Recommending Web Resources to Science Educators

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Abstract

We are working on a system to support a community of science educators (Kindergarten through 12th grade teachers) and science education stakeholders in improving science education in part through the use of Web resources. We are establishing a web site called *Science Forum* that will provide the technology supports needed to create a community of science educators. We are planning to add value for site users through the use of a recommendation system and face unique challenges with this special population. Science educators require a very low cost of entry, precise recommendations targetted to specific curriculum goals, connections to a community of like-minded educators whose judgements they value, and support for archiving their reflections on their implementation of a lesson using a Web resource.

Introduction

It is obvious that the Web is rich in science education resources. The extraordinary volume of hits on the Mars Pathfinder site (millions per day) is one indication. WestEd's *Tales from the Electronic Frontier* (www.wested.org/tales) highlights some compelling applications of a few of these resources: exposing learners to the diversity of the world's flora through exhibits by the Australian National Botanical Gardens, supporting inquiry into causes of poor air quality at a school in relation to global data, and inspiring the investigation of earthquakes in the quest to understand patterns in the distributions of different sizes of grains of sand.

These tales attest to the fact that many K-12 science teachers and other science education stakeholders view increased Web use as a way to support better teaching of science. Science teachers want to find and experiment with up-to-the-minute material that supports activities recommended by national science education standards (National Research Council, 1996). For example, these standards specify goals for science learning for different topics at each grade level, and teachers will search for resources having properties that will allow them to match their classroom activities to the goals set by these new standards (e.g., a Grade 3 unit on volcanoes with specific standards in mind; similarly for a Grade 8 unit on global warming; and a Grade 12 unit on ethics of the human genome project). However, commercial search services and web directories are proving ill-matched to many teachers' needs. Teachers who do use the Web rely mainly on their *peers* to find and tailor web-based science resources for classroom activities. Notably, teachers are increasingly finding these peers via participation in Web community sites, such as SRI's TAPPED IN (Schlager and Schank, 1997).

Given these conditions, it seems natural to deploy recommender technology to support science teachers, and we are currently exploring partnerships with companies that produce recommender systems and are evaluating other retrieval and delivery technology to determine its applicability to complement basic recommenders. This technology will be accessible to teachers by way of their membership in a community-based forum for discussing science education that we call Science Forum.

The long-term goal of the Science Forum project[1] is to create and sustain the distributed expertise of science educators with Web-based services. We envision Science Forum as a testing ground for Web-supported science education plus information science research. Teachers and researchers will co-construct solutions, adapt technology, and support a social system that includes science education stakeholders such as national science laboratories. By creating and sustaining a distributed community of science educators and science education stakeholders, Science Forum will aggregate existing best practices of K-12 educators and foster member-generated reflections on the use of Web-based science education.

In this working paper, we first present background on why teachers use the Web, and outline how a teacher might use Science Forum. Next, we identify the specific requirements for this application of recommender systems, then sketch our proposed solution.

[1] The project team is drawn from a group of computer scientists, educational researchers, and cognitive scientists in SRI's Center for Technology in Learning (CTL) and the Information Technology (IT) Group. Drs. Roy Pea and Chris DiGiano from CTL, and Dr. Moises Goldszmidt from the IT Group, are major participants.

Background

It should come as no surprise that educators use the Web for the same reasons as do other professionals, including the following.

- *Skills Development.* To obtain help in learning how to use the Web for themselves or their students, including subjects such as fundamentals (email, gopher and ftp resource retrieval, and Web browsing), Web searching using directory services and libraries, and Web publishing.
- *Teaching Practices.* To locate professional information on teaching practices and curriculum standards (from sites maintained by teacher training institutions) and tips from other teachers for project activities and for working with standards.
- *Browsing.* To become familiar with the type and breadth of science content material to be found on the Web.
- *Connecting.* To learn how other teachers have used the Web in their classrooms, and to develop community connections (Hill et al. 1995).
- *Lifelong Learning.* As background material to update their knowledge of a subject. Many elementary teachers, for example, report feeling ill-prepared to teach science.

Teachers also desire to use Web resources in order to bring science from the real world into the classroom. They require the ability to use what they find in creative ways and to adopt it to the specific interests and concerns of their students (Harris, 1995). Some of their concerns in this regard are as follows.

- *Science Content.* Motivating, media-rich depictions of science phenomena can illustrate lessons, and age-appropriate or locally relevant sites add additional interest.
- *Popular and Real Science.* "Science in the news" is a way to make a topic of study more compelling and the latest new findings in science from leading research labs (presented in a comprehensible form) can make science authentic.
- *Personal Science.* Finding a community affected by a science phenomena (e.g., people affected by the Chernobyl disaster) makes a science subject more immediate, compelling, and personal.
- *'Social' Science.* Web sites that are socially oriented, with ongoing activities such as virtual field trips, and/or topic-based discussion forums, can engage many learners.

