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ABSTRACT

A collaboration among teachers, education researchers, and computations scientists is described. The collaboration sought to apply advanced information technology in the K-12 classroom. In the Syracuse University Living Schoolbook project, developers created prototype Education Information Infrastructure (EII) services, conducted teacher team training, and established teacher projects to create multimedia content for EII services established. The EII services, which support new, individualized, interactive models of learning, are based on a client-server model linking high-performance multimedia servers with clients in the project schools over a gigabit testbed network. Seven integrated project layers and associated products and activities in the Living Schoolbook Project are identified: (1) assessment; (2) classroom; (3) curricula; (4) EII services; (5) Living Schoolbook prototypes; (6) core National Information Infrastructure services; and (7) base technologies. Large scale projects combining the expertise and resources of teachers, education researchers, computational scientists, the media industry, and computing and communications vendors are needed to develop education as a National Challenge application. (AEF)

**Paper**

# A Collaboration to Apply Advanced Information Technologies in Education

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## Abstract

A collaboration between teachers, education researchers, and computational scientists to apply advanced information technology in the K–12 classroom is described. Over the past year in the Living Schoolbook project, prototype Education Information Infrastructure (EII) services were developed, teacher team training conducted, and teacher projects to create multimedia content for EII services established. Large scale projects combining the expertise and resources of teachers, education researchers, computational scientists, the media industry, and computing and communications vendors are needed to develop education as a National Challenge application.

## 1. Overview

Our nation's schools struggle with an inadequate technology infrastructure, and our national workforce will soon lack the technical skill to compete in an information driven global economy. Education is one of our "National Challenges" (National Coordination Office, 1995).

This paper describes the early stages (now beginning year two) of the Syracuse University Living Schoolbook project to demonstrate a vision of the future using high risk high gain approaches with advanced technologies in education. We describe two EII services which support new, individualized, interactive models of learning. Our approach is based on a client-server model linking high performance multimedia servers at the Northeast Parallel Architectures Center (NPAC) with clients in the project schools over a gigabit testbed network. We are demonstrating leading technological approaches, and migrating our infrastructure design toward more widely available delivery strategies.

The recent convergence of the World Wide Web (WWW), the National Information Infrastructure (NII), and high performance computing and communications (HPCC) technologies is an important advancement that will further industry application of advanced technologies (Fox and Furmanski, 1995). Education too should exploit this opportunity, but this will require large projects and interdisciplinary teams. Our project combines temporary government funding, teacher teams, university researchers, content providers, public access, network support, and computer and communications vendors.

## Current Status of the Living Schoolbook Project

To summarize our experiences over the last year in the Living Textbook Project (Mills et al., 1995a, Mills et al., 1995b), now called the Syracuse University Living Schoolbook Project, we have:

- built a partnership of teacher teams, computational scientists, and education researchers with startup New York State funding;
- implemented a prototype state of the art Education Information Infrastructure based on NYNET, a wide area gigabit network donated to this project by the NYNEX Corporation;
- created two prototype Education Information Infrastructure (EII) services that run in our laboratory and are under test in our project schools (Fowler High School in Syracuse, NY, Rome Free Academy in Rome, NY, and Whitesboro Middle School in Whitesboro, NY;
- developed a process that allows teachers to leapfrog technical obstacles and create multimedia content for EII services that is integrated into their curricula.

The Living Schoolbook project has established a useful start and we argue that more of these types of projects are needed in order to understand the details of applying the nation's leading information technologies in education.

Section 2 describes our concept of EII services with illustrations of current prototypes. Section 3 describes our collaboration among project teachers, education researchers, and computational scientists. Section 4 summarizes our conclusions and recommendations on technology and education development projects.

## 2. Overview of EII Services

Education Information Infrastructure (EII) services are specialized services for education built on the National Information Infrastructure (NII), hence the name EII. We use the term EII "services" to distinguish the software we develop from software "applications" such as a text processor or graphics package. EII "services" might also be seen as "resources" that the teachers use to support existing approaches or create new electronic lesson plans. EII services leverage rapidly advancing World Wide Web, NII, and HPCC and grow as the supporting technologies grow.

EII or digital information services for education are important because they offer an ability to index, retrieve, and customize content for individual learner use. This supports learner-driven navigation, linking concepts and media formats, and crossing traditional disciplines to create interactive models of learning.

### Prototype EII Services

We have two EII services under development in the Living Schoolbook project—a Network Exploratorium and an Interactive Journey. The Network Exploratorium is a digital library incorporating digital video, image, and text content in a client-server model. This digital archive can be browsed and searched over the network providing a multimedia "information on-demand" resource in our project schools. The very successful Kids Web project (Coddington, 1995a) prototypes the Network Exploratorium.

We use a web interface to a text retrieval engine (currently freeWAIS SF) to search video content based on descriptive text (closed captioned text). Teachers and kids can search the text database, retrieve a video clip based on the search, and view the MPEG clip over the NYNET ATM network. We also have examples of image on-demand and text on-demand databases accessible to project schools over the Web.

