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

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

In Part I of this article, we described the role that the World Wide Web can play in supporting learning communities in K-12 education, bridging the gap between classroom exercises and the practices of the broader community. In Part II, we will lay out a plan for an educational Web server that goes beyond what is currently available, providing a truly vital and useful resource for classroom learning. Finally, we will describe current plans for the CoVis Geosciences Web Server, an educational Web resource designed according to the plans outlined in this article.

Part II: The Next Generation of Web Servers to Support Learning Communities

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The Need for Web-Based Educational Server Development Guidelines

To date, most resources on the Web were not developed with the specific goal of fostering K-12 learning communities. Yet, as the examples in Part I of this article demonstrate, many of the online resources that have been created are valuable to students and teachers. But we believe it is possible to do better. To facilitate the development of servers explicitly to support learning communities, we will present a characterization of *educational Web servers*. These educational Web servers will have a distinctive architecture that embodies the following features:

Just-In-Time Curriculum

An educational Web server must provide a just-in-time curriculum for students. This style of curriculum differs from the standard prearranged sequences of material found in most textbooks: It is organized so that students can access the resources they need to solve the problem at hand. This is analogous to what adults do when they consult a how-to book in order to solve an infrequent problem. If you need to know how to fix a leaky faucet, an entire course in plumbing would be too time-consuming and provide far more information than you need to complete the task.

Appropriate Activity Structures

In order for a just-in-time curriculum to be successful, students and teachers need access to a broad variety of information and reference resources such as those surveyed in Part I. But more importantly, appropriate activity structures must be provided that support students in learning the concepts and skills of particular domains. These activity structures should identify and point directly to materials required, as well as describe how activities could be carried out in the classroom (e.g., individual lab activity, whole class, small group). Currently, Web servers are designed on the assumption that there will be a lone student sitting in front of the computer, but the reality of classroom activity is more varied than this scenario.

It is critically important that these activities encompass the use of real data from the field being studied, enabling students to analyze that data using the same tools that are used in the field. It will be important to involve work-based learning communities in the design of these resources. Work-based learning communities will need to provide versions of their tools and data sets in a rich contextual background to help students and teachers learn their use. For example, atmospheric scientists work with a wide variety of data and analysis tools. The complexity of the environment, however, is mediated by a broad system of supports that have been established within the science community over time. Students and teachers who use these same data and analysis tools need to have such implicit conventions made explicit to help them make sense of the material.

using the Web to see a screen-shot of the CoVis Climate Visualizer, an example of an interface that makes implicit scientific knowledge explicit to students

Support for Appropriate Assessment

Educators will need support to develop appropriate assessment procedures for these new kinds of activities. These assessment techniques should be keyed to national and state educational standards. (See Goals 2000 for information on goals educators have set for teaching standards.) In addition, students can use assessment procedures to monitor their own learning progress.

An educational Web server could do more than recommend assessment strategies; it could serve as the vehicle for the assessment activity itself. For example, if student projects are published as part of the Web server, people from beyond the classroom could become involved in assessing and commenting on the work. These outside evaluators could be peers, parents, or scientists. If privacy is an issue, access to these areas of a Web server could be password-protected.

User Commentary, Authoring, and Browsing Facilities

An educational Web server must offer facilities for authoring and browsing user commentaries on activities and assessment techniques. Commentaries can be used to discuss the usefulness of specific resources and the activity structures designed to provide a context for their use, and to suggest modifications that might make them work better. This design goal of developing a self-improving, dynamic educational Web server provides a major improvement over static curriculum. These authoring facilities allow teachers and students to originate their own curricular ideas and to adapt curriculum concepts from the server to their own local conditions and issues. Comment facilities also make it possible for teachers and students to engage in collaborative knowledge construction and debate that fosters continuous modifications and additions to the curriculum.

Contact Facilities and Mentor Databases

Educational Web servers must also offer facilities for teachers and students to contact others who share a specific interest with them. These contacts can be as simple as Web entries containing email addresses, or they can grow to be as complex as Web-based protocols that assist teachers and students in making contact at a critical point during an activity with people who have appropriate expertise. The Web is now poorly developed in its interactive communication ability. In particular, little has been done to develop either infrastructure or content to set up opportunities for work-based learning communities. Explicit attention must be paid to this issue.

