information exchange
Passive learning	-->	Active, exploratory, inquiry-based learning
Factual, knowledge-based learning	-->	Critical thinking and informed decision making
Reactive response	-->	Pro-active, planned action
Isolated, artificial context	-->	Authentic, real-world context

To help make the change from traditional classrooms to transformed classrooms using technology, the ISTE standards present educators with a set of new challenging high standards for students. Presented in six broad categories, the ISTE Technology Foundation Standards for Students are to be introduced, reinforced, and mastered by all students. In addition, according to the ISTE, "The categories provide a framework for linking performance indicators within the profiles for technology literate students to the standards." Teachers and school system leaders can work together to use these standards and profiles as guidelines for planning technology-based programs and activities in which students achieve success in thinking, communication, and life skills.

1. Basic operations and concepts

- Students demonstrate a sound understanding of the nature and operation of technology systems.
- Students are proficient in the use of technology.

2. Social, ethical, and human issues

- Students understand the ethical, cultural, and societal issues related to technology.
- Students practice responsible use of technology systems, information, and software.
- Students develop positive attitude toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.

3. Technology productivity tools

- Students use technology tools to enhance learning, increase productivity, and promote creativity.

- Students use productivity tools to collaborate in constructing technology enhanced models, prepare publications, and produce other creative works.

4. Technology communication tools

- Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.

- Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

5. Technology research tools

- Students use technology to locate, evaluate, and collect information from a variety of sources.

- Students use technology tools to process data and report results.

- Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

6. Technology problem-solving and decision-making tools

- Students use technology resources for solving problems in making informed decisions.

- Students employ technology in the development strategies for solving problems in the real world. " (ISTE, 2000)

With high standards like these for all students, a nation's entire education system needs to work together with its partners in the business community and public sector to leverage all available resources toward the purpose of a highly skilled workforce and literate community. Key to the collaborative work is a design for the preparation and support of teachers who know how to design effective learning environments for students. That brings us to the issue of professional development.

Teacher Preparation and Continuous Professional Development in Technology

Thus far, we have reviewed the principles of a national strategy to expand the use of technology in education. We've presented key roles that national governments can

play in setting the conditions that allow for innovation, that encourage the creation of new hybrid organizations and approaches in education, and that lead eventually to the complete transformation of education. We have reviewed the goals for this system, a new set of high expectations for all students. But if we do not address the teachers, all will be in vain. The success of schools is in the hands of teachers. Resources spent on teachers represent the major investment of education every year. They face our students every day. Their level of skills and knowledge and their ability to use technology to create the most effective learning environments possible are key capacities of the system.

Much of the literature on information technology and teacher education can be summarized in one sentence, according to Jerry Willis. (1996) " Most preservice teachers know very little about effective use of technology in education and leaders believe there is a pressing need to increase substantially the amount and quality of instruction teachers receive about technology. " (p.978)

In studies conducted in the United States, teacher education students nearing the end of their preparation programs said that they do not use the computer on a regular basis. When they do use a computer their primary use of it is for word processing. Most preservice teachers, according to these studies, do not have experiences using databases, spreadsheets, telecommunications, and educational programs. Thus, "although teacher educators use computers for word processing and other routine tasks, very few teach with or teach about technology," according to Willis. (p. 984)

To address these kinds of conditions in teacher preparation programs, we once again turned to the International Society for Technology in Education. In 1991, ISTE published Curriculum Guidelines for Accreditation of Educational Computing and Technology Programs. Every institution applying for national accreditation for teacher education using the National Council for Accreditation of Teacher Education (NCATE) standards must respond to the following guidelines.

Teacher preparation programs should prepare teachers who can:

1. Operate a computer and use a range of software.

2. Evaluate and use computers and related technologies for instruction.

3. Apply current knowledge about instruction and assessment to the use of instructional technologies.

4. Critically evaluate and use application software and instructional packages that include the use of technology.

5. Demonstrate knowledge of the use of computers for problem solving, data collection and management, communications, presentations, and decision support.

6/7. Design and develop a range of learning activities that effectively integrate technology-based learning activities. These skills should be demonstrated in the students' subject matter or level specialty and should include a range of student grouping strategies and meet the needs of a diverse student population.

8. Demonstrate knowledge of the ways and multimedia, hypermedia, and telecommunications can support instruction.

9. Demonstrate the ability to use productivity tools such as word processors, databases, spreadsheets, and print/graphic utilities with students and for the teacher's professional use.

10. Demonstrate knowledge of ethical, legal, and equity implications of information technologies in society and model appropriate use of these technologies.

