

Using the WWW to Build Learning Communities in K-12 Settings - Part I. Global Network Navigator

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Using the WWW to Build Learning Communities in K-12 Settings

by Douglas N. Gordin, Louis M. Gomez, Roy D. Pea, and Barry J. Fishman

When students engage in school-based learning communities, they actively digest information.

In this two-part series, we will begin by looking at the current state of the art in Web-based technology for education through the lens of building learning communities. "Part II: The Next Generation of the Web Servers to Support Learning Communities" will address a vision of future education Web servers and the type of education Web server we plan to develop as part of the CoVis Project.

Part I: The Current State of the Art in Web-Based Technology for K-12 Education

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What are learning communities?
Building learning communities depends on good resources and communication links
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Examples of current resources: Data and analysis tools
Examples of current resources: Communication tools
Collaboration between students and work-based learning communities
Appropriating students' work into a community of practice

The World Wide Web (WWW) can play a vital role in the formation and successful operation of learning communities. Just 18 months ago, there were but 100 WWW servers online worldwide, while today there are over 10,000 WWW servers. Current estimates predict 100,000 WWW servers a year from now, according to M.K. Gray's *Measuring the Size and Growth of the Web*. This decentralized development of information resources, which cover everything from scientific databases to corporate products to traffic and weather reports, is an exciting development for the creation and support of learning communities. Many organizations and companies have developed these resources; only a few have given consideration to how the information might be used by K-12 education. By examining the current K-12 resources on the Web, we can begin to speculate about where educators, students, and others in the learning community may be taking the Web.

What are learning communities?

Learning occurs in the context of a community's accepted practices, values, and language. According to P.J. Hill's "Communities of Learners: Curriculum as the Infrastructure of Academic Communities" (1982), school-based learning communities are formed by students and teachers who engage in long-term cross-disciplinary projects in which students work together collaboratively. These collaborations allow them to learn from one another; they can determine what type of knowledge needs to be acquired based on the problems at hand. In work-based learning communities, students learn the practices of a discipline or profession, with the historical example being apprenticeships. Here the profession defines a "community of practice" that the student aspires to join; this term refers broadly to the practices of a field, its social organization, and its mores. Schools can play a role here too by helping connect students and work-based learning communities and encouraging students to critically reflect on the communities in which they participate. Access to resources and communication is essential to all types of learning communities.

Building learning communities depends on good resources and communication links

Learning communities are difficult to build because they require interactions with busy professionals and a variety of materials. In school-based learning communities, students have access to specialized information,

practitioners, and relevant data and analysis tools, as well as the means to present, defend, and revise their work based on the learning community's critique. For example, a teacher asks students to investigate the history of cotton production and the impact of those changes on the experience of the workers. Such a survey requires students to trace the history of technological innovations, interview current workers and research the lives of former workers, and to express and discuss their results. The Web could expedite these needs enormously by providing ready access to historical documents, books, and other reference material, and by enabling communication with appropriate people outside of the classroom. With the assistance of software such as the CoVis Collaboratory Notebook, the Web can also help students structure their thoughts and project work.



using the Web to the CoVis Project



using the Web to learn more about the Collaboratory Notebook



using the Web to read *Collaborative Hypermedia for the Classroom and Beyond: A Year's Experiences with the Collaboratory Notebook*

The needs of students in work-based learning communities are similarly demanding, including the need to learn about community practices and products, to find participants in the community who are looking for an apprenticeship, to build and store an accessible portfolio of work, and to reflect and critique the apprentice experience. These new connections to work-based learning communities that the Web affords are not necessarily designed to turn students into lifelong professional practitioners, but rather to provide an opportunity for them to understand and investigate many fields. The success of apprenticeships historically has demanded years of service, during which the initiate was immersed in all aspects of a profession. The hope is that shorter, more focused, and more varied experiences can serve to educate students in a variety of fields, thus providing them with the ability to integrate diverse expertise and to choose a field based on experience rather than on inheritance or chance.

In learning communities, students must connect to the existing communities of practice. For example, if a school-based learning community decided as a class to build a sturdier or more agile kite, students would review documents and pictures from resources on aerodynamics, kite manufacturing, and the atmospheric sciences. They would also contact community members working in these fields. The following list is designed to describe the increasing levels of interaction with a learning community:

1. Students access published work, such as papers, figures, presentations, and analyzed data.
2. Students access tools and raw data, such as, equipment for production, laboratory procedures and materials, community developed data sets, and analysis tools.
3. Students communicate with community members, either in written form or orally, such as by exchanging letters, email, or telephone calls, and by conducting interviews.
4. Students and work-based learning communities work together, such as performing an experiment together or planning collaborative activities.
5. A work-based community incorporates student work into published archives of its community's work (e.g., when scientists collect and use data collected by students).

