Infrastructure, Education and Digital Libraries: The Roads of Civilization

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Abstract

This report summarizes the author's contributions to the Conference on Advanced Computers in Education (CATE'96), including: a keynote address, seminar on infrastructure and digital libraries, workshop on EduPort, and participation in the panel discussion on global education infrastructure.

Introduction

The Egyptian Ministry of Education, the Supreme Council for Research Centers and Institutes and the Academy of Scientific Research and Technology organized the Conference on Advanced Computers in Education (CATE'96), which was sponsored by the United Nations Educational Scientific and Cultural Organization (UNESCO) and by the American Society for Engineering Education (ASEE). The goal was to provide a forum to present the best research in the field of information technologies in education; and to exchange information and experiences in the area of advanced technologies in education. Particular attention was given to selection of projects and research that take into consideration problems akin to the developing countries.

This report focuses on two topics: infrastructure development and digital libraries. The discussion centers on applicability to enhance education. Section One of this report contains an approximate transcript of the keynote address delivered by the author at the conference. Section Two argues for the need to build a global education infrastructure. Section Three expands on this issue with an analysis of the meaning of infrastructure. The needed requirements for an education infrastructure, based on experiences drawn from the EduPort [1] initiative are outlined in Section Four. Section Five summarizes the overall recommendations of the conference organizers. Section Six provides a brief summary and conclusion.

The Roads of Civilization

In the history of civilization the country upon which we meet today has played a key role. The development of infrastructures has played a key role in the advancement of civilization. From the transportation, to the communications, to the emerging information infrastructures of the world, we trace the evolution of humanity in agricultural, to industrial, to information driven societies in the development of infrastructures. Technical, social and policy issues will determine how we move into an information rich society shaped by elusive forces that cannot be easily anticipated or controlled. But it is what we do with education that will eventually guide how these forces will be used. Education must guide the way to a Global Age of Information. We know that education has been virtually unaffected through the ages. It has been pointed out, that in any other discipline, a professional extracted from any past century would not be able to function given the technologies of today. Consider a physician or an engineer. A teacher, however, from any time in history, can

function and teach in our schools today, as they would have in the past. In many ways, that is but a monument to the teachers of this world. Again, consider a doctor or an engineer attempting to apply his knowledge without modern tools.

The fact remains, however, that changes are forthcoming which will make it difficult for teachers to teach, and for students to learn in information driven society without appropriate use of technology. And maybe, simply and irreparably, only some people, in some places, will have access to teaching and learning. But technology itself is not the issue, as technology is ephemeral in nature because it is always changing. Technology is not lasting, knowledge is. It is in the preservation and sharing of information, for the acquisition of knowledge that our chances for equity depend upon. The issue is how we use today's technology to build and provide access to the digital libraries of the future.

It is appropriate that we gather here, to advocate for the Digital Library of the future, one rich, common, and free Digital Library that will gather the collective legacy of human knowledge and information, that will make that information available to anyone, anywhere, anytime. Even as we do not yet have a good definition for what a Digital Library is, the world has known since the third century when we lost the first great collection of knowledge that mankind had gathered, it can be defined as a function of preservation and access.

These parameters, preservation and access, will take on new meaning in this forthcoming Global Age of Information. Therefore, we must now seek a model based on collaboration and sharing. At a very modest level, I can share with you one example of what we can hope to see happen when technology is merged with collaboration. Two years ago, in Lincoln, Nebraska, a large agricultural State in the center of the US, a group of educators and researchers worked to explore how a new education infrastructure might change people's lives. The result, a project called EduPort, has not changed any lives yet, but it has taken the hearts and minds of many people far from Lincoln, Nebraska, in the heartland of the US.

The people that made this happen are not unlike the rest of the people in this world, the place is not unlike any other place. We can all relate to the same desire to put our schools in focus, to make information technology plans gravitate around the learning needs of our children, everyone can hope for that. What we discovered is that technology exists for all of us to do it with. We discovered that the technology works equally well outside the laboratories, and would in all places; that there are no true barriers for its implementation. Collaboration, not technology, resources, or location, is the key. This is a replicable model, because we need not implement the specifications but the vision.

