

# Giving Back to the Web: Social Filtering of World Wide Web Resources in High School Science

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Can high school students become contributors as well as users on the World Wide Web? This research explores a new Web-based curriculum idea, that of having students write and publish critical “reviews” of scientific resources. Writing reviews can be a means of both practicing critical evaluation of Web resources, and of making an authentic value-added contribution to the Web. This paper presents content analyses of 41 source documents and 63 critical reviews published by 11th grade students in a project-based science class. The source documents are described as to their publishing source, use of organizational elements, and use of graphics. Two aspects of student-written critical evaluation are analyzed: evaluation of organization and evaluation of graphics. While evaluations of graphics were somewhat thin in these reviews, this was due mostly to the lack of good content representations in the source documents. The on-line review form did successfully prompt students to make conceptual connections between organizational structure and their own sense-making process. Reviews also sometimes showed students engaged in perspective-taking related to potential readers. The literature review of this paper examines critical evaluation models and current social filtering models for large, distributed databases. A section on future directions for Web reviews describes a review-publishing system developed for the University of Michigan Digital Library system.

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**KEY WORDS:** World Wide Web; Internet; critical evaluation; critical thinking; media literacy; social filtering; digital library.

The World Wide Web is a vast new resource that holds both great promise and great challenge for high school classrooms. By making information from a variety of sources, purposes, and levels available to students via almost any networked computer, the Web can greatly expand the resources available to support open-ended student inquiry (Alloway *et al.*, 1996). On the negative side, the Web’s vastness and lack of central organization can make finding information difficult and time consuming (Harris, 1994; Wallace and Kupperman, 1997). These problems may also represent opportunity, however, as the Web offers a setting for students to practice critical thinking and analysis within a vast marketplace of information that mirrors the diversity of the society it serves.

The Web is a new kind of resource for high school classrooms. It is a digital resource, as opposed

to paper-based resource, which makes it possible for high school students to access a great deal of information quickly and, often, very cheaply. The Web is also a distributed resource, which means that almost all users of the Web are also potential contributors to its collections. This new type of resource presents both opportunities and problems. The curriculum idea described in this paper—student-written reviews of Web resources—is a potential solution to two different problems. The first problem is that it is difficult to find appropriate information on the Web, due to the lack of any central gatekeepers or indexing mechanisms. A proposed solution to this problem is for users of the Web to help each other through “social filtering” of information (Resnick and Varian, 1997). The second problem is the need for K–12 students to develop critical evaluation skills that will enable them to sort through the vast and diverse materials to find information that is appropriate and credible (Callison, 1993). Student-written reviews of Web pages area present a

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solution to both of these problems in that it allows students to practice critical evaluation skills, and simultaneously contribute to the ongoing social filtering of the Web.

## COMPONENTS OF CRITICAL EVALUATION

Drawing from previous work both in educational psychology and in the field of information science, this paper defines critical evaluation as having four components: summarization of content, evaluation of credibility, evaluation of organization, and evaluation of use of media. These four categories are components of useful reviews, and are also skills necessary for critical use of media. The first two, summarization of content and evaluation of credibility, are examined in detail in another paper (Bos, in press) and results will be described only briefly here. The second two, evaluation of organizational structures and evaluation of use of media, are examined in more detail.

### Evaluation of Organizational Structures

The Web is hypertext, which means that it offers a diversity of ways of organizing and navigating information that provide both opportunity and challenges for students. Given the known importance of features such as headings and other text features for strategic reading in more traditional formats, it may be worthwhile to focus students' attention on the navigational features of the Web as part of critical evaluation. Headings, outlines, and tables are features of normal text that are used frequently in Web resources as well. The Web also includes a number of new features such as graphical buttons, hyperlinked lists, image maps, and graphical site maps. Students should be aware of what types of organizational structures they may find on the Web, and how they may be used strategically to make sense of information. Studies of strategic reading have shown that, at least in the context of think-aloud studies, strategic readers are metacognitively aware of (1) the presence of text features, and (2) their own strategic use of them. It stands to reason that making students more aware of the Web's organizational structures, and prompting students to think about how these features aid in sense-making, may be important components of critical use of that medium.