This list will be used to organize the discussion found below on how the World Wide Web can be used to form learning communities. These categories are intended to guide next-generation WWW application design and future technology adoption strategies.

Examples of current resources: Reference tools

When students engage in school-based learning communities, they actively digest information. In pursuit of long-term projects and in defense of a controversial hypotheses, students must find relevant information. It is

in these information-seeking situations, rather than in just browsing for information, that we believe the WWW shows the most value for the K-12 community. The following examples barely scratch the surface of what is available. Our aim is to show utility to students, rather than to provide even a representative summary. The information resources for K-12 education provided by the WWW can be divided into five categories:

Libraries Many libraries are pursuing the opportunities for information exchange that the WWW allows. A noteworthy site is the North Carolina State University library.



using the Web to North Carolina State University library

Perhaps the quintessential vision of online information access for the information superhighway is placing the Library of Congress on the network. The difficulties in converting its current vast holdings of paper books into digital media also illustrates the distance that must be covered. However, the first step in this journey has already been taken, as can be seen by the Library of Congress home page. The general vision is simple and powerful: place the holdings of the Library of Congress online with flexible search engines, thus providing unprecedented access. Students could pursue virtually any topic, no matter how obscure or popular, without having to worry about whether the book is not in the inventory of their local library or it has already been checked out.



using the Web to the Library of Congress

Museums For example, the Museum of Paleontology has been erected on the WWW by University of California at Berkeley. A diverse collection of dinosaur images and information provides a particularly welcome resource for K-12 students, who are often fascinated by the ancient giants. Through these new venues, museums and libraries are continuing their primary task of providing access to cultural artifacts and descriptions of nature. The ability to visit the museum via the Web redefines what it means to "go" to the museum. For example, providing a picture of a dinosaur is much different than standing before a 55-foot-high reconstructed skeleton. The nature of these virtual visits will determine what is made available online.



using the Web to the Museum of Paleontology

Government Information Government information provides a treasure trove for those hoping to understand our society and to those who act as watchdogs. For example, through accessing government information and statistics, students can reevaluate newspaper editorials and study the human impact on the environment. In the latter example, the Environmental Protection Agency provides numerous data sets and statistics that students can access online.



using the Web to the Environmental Protection Agency

Similarly, the United States Geological Survey provides information and curriculum units.



using the Web to the United States Geological Survey

Another example is the United States Bureau of the Census, which publishes data and analyses through the WWW.



using the Web to the U.S. Bureau of the Census

Through analysis of these governmental data sets, students can examine anthropogenic changes in our environment and evaluate which populations will be affected, including both the number of people and their demographic characteristics. The goal is for students to acquire a deeper sense of their own community by summarizing its characteristics and contrasting them with other areas.

Curriculum and Activities The examples above were intended to illustrate the utility of these data sets and also to suggest the tenor of potential projects: Students can go beyond merely reporting facts and figures to using them to test or promote a theory. Often students need guidance to effectively use the information that can be found in remotely accessible libraries, museums, and government databases. A traditional way to package such guidance is through prespecified activities or a curriculum. Thus the WWW provides a new medium to deliver these curricula. A procedural example is provided through a lab experiment to dissect a frog, turned into a WWW interactive session by the Instructional Technology Program at the Curry School of Education, University of Virginia. Ample use has been made of images that illustrate the steps involved in the procedure. In addition, snippets of video are provided that show students going through these steps, thus providing a model to imitate. This multimedia presentation permits specification of the laboratory procedures well beyond what can be provided in a textbook. Further, the text, images, and video are flexibly intertwined, thus providing a more integrated context than a videodisk would.



using the Web to the University of Virginia's frog dissection page

Indices Resource indices such as Yahoo and search engines such as Lycos are valuable tools students can use to search for resources. However, pattern-matching on keywords is not sufficient. Richer and more flexible indexing strategies are needed. Pragmatic indices can be created that are designed to help accomplish tasks (as opposed to subject indices, which group together material on a similar topic). This type of task-oriented searching may facilitate students' exploration of the WWW by allowing them to flexibly and explicitly list their goals when accessing a link, thus providing the opportunity to maintain an external memory and executive assistant. In any case, the structure of the information and resources being provided by the WWW must be more clearly conveyed so that students can mine its extraordinary riches.



using the Web to Yahoo



using the Web to Lycos

Examples of current resources: Data and analysis tools

A more sophisticated level of access for students to communities of practice provides them with online tools to manipulate data and display it in a visual format. This ability allows them to analyze and interpret the data in new ways. Many of the tools currently available lack the necessary context to make them truly valuable to students. Nonetheless, the appearance of these dynamic tools is an important step in moving education beyond a model of student-as-consumer to a model of student-as-active-inquirer. The following examples are grouped by category:

Weather Maps Purdue University's Department of Earth and Atmospheric Sciences has developed a server that allows students to select weather images and data that are updated hourly, thus allowing students to do weather prediction and investigation.