We are serving a well-defined community of practice and interest, including teachers and school administrators, students, and education stakeholders. Within this, there is a stratification, e.g., among grade levels.

We believe that, as part of community membership, educators will yield background information for profiles. This could improve a recommender systems' correlations of 'taste.' There are existing members organizations of which we can make use (i.e., teacher professional organizations such as the National Science Teachers Organization, NSTA, with 53,000 members). Overall in the United States there are 2.5M teachers. 1.4M of these are science teachers where 300k are secondary grade science teachers, and 1.1M are elementary grade teachers.

We consider this application to be particularly challenging for a number of reasons. One is the *extremely* limited preparation time available to teachers to use the Web. Any system that does not demonstrate convergence toward a reasonably useful relevance metric as soon as a teacher starts using it will be abandoned (along with, perhaps, the use of the Internet as a whole). Nevertheless, some teachers are willing and able to effectively use search engines to find resources, so the bootstrapping of the recommendations, it appears, can work through their efforts.

Another difference is that general and task-specific profiling information will be obtained from participants of Science Forum that can refine the ratings to produce more accurate recommendations. Currently, few systems utilize both types of information: some use user profiling as a back-up when recommending fails, while others attempt to weigh a profiled user more heavily in the recommendation input. We face a number of empirical questions in our research, such as do we first classify users into groups based on their profiles, then recommend within groups? How do we employ these profiles within recommenders?

Science Forum will contain an organization of web-based science resources, and a corresponding set of social resources: a community of scientists, scientific professional organizations, and science education researchers. This will further exacerbate the problems of a recommender for Science Forum as these user communities separate, and as recommendations are desired across user groups. How, for example, do we weigh the (perhaps biased) recommendation of a science education web site developer against that of a teacher who has used the site in the classroom?

Our development of Science Forum involves working closely with various stakeholders in science education, continuously evaluating the forum design, and supporting the emergence of community sustained in significant part by teachers themselves. Given the goal of building and sustaining community, we expect to leverage the information created for recommending in order to make connections among peer group members and across groups as well. Recommender systems typically work hard to safeguard the privacy and recommendations of their users—while we share this goal, we also wish to build community in part using these systems.

The Science Forum Vision

Before outlining our approach, we present our vision for how Science Forum will be used by typical members.

The primary intended user is a science teacher, possibly with low tolerance for high technology. A typical use case is as follows: a science teacher learns about the site, perhaps by recommendation from another professional, from a link on another web page, or from a CDROM given out at an NSTA meeting or summer workshop. This teacher visits the site and may initially browse through the hyperlinked text, maybe stopping to read a CNN account linked to by the highlighted "Science in the News" story or a Science Puzzler. The teacher might look at a hierarchical classification of science resources, and review the question-and-answer area to see what sorts of questions are asked by their colleagues. The teacher might visit a student area to see what students are doing on Science Forum, and visit the K-4 teachers' science area. He or she might then decide to register in order to obtain access to more capabilities on the Forum. Registering will be optional but educators will be encouraged to register in order to receive the full benefits of the site, and will be ensured of privacy.

Registering will consist of filling in an online profile form After registering, a teacher can pose a query to a search engine, or can use his or her profile to guide further browsing. Right away, query results will be reflective of the profile. A teacher who decides to subscribe to a channel would later receive e-mail announcements of new sites that might be interesting, based on recommendations emerging from the profiles and web activities of other Science Forum user community members. Teachers can improve on the relevance match of these sites that are delivered to their desktops by e-mailing feedback on the value of the new sites for their work. A teacher who does not subscribe to a Science Forum channel will be shown highlights of new relevant sites on the visit to the Forum web site. As teachers advance in their sophistication, other features—such as participating in discussion groups, submitting URLs, and annotating (as in Goldberg, et al. 1992, Röscheisen, et al. 1995) or commenting on URLs—will be provided for their use.

We plan an extensive campaign to collect bookmarked URLs and locally developed web pages that teachers are willing to share as useful science education resources. Bookmarked URLs are high-value resources among a user community. We will also collect URLs from the broad range of science education affiliates. We will encourage interested teachers to submit URLs with metadata markups, or with annotations of how they used the site in their classroom activities. Providing teachers with the ability to make numerical ratings and to author commentary on the usefulness of sites that can be attributed to them individually (if they so choose) will empower the teachers as they generate content within Science Forum.