### Evaluation of Media Usage

A similar argument can be made related to media types: students should be made aware of the types

of media and representations available, and should additionally be prompted to think about how these components can be used in their own sense-making. Again, studies of strategic reading have shown that experts in a domain may rely heavily on graphical representations, such as charts, tables, and other figures, especially as part of their early sense-making process (Pressley and Afflerbach, 1995). Research in multimedia has produced a body of knowledge about how different media types can be used together (Kozma, 1991; Paivio, 1986) to provide multiple representations. There is also good information available about how some types of representations, such as line graphs (Shah and Carpenter, 1995), can be used by learners. The Web offers an expanding variety of media types, including (but not limited to) video, audio, different types of graphical representations, GIS systems, and new types of interactive representations that allow the user to actually manipulate the visual information given. Critical evaluation should focus on helping students first to recognize this diversity of media types, and then learn to use these types in their own sense-making processes. The set of critical evaluation skills described here is worthwhile, but is also hard work for students. This work may be more engaging for students if it is done in the context of authentic projects. Web reviews offer the opportunity for students to learn critical evaluation while making an authentic contribution to the Web by contributing to the ongoing social filtering of the Web's content.

## THE ROLE OF PERSPECTIVE TAKING IN REVIEWS

What makes a review different from any other decontextualized writing assignment? The key feature of a review that I will focus on is the role of perspective taking. The ability to recognize and coordinate self and other perspectives is an important higher-level aspect of sociocognitive development (Selman and Byrne, 1974) that may be tied to writing ability (Rubin, 1984) and some other types of problem solving. In the Web-reviewing task at hand, three perspectives are relevant: the students' own perspective as a researcher with a specific purpose; the perspective of other potential users who might have different knowledge or purposes than the student researchers; and finally the perspective of the information provider.

The first goal of writing reviews should be to help students develop and refine their own self-perspectives as information consumers. Expert readers

keep their own purposes and problems firmly in mind, and are thus able to efficiently extract relevant information from source materials (Brown and Pressley, 1994). In assessing a Web resource, students must judge whether material is relevant to their immediate purpose, such as writing a report on a particular topic. Often, resources that on the surface cover the appropriate topic still do not provide the type of detail needed for a particular purpose, and savvy information users must learn to recognize this. Developing a personal perspective may also involve forming personal opinions and preferences about such aspects as organization structure and use of media.

The second important perspective for a reviewer is that of other potential users. A published review is, after all, meant to be read and used by others. Other users may come to the same resources with different information needs, different levels of prior knowledge, and so on. A good review-writer should be able to answer the questions, Who else would this information be valuable for? What other questions, besides my own, might this answer?

A third perspective that is useful for Web reviewers is that of the publisher or author of a document. A distributed resource has many different types of authors with varied purposes, credibility, points of view, and technical knowledge levels. Different author types may also imply different biases in the selection and presentation of information. Assessing this perspective is an important component of a review.

### **CURRENT RESEARCH ON SOCIAL FILTERING OF INFORMATION**

This research on student review writing is intended to fit into current research on social filtering of complex information spaces. This topic is an area of current interest in the field of information sciences, as researchers grapple with how to manage vast, decentralized information spaces such as the World Wide Web. One way of organizing such decentralized information resources such as the Web is for users themselves to produce value-added contributions (Roeschein, Winograd, and Paepke, 1995) to the library. A variety of models exist for utilizing the efforts of digital library patrons to help organize collections. A simple example, often found on the Web, is when an individual with a particular interest area assembles a hotlist of quality sites. These hotlists, while not adding any new content to the Web, add value to the Web by providing an organized resource on a particular topic. Other, more sophisticated mod-

els of social filtering are being developed as well, as described in a recent review article by Resnick and Varian (1997). For example, PHOAKS is an automated system that scans Usenet newsgroups to identify informal recommendations of Web sites posted by individuals (Terveen, Hill, Amento, McDonald, and Crete, 1997). Another model of social filtering is provided by the experimental Recommender system (Roescheisen *et al.*, 1995), which allows either individual users or third-party organizations to provide value-added annotations to a library, allowing both evaluation and perspective. For example, a parent's advocacy group could use the system to annotate Web sites based on appropriateness and usefulness for children. Similar shared annotation systems have been piloted by other groups (Hill, Stead, Rosenstein, and Furnas, 1995; Ibsen, 1995). The idea of social filtering has also made its way into Internet commerce. An increasing number of commercial sites, such as Amazon.com, make use of book reviews written by individual customers.