A school, a university, a phone company, and a technology company worked together to make this project happen. Concerns and difficulties in realizing the project were replaced with curiosity and expectation. The best in all of us came to bear in making it happen. After a few short weeks of implementation, and many years of collective research, children and adults were able to marvel, very early, at what access to information really means. It means not just bringing the world to our eyes and ears, but being part of the process that realizes that. And in doing so we discover that this must be done by all of us. No single entity will be able to decide independently and mandate the direction in which these technologies will take us, because it requires all of us to build the roads. The solution envisioned by Benjamin Franklin when he created the U.S. Library System, where small groups of people gather content to share with large groups of people, is now inadequate, if we consider that today a weekday edition of the New York Times, for example,

contains more information than the average person was likely to come across in a lifetime during his century. Faced with the problem that more information was produced in the last 30 years than during the previous 5000, Mr. Franklin would have thought of a very different solution.

Collaboration to create the Digital Library of the future must be accompanied by an ecology of information, where we all add, we all index, and we all retrieve. But to what purpose does the circle widen? In some ways we are seeing this widening of the circle in the success of the World Wide Web. For education, however, not all that is being included is useful, and most of what is useful is not being included. There must be an incentive for making information available. It is not safe to assume that all the information of the world will be made available for educational purposes by these means. We must have deliberate goals, plans and methodologies that will ensure that information which is useful for teaching and learning is made available, and in forms that make it useful and reusable.

This is why we need to envision with our hearts and minds where we want these roads that we are engaged in building, to take us. Because, unlike others, this infrastructure - we are all building - making us all responsible for where it will take us. During this conference we will examine the technologies that are needed for this Digital Library of the future. We will explore ideas for how to make this happen. We will think of what it would mean to make it happen. But most importantly, after this conference, if the vision is clear, we will build roads that go to where we want be.

On Building Infrastructure for Education

There are nearly six billion people on this world capable of learning every day of their lives. Indeed the human mind is the least utilized natural resources on this earth. People are separated by faith, culture, language, and political conviction, serious differences, that only understanding guided by education can begin to bridge. But there are other barriers to overcome that can be conquered through the use of technology. People are also separated by geography, time, and wealth. There is no education infrastructure to make quality educational resources available to all people, but there exist technologies to build it with. Technologies exist to conquer those barriers and bring about a level of equity in the distribution of knowledge that could have never been presented to this world as a feasible option before. Technology cannot bring about understanding among people, but it can be used to build the foundations for better understanding, for learning. It can be used to build an education infrastructure.

Wired and wireless *communications infrastructures* are already built and are being enhanced with the use of more advanced technologies for accessing information. Satellites deluge the earth with information streams that we are only beginning to learn how to harness. These things are already in place, growing in reach and sophistication, but already here. We need to put them to use for education in such a way that they will connect, not make the differences more profound. *Information infrastructures*, on the other hand, are not only here but have been around much longer. The concept of sharing information is one that has followed man through civilization. This is a concept that has been enhanced progressively and consistently over time. Library systems have been instituted, and over time information and communications infrastructures have been coupled to bring people and information together. The questions have always been, and will be no different in the future: Who will benefit? What content will be available?

Information and communications infrastructures can bring people together or can have a highly differential effect among people. The next great infrastructure - that is to advance our civilization -

will be global in nature and it will focus on education. But this infrastructure will be much harder to build because it must take into consideration all those barriers that separate people. Communications and information initiatives, in and of themselves can lead to unexpected, possibly undesirable results.

There is a widely recognized need for making education a primary activity among those that will be supported by the new information and communications infrastructures. Education comes first in most plans. But, we know that learning will not take place naturally as a function of access to information. Any educator, in any part of the world knows that learning is a deliberate process that occurs with significant amounts of teaching. There is a distinction between accessing information (in any form) and learning.