The work and educational worlds must forge connections between their often-disparate learning communities. Currently, there are too few links between education and practice. Opportunities can be found for students to investigate issues that the work-based communities do not have the time or energy to pursue. Additionally, professionals work in established paradigms and modes of thought. These paradigms guide productive work, yet they can also blind one to productive alternatives. The eyes of our students can provide new ideas that incorporate more divergent influences into the workplace. The professional community can easily critique and prune such ideas; the role of our students can be to generate and design new possibilities. Through creating these designs and receiving feedback from community members, students can learn on a new level. In addition to critiquing the work of students, work-based learning communities could be formed that would provide mentors for students, opportunities for joint work, and mechanisms to acknowledge when the work of students was sufficiently useful that it warranted further investigation or incorporation into the learning community.

Overall, educational Web servers will only develop value for education insofar as educators and other participants in educational systems (e.g. parents, students, peers, and workers) take action to advance teaching and learning design and usability. Furthermore, the adoption of these Web servers must be actively promoted through integration into everyday learning activities. These activities form the core of a Web resource to support learning and establish new distributed communities for educational reform.

Powerful Search Engines

Educational Web servers need powerful search engines that allow users to specify teaching and learning tasks and then guide intelligent agent-based searches throughout servers across the World Wide Web. Teachers and students will need the ability to specify their searches based on subject domain (e.g. geology) and specific topics within broader domains (e.g. earthquakes). Large cross-indices such as Yahoo, the Whole Internet Catalog, and the Explorer server at the University of Kansas (which is explicitly dedicated to K-12 curricula) are a good start at such interfaces.

GO using the Web to the Explorer at the University of Kansas

GO using the Web to Yahoo's education directory

GO using the Web to the Whole Internet Catalog's education section

What is needed may more closely resemble the "search-and-refine" query interface of WAIS servers. In addition, these indices must be intelligently cross-referenced, to help students and teachers find materials that would not otherwise come to the surface in a straightforward topic search. In addition, search engines must over time come to be more sensitive to the age-appropriateness of materials. Ultimately, educators and users must feel that the benefits derived from using the resources located on these searches for teaching and learning outweigh the costs, including time and effort, associated with conducting the searches.

The CoVis Geosciences Server: A Proposed Educational WWW Server

The development of educational WWW servers will certainly be an evolutionary process. In this section, we offer a partial description of a next-generation educational WWW server now under development as part of the CoVis Project at Northwestern University. This server, known as the CoVis Geosciences Web Server, is intended to both provide support for project-based learning activities in CoVis classrooms and to serve as the mechanism for carrying out many of these activities. We have begun to map out the CoVis Geosciences Web Server's functions to ensure that it meets the needs of teachers, students, and scientist mentors who participate in the CoVis Project. We plan to make this resource available to CoVis classrooms and the general public in the fall of 1995.

The CoVis Geosciences Web Server will have five primary interlocking components:

- A database describing activities in earth and atmospheric science
- Online data sets that will be used by many of the activities described in the database
- Scientific visualization and analysis tools that are specially designed to help students ask questions about the online data sets
- Curricular materials that explain concepts underlying the activities, data, and visualization and analysis tools
- A database of mentors who are available to assist students working on activities

A high degree of interactivity is required for this server to achieve success. Community participation will determine the growth of the database of activities, the range of data sets, ideas and techniques for using tools, curricular materials, and even the membership of the mentor database. "Which Way Will the Wind Blow?" describes scientific visualization and analysis tools developed by the CoVis Project for high school students.

GO using the Web to the article "Which Way Will the Wind Blow?"

CoVis has developed curricular materials for students studying atmospheric science.

GO using the Web to modules on atmospheric science

While we will not go into detail on all aspects of the CoVis Geosciences Web Server here, we will explore the proposed design of its mentor database component. The mentor database serves a central function in helping to bridge the gap between the community of students and teachers, and the community of scientists and other knowledgeable people outside the classroom's traditional boundaries. Creating these bridges is one of the most important areas in which the World Wide Web can be useful to the educational community.