*The Interactive Journey*, still in software development, is based on a digital terrain and landcover database, a graphics rendering program providing terrain navigation, and web links to spatially-located multimedia databases (Coddington, 1995b). A geographic information system is a natural way of organizing spatially located databases. We believe that real time three dimensional navigation of our state or local region will provide a compelling educational environment for learners.

The Albany, New York, area in our Interactive Journey of New York State will allow students to navigate the state, stop in a region of interest, and link spatially located multimedia databases via web buttons.

### Building EII Services

Within the next five years, we expect the infrastructure required to deliver EII services to schools to become widely available. Today we can build useful interfaces to text and image content sources with plain old telephone service and high speed modems. However, digital video delivery places an approximate 100 times greater performance requirement on the infrastructure.

Powerful PCs and set top boxes connected to high speed networks is a likely scenario for 100 million homes, offices, and schools. Decoding a compressed video stream at the client end requires a powerful processor (software approach) or specialized video decompression chips (hardware approach). Full-screen NTSC digital video requires a network performance of 1.5 megabits per second. Phone line modems deliver one percent of this performance, and ISDN phone lines delivery ten percent of this performance (128 kilobits per second). We expect that education, business and other non-entertainment applications will be well served by a network providing less than full-screen thirty frames-per-second video quality.

Building EII services and using them in the classroom is an integration task connecting seven project layers ranging from the underlying technology base to assessing the impact on learning in the classroom. Table 1 below outlines seven project layers and associated products and in the project.

**Table 1. Project Layers and Associated Products and Activities in the Living Schoolbook Project**

| Project Layer | Products/Activities | By Who |
|---|---|---|
| 1. Assessment | Impact of EII services on learning | Education Researchers |
| 2. Classroom | Teaching, learning, creating content | Teachers, children |
| 3. Curricula | Modules, teaching units, frameworks | Teachers, Education Community |
| 4. EII Services | Network Exploratorium, Interactive Journey | Computational Scientists, Teachers |
| 5. Living Schoolbook Prototypes | Kids Web, multimedia databases | Computational Scientists |
| 6. Core NII Services | video on-demand, web navigation, multimedia | Computational Science Community |
| 7. Base Technologies | World Wide Web, NII, HPCC | Computational Science Community<br><br>vendors |

Teachers lead Layer 2. Classroom teaching, learning, and content building activities; project computational scientists build Layer 4. EII Services, and Layer 5. Living Schoolbook prototypes. Project education researchers lead Layer 1. assessment activities and work with teacher teams and computational scientists to integrate layers 2 through 5.

The Living Schoolbook project attempts to apply in education what has become a standard approach in all other National Challenge applications (e.g., civil infrastructure, digital libraries, energy management, environment, health care, manufacturing, national security, public access to government information). The elements of this standard approach include:

- using an infrastructure established for other purposes, an extension of the dual-use concept (military technologies applied in public sector) to multiple-use, all

National Challenge applications must use the same national infrastructure, note that our project does not build Layer 7. Base technologies in Table 1 above;

- a hierarchical client-server model, which is the most cost-effective approach, the model of millions of clients accessing a few thousand information servers over networks was enabled by the World Wide Web and reverses the trend toward standalone desktop computing of the 1980s;
- using scalable technologies, which is essential to building and managing cost-effective large systems, this approach established by the 1992 High Performance Computing and Communications Initiative which established the national Grand Challenge science program and advanced HPCC technologies;
- modular components, following the principle of software re-use which is essential in today's rapidly changing technology industry, products tend to be obsolete the moment they are introduced when developed by traditional software engineering practices;
- community technology standards, which are necessary to all of the above goals, systems must be open, portable, and interfaced with the Web.

Current education and technology initiatives tend to emphasize equality of access, the lowest common denominator for technology, and teacher driven initiatives. These are certainly critical issues, but for schools to leapfrog the present situation of a non-existent technology infrastructure into the modern information age of the 21st century, we must bridge the gap between the classroom and the advanced technology R&D lab.

We invested a great portion of the resources of the Living Schoolbook project to link classroom teachers with computational scientists to carry out the integrated set of activities outlined in Table 1. K–12 teachers do not have direct access to core NII services such as video on-demand technologies, or base HPCC technologies such as high performance database servers. Teachers need computational scientists for their technical expertise as computational scientists need teachers for their educational expertise. We recommend this as an appropriate model for funding agencies to consider while developing education as a National Challenge application.

## 3. Building a Collaborative Development Model

Section 2 outlines our concept of EII services and describes some of the integration tasks required to deliver these services over a network to the classroom. How do we go about developing rich sources of content and put these resources in a useful form for the classroom?

Our approach was to implement the project infrastructure (NYNET ATM gigabit wide area network) and project workplan over the first nine months of the project. The infrastructure design was top-down. The workplan, however, was outlined generally and crafted to allow a wide range of control for the schools and teacher team members. We developed a set of prototype EII services which teachers explored and made recommendations on how to improve. Our project coordinator is a classroom teacher who links project partners and the schools while serving as coach for the teachers as they negotiate the technology and the research and development environment of the project.

We conducted a series of teacher team workshops (10/94, 1/95, 3/95, and three in summer of '95) to build ownership in the project by teachers, and true collaboration between teachers, education researchers, and computational scientists.