With the application of technology, learning can be achieved by means of such strategies as the use of CD-ROMs and other forms of interactive multimedia courseware, as well as internet-supported activities and courses, and remote two-way access to teachers and courses. None of these approaches constitutes an *education infrastructure*, unless they are made to work in concert and be useful to all people, to advance our collective knowledge. The challenge is to combine learning with content access, on a global scale, through the use of technology. That will result in an education infrastructure.

A Universal and Global Education Infrastructure is needed and it will not evolve spontaneously from a collection of technologies, practices and materials. It must be envisioned, planned and built. We know that technical standards are as important as are the practices and approaches that foster collaboration. And, methodologies for deployment are as important as technical specifications. But the goal is most important, and must be held in common. If we agree that a global education infrastructure is the goal, if so, then, how do we define that goal?

Defining Infrastructure

Before outlining the components of a new infrastructure for education, let's examine meanings. *Infra* means under, below or hidden. *Structure* is something made up of parts that are put together in a particular way. In all cases the *infrastructure*, in addition, would be put together for a particular purpose by definition, as a function of its parts. A *library*, on the other hand, is defined as a collection of literary and artistic materials, or the place to keep such materials. Audio-visual media, films, videos, and audio recordings, are included in this definition as both art forms and literary sources. There is an added aspect to the definition of the word library: "for reading, reference or borrowing": *a purpose*. The concept of digital libraries gives purpose to the task of building a new *education infrastructure*. *Digital* refers to a form in which these collections can be kept. Therefore we must consider that a new form of materials will impact the way in which we read, reference and borrow from libraries.

But it is most likely the infrastructure itself, based on these definitions, that would be built, not the (digital) libraries. Libraries exist. Literary and artistic collections exist. The creation of such materials is not a task in building (digital) libraries; rather the task is bringing them together (collecting them), for a purpose. The move towards digital form does not alter the purposes, except perhaps in that the concepts of borrowing and showcasing content might be replaced more completely by the concept of sharing. Historically, infrastructures have provided the foundations for a wide range of activities, both of social and economic natures. The parts that go into building a particular infrastructure should act together to provide the supportive environment in which the

activities that it is to support will flourish. Consider that the materials that are used for education are now also in digital form, considered that the collection of materials that are used in education will exist in both physical and digital forms. Existing education infrastructures, composed of schools, libraries, media outlets, supporting both formal and informal, group and individual learning, must be rebuilt or updated to accommodate the added emphasis on the digital form.

There is another reason why existing education infrastructures must be upgraded. There is another "part" that has come to play a role in education: *networks*. A network is a fabric, in and of itself a structure, made up of parts. Networks, human or machine, wired or broadcast, are components of a given infrastructure. Therefore we distinguish between the components of an infrastructure, in this case also a network, as well as the Digital Library, and the concept itself of an infrastructure.

Let us examine next the meaning of the word education. Education is generally defined as the act or process of educating and of being or becoming educated, as well as the knowledge that is obtained by means of this process. Education includes, among many other intangibles not covered by definitions, both the process and the results, and the materials or tools of the activity. An *education infrastructure*, therefore, would include many tools and resources needed to support this activity. But an education infrastructure should then not be confused with the process of learning. An education infrastructure cannot teach, but it provides support for teaching and learning. Therefore, an education infrastructure should not be designed to "teach" and "improve learning" (that is the mission of the activity), but to support quality and equitable learning, which hopefully will result in improved learning and improved outcomes from the same processes.