11. Find and use the resources needed to remain current in the educational uses of information technologies.

12. Use information technologies to enhance personal and professional productivity.

13. Use information technologies to facilitate the emerging roles of students and educators.

If every prospective teacher leaving higher education were prepared in these ways, technology would be well integrated into the school curriculum. But we have a long way to go before that happens. In the meantime, most of the teachers who need to learn to use technology are already in the classroom. So our strategies and the roles we play in creating policy and resources must address the inservice teacher. To do that, there needs to be an entire system of professional development designed to help teacher's at several points along the continuum from early years of teaching through the maturing years of teaching and on into higher levels of educational leadership.

In work at the Vermont Institute for Science, Mathematics and Technology, a systemic design for Professional Development is emerging. The design of the system has involved key stakeholders from higher education, science and mathematics professionals, and teachers looking at and adapting a framework provided by the National Staff Development Council. (NSDC & NASSP, 1995) The NSDC Standards for Professional Development emphasize the role of leaders in providing a context for professional growth, the content needed to provide students with the best opportunities for learning, and processes for adult learning that model the processes desired in the classroom.

Professional Development is envisioned as a continuum from secondary education, through higher education, extending into the years of practice as professional educators. Crucially important to the success of professional development are the transitions between traditional institutions that educate people along this continuum and the use of advanced technologies to responsively deliver needed training and support to teachers. That is why extensive energy is being placed today on the preparation of teachers who will be prepared to use technology in teaching and learning, and upon creating a sustainable system of mentoring new teachers through their first few years of practice. New partnerships are encouraged between secondary schools and colleges, and

between colleges and the world of work, including the primary and secondary school system that is the world of work for future teachers. Future teachers are increasingly being prepared in field based internships that last as long as a full school year, taking most of their graduate courses in the field, in the school where they are "practice teaching." These intensive field placements, called Professional Development Schools (PDS), are often made with groups of future teachers working together in a close-knit community of learners, working under the guidance and supervision of a higher education faculty teamed with a teacher-leader from the secondary school.

The National Institute for Community innovations has found that professional development schools offer a rich setting for the infusion of technologies and new teaching approaches. The support systems and the openness to new ideas that are found in PDS's far exceed traditional teacher preparation programs and schools without outside professional influences on professional development. In a project that I will describe soon, A Virtual Professional Development School Consortium of 30 partnerships between higher education and secondary schools are experimenting with technology infusion and using telecommunications to extend and expand their work together.

At the heart of good Professional Development is a set of values shared by experts in human development, curriculum, instruction and assessment development, and by organizational specialists. Susan Loucks-Horsley and her co-authors in several publications (NSDC & NASSP, 1995; Loucks-Horsley, Hewson, Love and Stiles, 1998; Loucks-Horsely, et al, 1987) have emphasized some core beliefs that are worth mentioning here:

- Professional development experiences must have the success of all students and high standards for their learning at the core. With a great diversity of students in classrooms, and the enormous divisions present in all societies many resources need to be focused on learning and developing the best means for reaching all students.

- Excellent teachers in every discipline area have a special and unique kind of knowledge that must be developed through their own professional learning experiences. Pedagogical content knowledge - knowing how to teach specific concepts and principles unique to the discipline - must be the focus of Professional Development.

- Professional development experiences should reflect the same principles that guide the reform of student learning. People teach the way they were taught, so professional learning experiences should model the best practices of active, collaborative learning, and provide opportunities for elaboration of ideas and creative expression in communication about the solutions to complex problems.

- Learners need the content of learning to come from both inside and outside their own perspective and to be informed by both experience and the research of the others. An effective professional development system will balance these influences while guiding teachers to acquire the knowledge skills and attributes needed to completely transform education.

- Education and training of teachers and leaders must align with, support and sustain the larger reform agenda of the organization, the community, and the nation.

When professional development occurs in this kind of an environment, innovation is stimulated and supported and the evolutionary pathway can be charted, communicated to others and then widened for all to traverse. These are the conditions needed for specific models to arise that show the transformational uses of technology.

Transformational Technology Applications in Education

What does the new technology allow us to do that cannot be done without it? We don't want to focus on doing the same old things we do today but with a new tool, we need to think about what needs to be done differently. If we use technology to deliver the same education that we deliver today, we may gain a little ground in speed and efficiency, but learners will not exit with the new skills and knowledge they need for the 21st century. We must use the new tools to teach a new content, in a new way, for a new purpose in order to reap the maximum benefits of improving our economies and cultures.

Let us think again about Tom Carroll's story of sailing vessels that became steam-powered vessels, but whose purpose - shipping - became segmented into the overnight air and ground express package delivery system as well as an ocean-going business. The technology of the engine disrupted the old system completely and ended the monopoly of boats on overseas shipping. We can expect education and training to be disrupted and completely changed too. The disruption will come about as the new technologies at first show us the possibilities. Then the technologies are formed into adaptive hybrids, and finally, the new tools are used to build constructive transformations of what Phil Schlechty (1997) calls the roles, relationships, rules and structures of the old system.