There are very few precedents for social filtering research in a K-12 environment. One pilot system is the KIDS system (<http://wwwscout.cs.wisc.edu/scout/KIDS/index.html>), which is part of the larger InterNIC project at the University of Wisconsin, where students can write and contribute reviews of Web sites on any topic. Individual teachers have also independently recruited students to help winnow through the Web's vast collections (Lustick, 1996). However, no previous studies have examined either how K-12 students may go about writing critical reviews or what the nature of K-12 student authored reviews may be.

### **RESEARCH QUESTIONS**

Analysis of data from two curriculum projects in a high school science class will address the four research question listed below.

1. What kinds of resources do students find when doing scientific research on the Web?
2. How can students critically evaluate the organization of Web resources?
3. How can students critically evaluate the media in Web resources?
4. How do students evaluate the bias of Web documents?

### **SUBJECTS AND SETTING**

The setting for this study was two 11th grade science sections at an alternative high school in a

medium-sized midwestern college town. This high school of approximately 400 students accepts new students through a combination of lottery and first-come-first-served sign-ups each school year. This lottery system is controlled to ensure a proportion of both minority and special-needs students. Although students at this school are not a representative sample of any particular population, they are not believed to be overly represented by either high- or low-achieving students. Most graduates of this school do attend college.

The class involved in these studies was in the third year of the Foundations of Science (FOS) sequence, which is an integrated science curriculum which follows the principles of project-based science (Blumenfeld *et al.*, 1991), and has a heavy emphasis on the use of educational technology. The science curriculum integrates the three traditional content areas of earth science, biology, and chemistry into one 3-year sequence of investigative science projects.

Forty-four students took part in these projects, in two sections taught by different teachers. There were 27 girls and 17 boys in this group. In each review-writing project, students were allowed the choice of working in groups or individually, with the stipulation that they needed to produce the equivalent of one review each (e.g., a group of two students could work together to write two reviews, or could work individually and each write one review).

Students wrote Web reviews as part of their normal background research at the beginning of two 8-week projects. At the end of each of these two projects, students worked in groups to produce a culminating artifact, which was also published on the Web. The air pollution project (project #1) took place in September and October, and the final artifacts were reports of students' local testing of air pollutants. The infectious diseases project (project #2) took place in February and March of the same school year, with the final product being a HyperStudio hypermedia report about a particular disease.

## DATA SOURCES

The data for this paper are 63 reviews published by students in the two review-writing projects, and the 41 original Web source documents that could be retrieved by researchers shortly after the projects' completion. This research will present a series of short content analyses of different sections of the students' reviews. Unless otherwise stated, the number of cases

(*N*) for each study refers to a number of reviews, not a number of student authors or source documents. Most of the content analyses will focus on a single section of reviews published in one project.

Forty-one original source documents are also examined. A number of source documents are missing because of one of several reasons. Some students also chose to review resources that were not on the Web, such as library books or magazine articles. In other cases, students appear to have given an incorrect URL and the researcher was unable to find the correct one. In other cases it appears that the pages were either removed from the Web, changed, or moved to different locations shortly after the students completed their reviews.

## SOFTWARE ENVIRONMENT

Students published reviews by filling in a Web-based form that solicited comments in text fields tailored to each project. After students submitted a review, a cgi script parsed the student reviews and published it onto the Web, along with other reviews from the students' class section (Appendix A and B). Review publishing was supported on the high school's own Macintosh server, although it could as easily have been supported on another server at a remote location. We used Maxum's \$136 *Netforms* software, which allows nonprogrammers to parse the output of HTML forms and write the contents to Web pages or other text files. This review-publishing model represents an inexpensive, scalable model that could be implemented by most school districts.

## RESULTS

### Characteristics of Reviewed Documents

Before examining how students evaluated Web resources, it is important to understand the nature and characteristics of the Web resources themselves. To provide some baseline understanding of the kinds of resources students in this project found, three analyses are presented and discussed. Source documents were analyzed for the types of publishing sources, organizational features, and use of media.