Finally, let us consider the concept of a *Universal and Global Education Infrastructure*. The word *global* comes to bear on the definition because of the network aspect of the infrastructure. Once we include a network, physical boundaries start to be obliterated, and the concept can and should become global. Conceptually global is more appropriate than *networked* in this case. *Universal* refers to content. We have the ability, as has been demonstrated with the advancement of multimedia technology, to support all classes of content in the digital form. The word education qualifies the infrastructure by referring to the activities that the infrastructure will support: *teaching and learning*. Therefore, we conclude with a definition for the concept of:

A Universal and Global Education Infrastructure, *as the foundation, or underlying set of components, that can be used to support various forms of networked teaching and learning activities; and to the organized collections of literary and artistic materials, in digital and other forms, needed to carry out those activities on a global scale.*

The EduPort Infrastructure

This section provides only an outline of EduPort, as a prototype and testbed for exploring the concept of a Universal and Global Education Infrastructure. More detail can be obtained from the EduPort Home Page and NewsLetter [2]. The goal of the project is to explore the issues in building, or rebuilding our education infrastructures, given new available technologies. It focuses on those technologies, accompanied by a methodology for their use. It also focuses on issues that relate to content, as the primary application that the infrastructure will support. The project has served as a research testbed, but it is now evolving into a practical initiative, and beyond an initial prototype, pilot sites are now under development. The fundamental aspects of EduPort included:

1. A systems architecture
2. An application framework
3. A model for collaboration

The research effort gravitates around the systems architecture and application framework, and it is based on conceptual exploration and applied practice. These aspects of the project drive requirements for the implementation model based on collaboration by researchers, technology and communications providers, content providers and specially the educational community.

Systems Architecture

The systems architecture serves as the blueprint for identifying and integrating the technologies needed to build the required infrastructure. What drive the design of the systems architecture are broad goals and discrete objectives. Development of the EduPort infrastructure requires first that these goals and objectives be clearly defined. The broad goals relate to building infrastructure, and the more discrete objectives relate to the deployment of pilot project sites. Implementation of the EduPort systems architecture requires these basic components:

1. Servers
2. Networks
3. End user or receiving devices
4. Digital libraries

These main components interact with each other to create the required infrastructure, in the case of EduPort, aimed at a regional scale. The following illustration shows a complete solution for the EduPort Architecture, including these four main components. Notice that distribution of content includes the use of both regional and gateway servers for scalability. Dissemination at local levels takes place via PC or TV devices, either directly from the Regional Server, or from the local Gateway. Available communications technologies play a major role in the deployment of EduPort. Wired backbones, both high speed (1.5 megabits/sec or higher), and standard Internet connectivity can be used to the limit of their capacity. The use of Digital Broadcast Satellite (DBS) from a headend connected to the Regional Server is also possible. DBS can be used for content download or for delivery of data via a *content carousel*. A *Data Carousel* is an IBM solution that allows the end-user to experience apparent interactivity with the data being broadcasted without the benefit of a back channel.

Application Framework

The EduPort infrastructure requires a comprehensive framework for its use and application. An infrastructure is larger and more encompassing than a given system, therefore a set of applications are not enough for exploiting such environments. The concept of a *framework* for application is more suitable. The application, in this case, that of digital libraries, is then synonymous with *content*. For the EduPort infrastructure that framework is a function of:

1. Content organization scheme
2. Methodology for integration with curriculum
3. Presentation, user interaction, user feedback

Content and information about content is stored in the library, along with knowledge on how to apply the content to target specific educational benchmarks (e.g., goals). The users reflect knowledge that is gathered from the application of the content back into the library in the form of annotations. An EduPort Home Page using the HTML standard employed by the World Wide Web

is used to gather, organize and present metadata about content. This framework provides the ecology of information that is needed for participation in the large-scale collection of knowledge for the Digital Library.