using the Web to the Weather Processor

Scientific Visualization The tools used by an expert community often help define the basic questions and assumptions used. In particular, scientists in recent years are employing scientific visualizations (SciVs) as a primary means to communicate discoveries and to perform speculative investigations. A common use of these visualizations on the WWW is to provide different views of data in order to help determine the data needed. For example, the Lamont-Doherty Earth Observatory of Columbia University will dynamically render climate data sets as directed through a vast array of parameters as well as provide the underlying data to the user.



using the Web to the LDEO Climate Group's Data Catalog

Similarly, the Pacific Marine Environmental Laboratory of the National Ocean and Atmospheric Administration (1995) renders several oceanic data sets and will deliver the data to users in spreadsheet form.



using the Web to Live Access to Climate Data

Another example comes from the Learning Through Collaborative Visualization (CoVis) Project at Northwestern University. Practicing atmospheric scientists were interviewed and their methods and data analyzed, leading to the design of specialized educational software the students could peruse and use to construct SciVs of climate and the earth's radiation budget. These visualizations are provided at multiple levels of detail to aid students in detecting large and small grain patterns within the global climate system.



using the Web to Scientific Visualizations of the Earth's Climate

Interactive Mapping Evaluating the data available on the WWW often requires flexible tools that allow the iterative selection of data and analytical operations on it. Tools like this are becoming increasingly common on the WWW through the use of forms. An example of a WWW server providing interactive analysis of data (even before the introduction of forms) is Xerox's map server. This server facilitates the interactive exploration of digital maps; users can select a part of the globe to examine, zoom in on the globe, and specify what aspects of it to portray (e.g., rivers or political boundaries). In this manner, not only is information provided, but an environment for querying and investigating that information is specified. A fascinating example has emerged of an application that combines the information on recent earthquakes with the Xerox map server to provide customized maps of where recent earthquakes have occurred.



using the Web to the Xerox PARC Map Viewer

Examples of current resources: Communication tools

Students, teachers, schools, and professionals use communication media on the WWW to forge school-based learning communities. Interactive mechanisms are still relatively undeveloped on the WWW, but include forums, which are similar to Internet newsgroups, and chat sessions, which allow synchronous communication of short messages between users. These facilities have potential beyond that of Usenet newsgroups and Internet Relay Chat (IRC). These possibilities arise from the flexibility of the WWW to incorporate multimedia, hypertextual links, and structured forms. Some of these advantages are realized in the communication mediums reviewed below; in particular, we are interested in those capabilities that allow students and teachers to create logs of their activity and in their collaborative construction of Web pages. We expect development of structured interactive communications like these to be one of the most important

developments for the establishment of learning communities. The examples provided here are grouped into three categories.

Connecting teachers and students with one another This category refers to connections both within a single classroom and across classrooms. Washington, D.C.'s Gonzaga College High School is using its Earth System Science Community Curriculum Web server as a place for students to file progress reports on their activities, to list problems or questions, and to enumerate the resources they employed that day.



using the Web to the Earth System Science Community Curriculum

Teachers file reports as well. These reports are available to the entire community (indeed to the entire WWW), though selected portions (e.g., the teachers' reports) are password-protected. These facilities provide an excellent example of how the WWW can be used to forge a school-based learning community that is also open to work-based learning communities. Scientists and others could potentially serve as mentors by observing the students' ongoing work and through understanding the suite of tools and data that help comprise the environment in which they are working.

The CoVis Project has established WWW pages that students and teachers collaboratively construct by adding WWW sites along with a description and annotation.



using the Web to the CoVis Classroom Home Page

These pages serve as a place to share key "finds" on the WWW with each other. Another example of annotating the Web is the provision for newsgroup-style threads, which may include pointers to WWW pages.



using the Web to start a new thread

Another exemplary project is Web66, which helps teachers and schools get started publishing on the Internet by setting up FTP, Gopher, and WWW servers. While this style of communication does not fit with the interactive motif of this section, Web66 does provide interactive communication by maintaining a listserv that connects educators who are supporting WWW servers.



using the Web to Web66

The Global Schoolhouse Project is also seeking to build a community between schools. Their WWW server provides an asynchronous electronic spine as a repository of diverse information, including a description of the project's goals, a list of its participants (organized by school, with home pages for teachers and students), a "hot list" of software being used by the project (i.e., clicking on the name of a piece of software transfers it via FTP), and access to mailing lists and curricula.