It is important to make a note about what population of Web documents is being examined here. These Web resources are by no means a random sample of the Web. Rather, these are a set of pages identified

**Table I.** Sources of Web Pages Reviewed, by Category

	Government (US)	Government (foreign)	University	Nonprofit organization	Commercial (nonpublishers)	Commercial information provider	Individuals
Project #1 ( <i>N</i> = 23)	10	3	2	4	3	1	0
Project #2 ( <i>N</i> = 24)	6	4	3	7	2	1	1
Totals	16	7	5	11	5	2	1

by students with some Internet skills in the course of normal classroom research. As such, they are a valuable sample of pages because they represent the kinds of resources students may find when doing science research on the Web.

### Publishing Sources of Reviewed Web Documents

It is predicted that the World Wide Web will provide access to a richness and diversity of information resources far greater than that previously available to K–12 students. I examined the distribution of the types of sources found by students in these projects. All the Web pages that could still be accessed a few weeks after the finish of each project were examined and classified into one of the following categories: US government sources (federal or state), foreign government sources, University sources, nonprofit agencies, commercial sources (nonpublishing), commercial information providers, or individual Web page publishers. Sometimes the same source was reviewed multiple times by different students, and thus appears as more than one entry in the table. Table I shows the distribution of sources from the two projects, separately and across the two projects.

This table provides the basis for several observations. First, as predicted, the Web provides a unique information environment for K–12 students, where they may access information directly from a diversity of sources. Normally, almost all of the information students are exposed to in doing K–12 research is gatewayed through commercial information providers such as book and magazine publishers. Table I shows that, in this project, commercial information providers were a minor source of scien-

tific information for these students. In contrast, government sources were very well represented in both projects. US government agencies such as the Environmental Protection Agency and the Centers for Disease Control have made extensive use of the Web as an information outlet, and students in this study made good use of those resources. Students also reviewed Web sites published by foreign government agencies in Canada, Great Britain, and Australia, and the World Health Organization (which was included in the foreign government category), which are even less traditional source of information for American K–12 students. Students made frequent use of sites published by nonprofit organizations, especially environmental advocacy groups, and private for-profit companies. These last two categories are interesting because they are nontraditional sources, and also because they hold the most potential for biased points of view, in that both groups may have political or financial interests tied to the information being provided.

### Considerate/Inconsiderate Text Organizations of Reviewed Web Documents

The concept of “considerate” text structure is related to the organization of Web resources. A considerate text, generally, is one that is well written and well structured, and that is presumably easier for students to understand and learn from. Table II shows some of the features observable in the reviewed Web documents that may be linked to the considerateness of the documents, borrowed or adapted from considerate text measures by Bauman (1984) and Armbruster and Anderson (1981). Documents were inspected to see if they included multiple informative headers, tables

**Table II.** Features of Considerate Text Organization Present in Web Documents

	Multiple headers	Table of contents	Bullet-type list	Topic sentences	Introductory paragraph
Project #1 ( <i>N</i> = 22)	10	4	10	7	4
Project #2 ( <i>N</i> = 21)	13	3	13	8	4
Total ( <i>N</i> = 43)	23	7	23	15	8

**Table III.** Use of Media in Reviewed Web Documents

	Navigation icons	Decorative graphics	Informative photos or illustrations	Graphs, charts, or tables	Diagrams	Flow charts	Video, sound, or animation
Project #1 ( $N = 23$ )	9	12	3	6	1	0	3
Project #2 ( $N = 24$ )	12	10	5	3	1	2	2
Total ( $N = 47$ )	21	22	8	9	2	2	5

of contents, bullet-type lists of content items, topic sentences, and introductory paragraphs.

Use of multiple headers and bullet-style lists of information were the most common text characteristics observed. These often co-occurred in Web pages that displayed a distinctive “Web style” for presenting information. The Web style features short paragraphs, often only 1–2 sentences, with headings every 1–2 paragraphs, and longer information blocks divided into bulleted lists. This style also explains the relative paucity of topic sentences. Often, the headers took the place of topic sentences, sometimes in a question-and-answer format, where the header posed a question that was briefly and directly answered by a few short sentences of text. Although this style would seem to limit the depth of science content that could be communicated, some documents used this format well and communicated fairly detailed content in this way, adequate for a high school–level report on the topic.