EduPort End to End Architecture

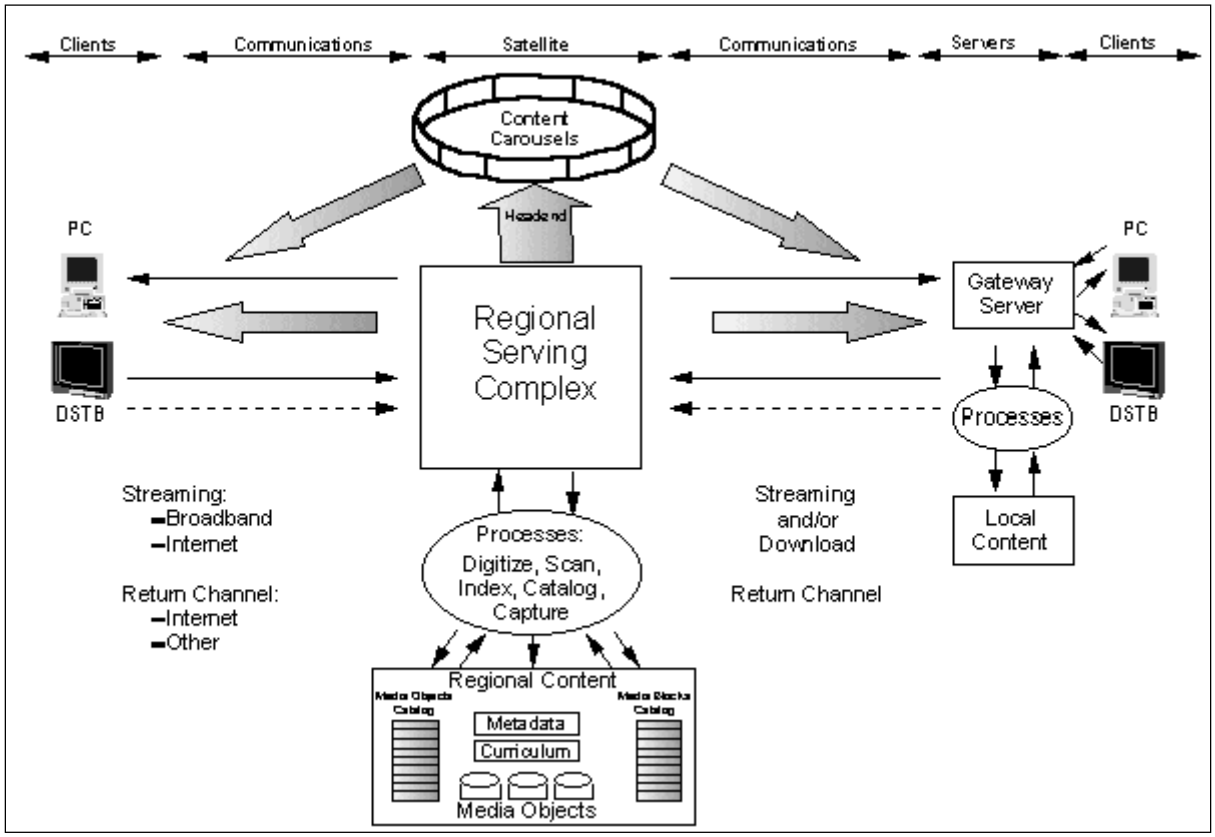

Figure 1. Diagram of the EduPort end-to-end integrated solution architecture.

Both the solution architecture and content models, illustrated in Figures 1 and 2, were engineered to support a universal and global education system, giving primary consideration to the preservation and access issues. The model for collaboration is at the interception of the two.

Model for Collaboration

Our model for collaboration includes a plan to:

- ✓ Identify and gather content that maps principally to curriculum goals.
- ✓ Convert content to digital form, index and catalog it according to given educational benchmarks.
- ✓ Organize content distribution on a regional basis.
- ✓ Organize content dissemination locally to schools, other educational institutions, and the home.
- ✓ Develop a technology solution for making the infrastructure accessible worldwide.
- ✓ Share information and influence standards, for use of digital technologies in education.