## Training Sessions

Training sessions were held using a "jigsaw" instructional setting where after an introduction, teachers selected areas of interest for further training: client technologies (Power Macintosh and Silicon Graphics Indy), video conferencing, and Kids Web, the Network Exploratorium prototype. Training sessions built technical confidence among the teachers who then served as an "expert" for their school colleagues. This model of training minimizes the time project teachers are asked to leave the classroom, maximizes the time teachers spend together in groups, and builds teacher interest and confidence in the project.

## Multimedia Content Development

In the project startup phase, we provided technical training and proposed that teachers create web sites for their schools. Teachers maintained control of the design, content development, and pace of production.

During the June, July, and August '95 workshops, teacher teams designed projects around our prototype EII services. To address curricula issues, teachers early on determined what content would be meaningful to students and useful in classroom projects, and designed multimedia projects around the Network Exploratorium and Interactive Journey services. Design and content production is led by the teacher teams; project computational scientists incorporate the content into NPAC databases interfaced to the web, and deliver these services via NYNET to the project schools.

Three Whitesboro teachers (middle school science, history, and computers) designed a local component of the Interactive Journey where students visit the Herkimer Home, a local historical site, and "tour" the architecture, artifacts, gardens and natural history, the site, the location of the site, and its historical significance (see Figure 3). Two Rome teachers (art, social studies) designed an Exploratorium project based on historical art in the Central New York region. Drawing on small museums, publicly owned paintings, and the Oneida Indian Nation, this project documents folk art, Native American, and Work Progress Administration art styles and its historical context. A team of Rome/Fowler teachers (English, Journalism, Foreign Language) designed a community ethnology project to link Web-based content on race, age, and gender with video-taped interviews by students of various community groups to create a database on local social perspectives.

Nearly a year into the project, during the stage of multimedia project, design teachers put aside the technical obstacles they were struggling with (e.g., web, client machines, file transfer) and concentrated on developing innovative educational services. This step by the teachers is absolutely necessary to our project model of collaboration between educators and computational scientists to create innovative education services.

## Technology Issues

Our success in implementing a state of the art information infrastructure for education, developing prototype EII services, and establishing a process for building educational content by teacher teams resulted from a dedicated effort to build an innovative project by all partners involved (see Mills et al., 1995a, 1995b).

Must technology work the first time for teachers to proceed? In the Living Schoolbook we are attempting a high risk, high gain approach. Teachers use a research network that is susceptible to downtimes due to experiments, demonstrations, and routine network upgrades. We have found that teachers can work in the same volatile environment as researchers. Difficulties with technology of course occur and are disruptive. Obstacles in our project ranged from a personal level (a teacher may find it difficult to innovate after

30 years of traditional teaching), to very specific hardware issues such as machine crashes, file transfer problems, unfriendly UNIX security warnings, and Internet performance issues.

## 4. Summary and Conclusions

The approach of teaming application experts with computational scientists had worked successfully in many disciplines (Fox, Williams, Messina, 1994). Large systems, advanced technologies, and multidisciplinary teams have been used to advance other Grand Challenge and National Challenge applications, and should be used in education too.

However this approach does not appear to be embraced by the education community where emphasis is focused on teacher-led initiatives, bottom-up program design, and the poor state of our schools' technology infrastructure. We contend that we also need leading examples to show what could be done with advanced technologies in the classroom. The Living Schoolbook Project is a useful start but many more of these projects are needed to understand the implementation details of using advanced technologies to improve learning.

In a collaboration between teacher teams, education researchers, and computational scientists, we prototyped two Education Information Infrastructure (EII) services, a Network Exploratorium and an Interactive Journey. The Network Exploratorium is a general multimedia digital library built on a client server model delivered over a high speed network to the classroom. *The Interactive Journey* is a spatial organization of multimedia databases built into a three-dimensional navigation environment. Teachers are creating multimedia content and computational scientists are building the high performance multimedia database servers to host these services.

Building EII services is primarily an integration task; we defined seven project layers (assessment, teaching and learning, curricula, EII services, project prototypes, core NII services, and base technologies) combining the expertise of teachers, education researchers, and computational scientists. To advance education as a National Challenge application, it is clear that computational scientists need the education expertise of teachers, and teachers need the technical expertise of computational scientists. We observed a major step at the conclusion of year one in our project when teachers put aside technical obstacles and began to design innovative classroom projects and build supporting multimedia content. A state of the art technological environment is by nature subject to occasional downtimes and failures, but teacher demonstrated that they can work in the same volatile development environment as researchers.

## Glossary of Terms

ATM—Asynchronous Transfer Mode

EII—Education Information Infrastructure

HPCC—High Performance Computing and Communications

ISDN—Integrated Services Digital Network

LSB—Syracuse University Living Schoolbook Project

MPEG—Movie Picture Expert Group

NII—National Information Infrastructure

NPAC—Northeast Parallel Architectures Center at Syracuse University

NTSC—National Television Standards Committee

NYNET NYNEX Corporation wide area ATM network

WWW—World Wide Web

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