Other features of considerate texts are much less common in these pages. Percentages of usage of introductory paragraphs, topic sentences, and tables of content were low.

It is difficult to easily characterize the Web pages as considerate or inconsiderate based on this level of data. Some characteristics of considerate texts are present in these documents, but none are ubiquitous. It may be worthwhile to have these stylistic features identified in analyzing students’ reviews of organizational structure.

### Use of Media in Reviewed Web Documents

Graphical representations and other multimedia features are a potentially important way for Web pages to communicate information. Therefore, it is worthwhile to examine the reviewed Web pages and examine their use of media. It is also important to make distinctions between media that facilitated content understanding, and media that primarily served other purposes such as making a page more attractive,

or being used as navigation icons. Pages were examined and media were identified in seven categories (Table III).

Overall, multimedia elements seemed to be underutilized in the Web pages reviewed in this project. Only a small percentage of pages used scientific representations such as graphs, charts, tables, diagrams, or flowcharts. An even smaller percentage of pages used some of the advanced features allowed by the Web such as video, sound and animation, and of the five pages that did so, three of these were simple animated GIFs. Nevertheless, it may be worthwhile to examine in later sections how students evaluated these graphical elements when they were present.

### Analysis of Student-Written Reviews

The next sections examine the reviews students wrote and published across the two curriculum projects. The sections of the reviews examined here are evaluation of organization, evaluation of media, and evaluation of bias. A variety of content analyses were performed on each.

#### *Evaluation of Organization*

Students in both projects were asked to evaluate and review the organizational structure of Web resources. Both sets of reviews were coded by a single rater for the presence of two aspects: description of specific organizational features and connections between organizational structure and information accessibility. These aspects were thought to be the most relevant for both critical evaluation and reviewing. Recognizing and naming organizational features is important for the student-reviewer’s developing media literacy, as well as being useful for review readers. The second category, connecting organization structure to accessibility, is important for developing students’ self-perspective and other perspectives on media. Students were explicitly prompted to think about both their and others’ perspectives

**Table IV.** Frequency of Two Aspects of Student Reviews of Organization

Aspect of student reviews of organization	Count	Percentage
Project #1 air pollution ( <i>N</i> = 19)		
Describes specific organizational features	8/19	42
Connected organizational structure and information accessibility	12/19	63
Project #2 infectious diseases ( <i>N</i> = 24)		
Described specific organizational features	17/24	71
Connected organizational structure to content understanding	20/24	83

with prompts such as: “Can you find answers to specific questions without searching the entire resource?” Table IV shows frequencies of these two aspects in both projects.

As Table IV shows, 42% of student reviews in the first project named specific features of their source page’s organizational structure. This rose to 71% in the second project. Possible reasons for this include the review form, which was rewritten to explicitly prompt for names of features; practice time, because students would have had a round of practice writing reviews in the first project; or in-class preparation related to an ongoing project on hypermedia design (see Bos, Krajcik, and Soloway, 1997).

Although the Web offers a large variety of navigational and organizational structures, the features students named in their reviews were the more ordinary Web features, especially tables of contents, headings, and navigation buttons. No students reported the presence of advanced features such as interactive site maps. This is probably attributable to the paucity of advanced organizational features in the reviewed Web pages.

As for the second aspect of interest, 71% of student reviews made some conceptual connection between organization and their or others’ ability to access information in that resource. This rose to 83% in the second project. Again, possible reasons for this included the review form, which was rewritten to explicitly prompt for these connections; practice time, because students would have had a round of practice writing reviews in the first project; or in-class preparation related to an ongoing project on hypermedia design. The types of statements that showed this conceptual connection ranged from fairly well elaborated: “The info is presented in an orderly fashion. However, there are few subheadings, so the reader must look through the article in order to find what he or she wants,” to more minimal: “It is well organized, and the whole resource can be searched quickly.”