Recommending Resources

We have a particular interest in 3 Web technologies for Science Forum: metadata tagging of resources combined with metadata-enabled browsers, intelligent push technologies, and recommendation systems. We discuss the last one in this section; the others come under future work.

We propose a system that begins with a Web-based questionnaire that will be used both to create teacher profiles and to identify key Web resources. Having the questionnaires filled out is key to developing the profiles and seeding the resource database, therefore motivation is a key consideration. Maltz and Ehrlich's (1995) discovery that "if they [the users] knew something useful was happening to their votes, they would have kept voting." requires us to motivate teachers by way of descriptions of the projects goals and the impact on the K-12 teaching community. We also plan incentives such as their receiving a list of the latest hot Web sites that are within range of their profile upon completion of the questionnaire.

In addition to questionaires that elicit teacher's favorite URLs, we will mine the bookmarks of "web-savvy" teachers (as done in SiteSeer, Rucker and Polanco, 1997). We expect to have a constantly evolving database of URLs clustered according to an analysis of their content. These URLs will come from bookmark mining, URL submission, and mining web sites that list resources for teachers. We are also investigating the possibility of mining bulletin boards that teachers use for discussion of lessons.

In this domain, the web pages being recommended are candidates for content analysis, suggesting that a combined content-based and collaborative filtering approach might be best to provide the precision we require. We intend to adopt a hybrid, distributed agent-based approach to develop our recommender system, as was done in the Fab recommender (Balabanovic, 1997).

We anticipate that so-called mentor teachers or early adopters will provide many of the rankings, and fully expect other teachers to "free ride" on their recommendations. It is a simple fact that not all teachers will become technology adopters, and we do not want our system to penalize them for this, instead we intend to support them as much as possible.

Recommenders harness the collective knowledge of all of a site's "customers" to make predictions, and as the user profiles and judgements accrue, increasingly valuable

personal service can be provided. Recommender technology in Science Forum will enable science teachers to provide reflective judgments—both quantitative ratings and qualitative annotations—about the usefulness of science education resources. Qualitative judgments, atypical in recommender systems, are required in Science Forum in order to better allow segments of the science education community to identify and properly use such resources.

To allow for individualized access and services, we will develop profile models that can be maintained for each teachers' specific interests and educational needs. The profiles can keep track of a teacher's grade level, current topics being taught, technical expertise, experience in searching and performing other activities on the web, local needs of their students, and so forth. The profiles will be open in the sense that teachers can access and edit their own profiles. We are interested in researching the application of probabilistic modeling for adaptive profiling (Billsus and Pazzani, 1996; Sheth and Maes, 1993) to augment these static profiles.

Major research questions remain on whether user profiling (such as grade level and the like) can be used in recommending, and whether recommending techniques that work for NetNews (Resnick, et al.), books, music, and web sites will be applicable to on-line science education resources.

Other Technologies in Science Forum

Recommender technology is not the only area where we see a potential application benefit, and we discuss two other areas that will impact our efforts. We are particularly interested in how these 3 areas can interact, for example, recommender profiles used for push technology.

A large partnership of 19 organizations (including the U.S. White House Office of Science Technology and Policy and the U.S. Department of Defense) has joined the nonprofit organization EduCom (with its 600 participating universities and 100 corporate affiliates) in what is effectively a standards project. The Instructional Management System (IMS) Project (Educom, 1997) is attempting to develop a common, open-access technical framework of metadata for coding learning materials. Its specifications and prototype software systems will be freely available. Coupled with the planned release in 1998 of new web browsers designed to allow coding and search of metadata fields for web pages, a widely accepted metadata language for science resources offers the opportunity to bring unprecedented order to on-line science educational resources. We anticipate that science content producers will readily adopt this specification in order to make their materials more accessible to educators.

A second interest of ours for application in Science Forum are the recent developments in "push technology" for the Internet, such as PointCast and Netscape Netcaster. These make it possible to "narrowcast" news about newly available resources that fit the topical interests of user subpopulations. We expect that science educators could be automatically notified on a net channel of developments in their topical subjects, with URLs to these resources provided as well (or of pages that have changed, as in Starr, Ackerman, and Pazzani, 1996). However, research is needed to determine the impact of such techniques on ease of use of the web specifically for science educators' tasks. Further work is required to understand how filtering can be applied to the content of these channels.

The Science Forum system is currently under development at SRI. We are focusing our early efforts (supported by internal research and development funds) on methods for obtaining URLs and on applying content-based analysis and clustering methods (Goldszmidt and Sahami, 1998) to organize the results. We plan to conduct early testing with teachers in 1998.

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