using the Web to the Global Schoolhouse

Another area where efforts have begun, but are not yet well developed, is in establishing a learning community among teachers. This is particularly important, because teachers are often shut off from professional contact with their fellow teachers and researchers due to the physical architecture of educational environments, namely separate classrooms with one teacher and many students. The Web can provide vital links between teachers, allowing them to share professional advice and to adopt new practices and methods. Mechanisms of fostering such change are crucial if new technologies are going to be successfully incorporated into classrooms before a

new generation of teachers enters the profession. An exemplary effort in this regard is the Texas Education Network (TENET) project, which seeks to forge community and pool expertise among that state's educators. One aspect of TENET is their WWW server, where a wide range of information can be found, including legal, technical, and practical aspects of telecommunications.



using the Web to TENET

Connecting parents and local communities with schools One advantage of the WWW is that parents and interested Web users can provide students and teachers with an attentive audience. The primary audience for students is usually teachers; thus the performers are always vastly outnumbered by the audience members. When a school uses the WWW to make student work available to the broad-based audience of the Internet, students suddenly have a new, greatly expanded audience for their work. A number of schools have started to make student work available in this way. One notable example is Grand River Elementary School in Lansing, Michigan.



using the Web to Grand River Elementary School

The students of Hillside Elementary School in Cottage Grove, Minnesota, also provide a Web page to the public.



using the Web to Hillside Elementary School

Both of these schools assist students in creating their own personal WWW pages, in effect giving the students a personalized presence on the Internet. If a school is able to make student work available online, a leap is made from showing parents what students *should be* doing to what students *are* doing. Beyond seeing their own child's work, parents can view the work of other students. This allows parents to see how their child compares to others, so that they can judge their child's academic progress based upon quality of output, not on grades or class rankings. Furthermore, through the addition of a forms-based interface, parents could provide feedback or critiques on their child's work.

Local communities serve as another primary audience and source of resources for schools. The WWW can provide schools with an alternative mechanism for communicating with their local communities. For example, people who live in Arlington, Virginia, can get current information about their local public schools online.



using the Web to Arlington, Virginia

The Houston Independent School District has taken advantage of the excellent Armadillo WWW server at Rice University to announce the mission statement for a new lab school.



using the Web to Armadillo

Putting students in touch with experts Only a few WWW sites have facilities that put students directly in contact with practitioners, experts, or scientists in order for students to ask questions. For example, "Ask Dr. Math" allows students to present mathematics problems to the team at the Geometry Forum and receive answers to their questions.



using the Web to the Geometry Forum

Other resources use the WWW to publicize how students can contact experts outside of the WWW. For example, the United States Geological Survey advertises its "Ask-A-Geologist" service.



using the Web to Ask-A-Geologist

Collaboration between students and work-based learning communities

As stated earlier, the WWW is not being used directly to accomplish collaboration between students and practitioners or experts in long-term meaningful ways. Instead, some WWW servers are helping to publicize efforts that are occurring using other communication facilities. One of the most fascinating of these is the JASON project, which seeks to build community by having students remotely participate in scientific field trips or "telepresence." Such trips are accomplished through highly advanced robots that are capable of exploring the depths of oceanic vents or the inner molten reaches of volcanoes. Students participate by suggesting courses of action and by asking questions. Jason's WWW server aids in this process by providing a basis for teacher in-service education, dissemination of curriculum, and multimedia recapitulations of past explorations.



using the Web to the JASON Project

Appropriating students' work into a community of practice

In this area as well, the WWW does not yet have many facilities for students to build or engage in collaborations with practitioners. Hence, we again concentrate on WWW servers that describe such activities conducted through alternative mediums. In particular, the Global Lab Project at the Technical Education Resource Center (TERC) is linking classrooms around the globe with each other and with experts in order to accumulate student data for scientific use.



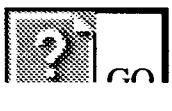
using the Web to the TERC hub

One TERC project had students around the United States collect experimental data on acid rain and then pool the data for analysis by experts in that subject. This effort produced a unique and valuable resource for environmental scientists. A strength of TERC's projects is that they have found ways for students' work to be of genuine use and of interest to scientists, thus creating mutually beneficial relationships. This is consistent with the philosophy of their chief scientist, Robert Tinker (Mapware on TERC), who wants to transform students and schools from isolated islands of concept learning into powerful social resources.



using the Web to learn more about Rober Tinker's philosophies and TERC's projects

In a similar vein, Vice President Al Gore is leading Project GLOBE, which calls for scientists to organize and lead student data collection into environmental conditions, such as air and water pollution, stratospheric ozone levels, and carbon-dioxide emissions.



WWW servers provide a valuable medium toward the goal of enabling schools to forge learning communities. They can serve as central repositories of general project information and provide access to software, expert tools, home page biographies, mailing lists, forms, and email. In this way, WWW servers provide a common infrastructure. This provides a place to accumulate results from more transient communication media like video conferences and email. WWW sites are evolving as a medium for newly formed communities to consolidate identities and build shared vocabularies and expertise. As the WWW evolves to support interactive communication more fully, it should prove better matched to the important social goals of creating learning communities.



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