Reviews of organization showed evidence of both students’ developing self-perspectives and out-

side perspective taking. Students showed developing self-perspective when they reflected on their own ability to learn from the resource, and expressed personal opinions about different features. An example of a fairly opinionated review is: “This is a very unorganized article. It skips around between topics often. There is no clear definition of the article’s purpose aside from the title. You must skim through the entire article in order to find answers to your questions because it is complex.” This student reviewer shows evidence of developing opinions on how information should be organized and how an article’s purpose should be communicated. Students also sometimes showed that they understood the difference between an article that is well organized and an article that is useful for the readers’ sense-making process: “The article is organized fairly well, having each graph being well labeled and well placed. Yet it would be hard to find specific answers without looking hard for them.”

Reviews often seemed to be showing development of an outside perspective. Students often seemed to be mentally putting themselves into another readers’ shoes, and anticipating what structures and information they might find useful: “it is well-organized, there are titles for the sections they talk about, i.e., progress with research, progress with ofloxacin-multicentre field trial, future targets, priorities for research, steering committees. It is from the WHO home page and has a button to go there and the LEP homepage that have info on anything else you’d want to know about leprosy.” The phrasing of the last clause—“anything else *you’d* want to know about leprosy”—as well as the inclusion of linking information indicates that this was written for other readers. Another example of this kind of phrasing is “The info is presented in an orderly fashion. However, there are few subheadings, so the reader must look through the article in order to find what he or she wants.” Overall, evaluation of organization seemed an especially fertile category for students to develop both their own self-perspective and an outside perspective on information sense-making.

**Table V.** Frequency of Four Aspects of Student Reviews of Appearance/Graphics

Aspects of student reviews of appearance/graphics	Count	Percentage
Project #1 air pollution ( $N = 19$ )		
Describe interaction between graphics and content understanding	5/19	26
Describe content of graphics	3/19	16
Describe representational type of graphics	3/19	16
State that graphics were minimal or absent	8/19	42

### *Evaluation of Graphics and Appearance*

Students were asked to evaluate the appearance and multimedia elements in the Web pages they reviewed for both curriculum projects. Evaluation of media and appearance is not presented for project #2 because the results add little to results found in project #1. Detailed analysis is available in the author's dissertation (Bos, 1998).

Recall that previous examination showed that the pages that students reviewed were not very graphics rich. The more interesting representational types were not well represented enough to make a good study of how students might evaluate this type of information (see Table III). Still, it may be worthwhile to examine what aspects of the student evaluations of appearance did emerge. Reviews of appearance were examined for four aspects (Table V).

Five of 19 reviews made a conceptual connection between the appearance or graphics on a page and content understanding. An example of such a statement would be, "(the site) contains a useful bar graph of the relationship of distance traveled in car and release of CO." Although 5 of 19 is a poor overall showing, recall that most of the pages did not contain graphics serving purposes other than being purely decorative or navigational.

Overall, student reviews of appearance did not yield very rich data in this study. This study did yield a set of challenges for future review-writing projects, which are to find Web resources that make better use of the media and help students develop their own opinions and ideas about graphics.

### *Evaluation of Bias*

In project #2, student reviewers were asked to identify possible biases in Web documents. This idea gets at the third kind of perspective taking necessary for effectively reviewing the Web, which is identifying the perspective of the publisher.

Most reviews addressed this by stating that there was no bias on the reviewed document. Out of 25 available reviews, just 2 described some kind of bias,

and 21 claimed the pages were unbiased, sometimes with justification. Of those that claimed no bias, 10 did not back up this claim, 7 of 25 referred to the unbiased nature of the information, and 4 of 25 referred to the nature of the source. Few reviews seemed to engage in the kind of perspective taking related to the publisher that I had hoped they would. In retrospect, it seems that instead of asking students to identify biases, the reviews should have asked for "point of view" or "perspective" to prompt more perspective taking. However, a few items of interest did emerge in these reviews. The researcher examined the source documents and identified two with clear biases, one of which was clearly identified as such by student reviewers, and one of which was not.

The first example of a Web document with clear potential biases was a page providing information about the immune system that was published by a company selling vitamin supplements. In their review, the students admitted this possibility: "there are definite biases as the publisher is a manufacturer of nutritional supplements." The students then argued that this bias is mitigated by three factors: the content contained no new claims, the site "is not commercially oriented," and the information was extensively referenced (to a textbook.) This was a thorough and well-thought review, and it is encouraging that students did recognize the potential for bias in the (only) commercial site reviewed where such potential was clear.