Sharing the burden of digitizing and indexing content is as basic to the goals of the project as technology is. It is important to establish a center of competence that can oversee the infrastructure development activities and maintain a balance between the growth of content and the reach of connectivity. In general a large project has more efficiency, but requires more centralized management and local deployment participation. In the case of EduPort, sharing content is essential to the growth of the infrastructure and its applicability, as more educational benchmarks can be gathered by increasing the Digital Library. The economy of scale of a collaborative effort results in maximizing available resources and minimizing cost per student, over all students serviced.

EduPort Content Framework

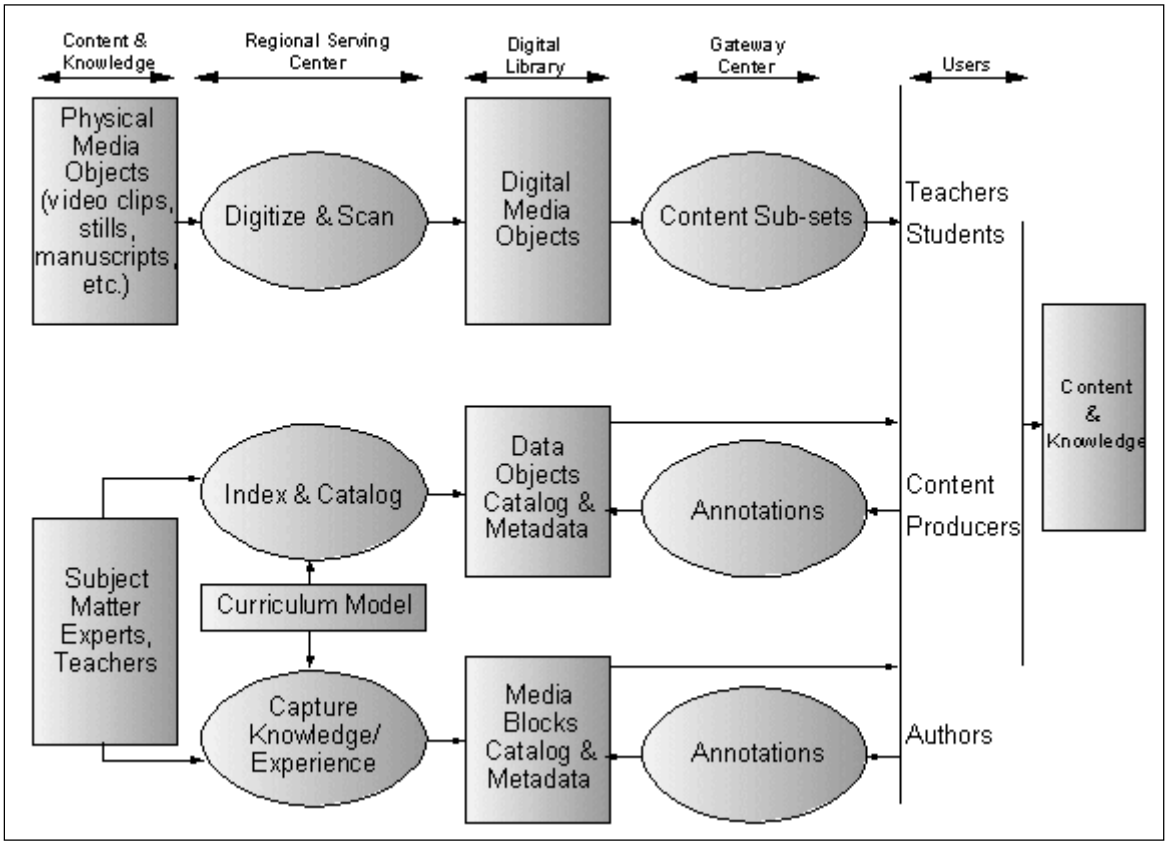

Figure 2. Diagram of the EduPort end-to-end content model.

Panel Discussion and Recommendations

Relevant to the issue of this report, the panel discussion that concluded CATE'96 focused on building a global education infrastructure. The guidelines used by the panelists are included in this section. At the end of the conference the organizers presented their recommendations. A summary of those recommendations is included in this section, as a concurring conclusion for this report.