Two projects in the U.S. help illustrate the transformative potential of the new technologies to create networks of leaders and new training opportunities in education. These projects use online environments and face-to-face learning to create a new level of integration of group collaboration in virtual as well as real spaces where the focus is on examining the quality of work in education. The work spans from student produced samples of fine arts, music and texts showing critical thinking and elaboration of ideas, to teacher and school leader work on the conditions of schools, the training and support of teachers, and the development of programs that use technology in teacher preparation.

The student-focused project is called "The WEB Project," a name which came about before the advent of the World Wide Web. The project began as an attempt to create records of evidence of student learning that spanned several technologies such as multimedia and use of telecommunications, but the project found as the World Wide Web developed that it could easily transmit and share work across the Internet. This led to the building of professional networks and groups of students and teachers who were learning from each other. (See http://www.webproject.org)

Students in the project create original work in their classrooms or at home, post their work on the internet and receive advice and ideas from other students, teachers and professional artists that are far away. The discipline-based professionals who offer advice use the professional language associated with the fields of knowledge. The project has found that there have been important learning gains on all sides. Students have acquired

more advanced vocabulary and understanding of the arts as they have sought out their teachers to help explain the professional comments left on the Internet. Teachers have also grappled with the new ideas and content of their disciplines in ways that are common to the profession but uncommon in classrooms, for example, using composition as a primary avenue of teaching about the expressive power of music. And the professionals have gained a better understanding of the earlier stages of learning in their discipline and as well, they have formed new relationships and friendships at remote distances. Best of all, in a few studies conducted by the project, student academic gains in other academic areas have been found as a result of student involvement in collaborative and creative work in the high standards and expectations environment. These results have happily come about for students who are most in need of academic improvement.

What is transformational about the WEB project is that the learner, particularly the challenges, intentions and questions of the learner, are made the center of the dialogue between partners in the education of the learner. This stands apart from the typical relationship of the school curriculum and a teacher driving learning. It has transformed the role of the teacher into a helper and translator of the professional vocabulary. It has changed the rules of learning into a responding system that is initiated by the learner. It has changed the relationships between learners into one of a network of critical friends. And it has changed the structure of learning into an any-time, any-place event.

The second project is "The Virtual Professional Development School Consortium," which has been funded by the U.S. Department of Education to create a new working relationship among 30 institutions of higher education in nine states. These sites are partners with primary and secondary schools in the creation of a new model of teacher preparation. In traditional programs of teacher education, future teachers spend as few as 12 weeks in a field-based experience in real classrooms prior to receiving their initial license. But many of those new teachers leave the profession within the first four or five years of service, and many believe this is due to an inadequate understanding of the realities of school life. Building on the experience of the medical profession, education schools in the 1980's began to establish intensive field based programs. Higher education institutions would form partnerships with primary and secondary schools in their community and would place groups of future teachers in the schools for an extended period of training and mentoring. However, only schools that were situated in close proximity to higher education received the benefit of these programs. My colleague Bob McLaughlin and I proposed to extend the reach of the partnerships by using advanced telecommunications technologies for delivering content and mentoring experiences to future teachers who were placed in remote locations.

The Virtual Professional Development School Consortium provides an on-line learning space for a variety of groups and colleges to work together in the preparation of teachers. The asynchronous network of schools and colleges extends nearly 3,000 miles and allows sharing and creation of work across those distances at any time of day or night. (See http://www.nici-mc2.org)

This project is transforming the relationships among K12 schools, higher education, and outside technical assistance providers. It is transforming the structures by which in these key players interact to plan and learn together. It is changing the roles of the classroom teacher, the higher education professional, and the future teacher by forming learning groups where these roles are equal players. And it is changing the rules

of what is considered a creditable learning experience by combining graduate studies with continuing education and ongoing research in the same project.

Conclusion

In order for nations to see the full benefits of increasing educational technology, the strategies and roles for the government must point to a new horizon for education. New technologies must be seen and as part of the evolution of the society's economy and culture with the understanding that in order for a transformation to take place, there must be a massive disruption and reconfiguration of the roles, rules, relationships, and structures of education and training. The change will take place by engaging people in creating and elaborating:

- The vision of the possibilities of the new technologies,
- The assistance needed to create new tools and form adaptive hybrids from existing tools and structures, and
- The continuous support to build toward a constructive transformation of the whole society for all of its members.

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National Institute for Community Innovations (NICI)	http://nici-mc2.org/
The NICI Campus and eLibrary	http://compass.nici-mc2.org/
The WEB Project	http://www.webproject.org/
The Vermont Institute for Science, Math & Technology	http://www.vismt.org/