The mentor database provides a sort of learning and teaching "ride board." In the student union of most college campuses, there are ride boards with postings of rides requested and rides being offered. In a mentor database, there will be a broad range of student projects being conducted at any moment in time, and a broad range of expertise offered by scientists and others who volunteer to help advise students on their projects and activities. We recognize that we are not the first to attempt to create an online database of resources for classroom use. The Electronic Emissary Project at the University of Texas at Austin is an example of such a database, designed to be accessed through a Telnet session.

GO using the Web to an article on the Electronic Emissary Project

What we propose to do is build an environment that simplifies and integrates access for mentors and other materials in a unified, Web-based environment.

The CoVis mentor database will be populated by volunteers. Although the majority will be members of larger scientific organizations, such as national energy labs or university departments, there is the opportunity for anyone with a particular interest or expertise in earth and atmospheric science to join. In either case, it is paramount that being a mentor not pose an unreasonable burden on these volunteers, either in time spent mentoring or in administrative overhead.

On a ride board, volunteers avoid burdensome requests by stating the precise terms in which they are able to offer help. The CoVis mentor database will be structured to do the same thing. Using a forms-based interface on the Geosciences Web Server, potential mentors will be asked to specify not only their particular areas of expertise, but also the manner in which they would like to interact with students, including time spans and mode of communication. For example, a mentor might specify that she is an expert in ocean-floor seismic activity, is interested in working with a small group of students over an extended period of time, and can be contacted via email, telephone, or fax. Another mentor might specify that he knows a lot about weather prediction, but is only available to answer short questions, and prefers to be reached via email or videoconferencing.

Teachers will be responsible for making and maintaining appropriate matches between mentors and students. When a teacher thinks that students are working on a project that could benefit from outside mentoring, he or she will call up the database and complete a form that asks for a specification of the project topic, age level, number of students, start and end dates of the project, and other information believed to be pertinent to the request. The database will return a list of potential mentors, and the teacher may then search their full database records in order to make decisions about possible matches. If a mentor agrees to take on a particular student project, the database will be updated to indicate that they are currently unavailable as a mentor to others. This mechanism will help prevent mentors from feeling bombarded or overworked.

Because activities and analysis tools are integrated in a Web-based environment, mentors have a unique opportunity to participate in student work. When the Web is coupled with a specialized collaboration and project inquiry tool like the *CoVis Collaboratory Notebook*, mentors have access to the entire scope of student work, and can offer feedback and advice as they see fit.

GO using the Web to visit the Collaboratory Notebook

Looking to the Future

We view our design for extended interactions between mentors and students as an important improvement upon the question-and-answer-only mode of most email mentorships. Without access to the context of a student's question, it we believe that mentors are unable to provide appropriate answers.

The greatest challenge in designing the CoVis Geosciences Web Server and other educational Web servers is to make them support their own growth. A classroom where students pursue open-ended inquiry and look to the network for data and mentor support will by nature be in constant flux. An educational Web server, if properly designed, will be able to change and expand to reflect the discoveries made by teachers and students in their everyday work.

The Web is in its infancy and has only just begun to mature to meet the needs of specific user audiences. As it grows, many different communities will customize it and shape it to meet their specific needs. Learning communities in general, and K-12 learning communities in particular, present a broad array of design challenges for the Web. But these challenges must be met if Web servers are to become well-integrated and vital components of learning environments.

In Part I of this article, we gave examples of many Web servers that already have value for learning communities. At the same time, we argued that there is a long way to go before the Web will be a significant tool for constructing and sustaining school- and work-based learning communities.

In Part II, we outlined what we believe to be the key features required for a Web server to become an *educational Web server:*

- Just-in-time curriculum
- Appropriate activity structures
- Support for appropriate assessment
- User commentary, authoring, and browsing facilities
- Contact facilities and mentor databases
- Powerful search engines

Matching resources to teaching and learning tasks is the primary design objective of an educational Web server; the design of these servers will provide important challenges to application developers in computer science, networking, education, and learning sciences. We urge the designers of future Web resources for education to evaluate their plans with respect to the criteria outlined here. These specifications are meant to help spur thinking and development in this area, so that the Web and its applications will more directly meet the needs of schools, education, and learning communities.

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