Panel Discussion: Building a Global Education Infrastructure

This conference, not unlike every other forum on the topic, raised many more questions than it produced answers. But such are the questions that lead to solutions and plans of action. For exploring the concept of building a global information infrastructure, the following questions were presented to the panelists in order to elicit thinking and responses drawn from personal background and experience.

- ✓ What is a global education infrastructure?
- ✓ To what end should such an undertaking be directed?
- ✓ What are the elements of its construction?
- ✓ What technical and organizational models should be considered?
- ✓ How will costs be distributed?
- ✓ Through what vehicles will the educational communities around the world be able to participate?

In general, these questions drive requirements in the areas of:

1. Systems and communications
2. Content organization

How these requirements are addressed is determined by the by:

1. Services
2. Solutions

In our EduPort example such questions are covered in more detail in the various references to other reports [3 & 4], accessible from the EduPort Home Page. The services issue could be made as an analog to a plan or model for implementation because it relies on more than technical solutions. The services issue is social and economic in nature, and relates (among other things) to the question of cost and purpose. That aspect cannot be fully understood in global terms, but requires policies and other initiatives that have more local dependencies. Pilot projects can influence those policies, however, by providing guiding examples.

A collaborative model, such as advocated in EduPort, can be defined to bring the costs down and make the benefits more equitable. The model should be designed to deal with:

✓ Planning ✓ Sustainability ✓ Scalability ✓ Reliability

With respect to replicability the consideration is urged that pilot projects are of vital importance. In such demonstrations we are able to focus on the less subjective aspect of the problem: the technologies; and are able to learn by way of experience about the other more complex aspects: those that relate to people, learning, and policies, as they would apply to each region and locality. Pilot projects can be used to guide decision makers, and to keep the educational communities informed. These projects elicit envisioning by both groups. Without experience in these technologies, which are fragile and in the formative stage right now, vision is critically important. Indeed, vision and leadership are the keys to advancing the goals that are being proposed. These goals are moving us in the direction of paradigm shifts, order-of-magnitude and culture-affecting changes. Goals so profound deserve testing ground, and many opportunities to take hold.

We started out with agreement on what is perceived as a need to collect and preserve knowledge and information. Indeed this agreement, we recall, was reached during the third century, and has been revised by way of various deployments through the ages. Enhancing that concept now, with that of a new infrastructure to support information and knowledge gathering, dedicated to education, answers perhaps the most profound questions posed to the panel:

- ✓ To what end should such an undertaking be directed?
- ✓ How (at this point in history) advance our civilization?
- ✓ How to bring the world into a future ruled by technology and information?

Concluding Recommendations

Three days of exposition and interaction led to an extensive set of well thought-out group conclusions. These conclusions fall in three categories:

1. Global
2. National
3. National with global implications

Only those conclusions that apply globally are summarized here:

✓ Digital libraries will be the main tools for education in the 21st century. It is expected that digital libraries and super networks will enhance the ability of teachers and students to access materials. Therefore, building education infrastructure is a must. National and international projects must be initiated and supported immediately.

✓ The fast rate in the growth of information and information technology requires great efforts; to develop enhanced teaching skills and dynamic teaching curricula. The increasing role of multimedia computer-based learning must be coupled with the retraining of teachers in national educational institutions, to improve their capabilities in computer and information technology.

✓ Currently used methods of education and training must be modified to suit future (digital) information technologies such as multimedia, superconnectivity, educational video, distance learning, etc. Therefore, reengineering educational methods must be carried out to meet future national and international learning demands.

✓ The Internet is emerging as a powerful tool in teaching, training and exchanging of information, reflecting a new vision of learning in the educational process. The immediate start of national projects in distance learning environments, using computer-mediated communications and applying the World Wide Web is essential.

✓ National projects and software development for production of intelligent tutoring systems and intelligent agents in native languages must be encouraged. Building computer-based instructional software for linguistics and language processing in native language environments should be supported, using friendly interfaces, and by cooperative efforts of private and governmental sectors.

✓ The introduction of computer assisted learning for school children is the only way to overcome the technology gap between national and international educational systems. School libraries must be supplemented using the Internet and Digital Libraries.

Summary

The problem of supporting education with technology is large and complex, and must be addressed with dedicated plans and tools, not as a by-product of industry practices or other national initiatives. An education infrastructure, universal and global, is needed and will not emerge spontaneously from a collection of connectivity and technology developments alone; a total and integrated solution is required. The inherent problems relating to language and cultural difference make this particular infrastructure undertaking unique. We must consider that its goals are to educate and prepare people for participation in a global economy, and for life in the Global Information Age, goals difficult to deploy at regional levels.

Furthermore, a global education infrastructure requires participation in building of the dedicated Digital Library that will bring about the universality these goals. This library can be shared globally, but should support local needs. Inclusion of content should be a deliberate process. Costs and benefits are related to scales of implementation. Balance can be achieved by means of collaboration. The value that we place in the education of our children, in our future, is reflected in our current education systems. Dynamics of a world ruled by technology and information pose a great challenge to our education systems. These new infrastructures really challenge us to a future where no mind will be wasted, no potential unrealized. Let's seize that challenge!

Pursuing National Goals With Global Implications = Worldwide Goals

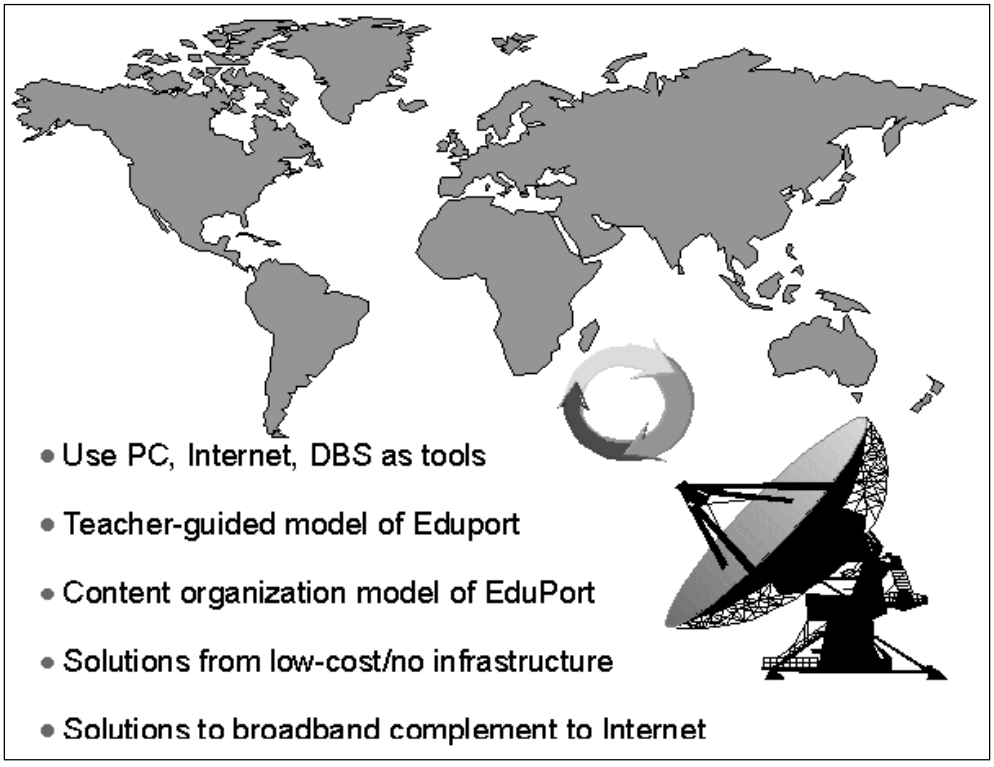

Figure 3. Summary and impact o the solution.

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