A different pair of student reviewers did less well identifying bias on another Web page, which researchers identified as having possible biases of style and source conflict of interest. This page on malaria was sponsored by the fundraising group "Rotary against malaria." The students who reviewed this page did not know who had published it. There was a link labeled "Rotary against malaria," but the students may not have recognized this as the name of the sponsoring organization. The students also did not notice some quirks of style not seen in more purely factual resources. The page made use of capital letters to highlight sensational points about malaria worldwide, for example, "The problem is GETTING WORSE because of several factors," and "MALARIA IS A



MAJOR WOMEN'S ISSUE." The page went to pains to show that malaria affected victims who were both poor and undeserving, and that the problem of malaria was getting worse. Although there is no direct solicitation of funds on the page itself, a more savvy reader, one who realized that "Rotary against malaria" was probably a fundraising group, might have realized that the page did have a particular bias toward making the worldwide malaria situations seem dramatic, timely, and tied to (changeable) economic conditions.

An interesting hypothesis that arises from these two individual cases—the vitamin supplement page and the malaria page—is that perhaps students were more well prepared to identify bias in commercial sources than in noncommercial sources. Addressing this student attitude stands as a challenge for future review-writing projects.

## DISCUSSION

This paper examines the potential of student-written reviews of Web pages as a means of social filtering the World Wide Web. Student-written reviews may be an effective way to teach critical evaluation, and these reviews may also be a useful and authentic contribution to the Web's collections. In two curriculum projects, high school science students wrote and published reviews of scientific Web documents that students had found in the course of their own research. This paper and a companion paper (Bos, in press) analyzed 63 student-written reviews and 41 Web source documents in a variety of categories. Four research questions are addressed here:

1. What kinds of resources do students find when doing scientific research on the Web?
2. How do students evaluate the organization of Web resources?
3. How do students evaluate the appearance and use of media in Web resources?
4. How do students evaluate the bias of Web documents?

### What Kinds of Resources Do Students Find when Doing Scientific Research on the Web?

Very little is known about the types of resources students can be expected to encounter when doing scientific research on the World Wide Web. An important goal of this research has been to identify characteristics of the types of scientific resources student re-

searchers are likely to encounter on the Web, focused on understanding both the challenges and possibilities of students' critical evaluations. This paper examines sets of Web source documents found by 11th grade students in two projects, and identified a number of their characteristics, including publishing source, organizational features of considerate texts, and frequencies of use of multimedia elements. This paper also identified a prevalent and unique Web style.

The Web resources that students found came from a wide variety of sources, including (in order of frequency) pages published by US government and states, nonprofit organizations, foreign governments, commercial sources, university sources, commercial publishers, and individuals (Table I). This diversity of sources confirms the potential of the Web as an extraordinary new medium of information access for students, but also speaks to the need for students to develop critical evaluation skills.

Other characteristics of the student-reviewed Web documents were tabulated, including considerate text features and use of media. These Web documents frequently used organizational features of headings and bullet-style lists, but less frequently used considerate text features of topic sentences, introductory paragraphs, or tables of contents (Table II). A particular Web style was often observed, which featured frequent headings (often in the form of a question) interspersed with 1–2 sentences of information. This format often took the place of other, more traditional text organization styles (e.g., use of topic sentences), which might have fit established models of considerate texts. In terms of media usage, the pages made heavy use of navigation icons and decorative graphics. Pages made only sparse use of the more exciting media types afforded by the Web including graphical data representations, video, animations, or sound (Table III).

### How Do Students Evaluate the Organization of Web Resources?

Student reviews of Web organization provided good data for studying the perspective-taking aspects of reviews. Students developed their own perspective on hypermedia organization by reflecting on what organizational structures they liked, and what structures aided their own sense-making processes. Student reviews also often showed perspective taking on behalf of other readers. Student-written phrases such as "there are few subheadings, so the reader must look through the article in order to find what he or

she wants” suggests students were thinking about how another readers might access and use the Web pages they were reviewing.

As components of self-perspective, reviews were also examined to see how often students would name specific organizational features, and whether they would connect the organizational structure to the accessibility of the information (the user’s ability to learn from the resource.) The review forms prompted for these analyses, and they were observed in both projects (Table IV). Percentages of both of these aspects were higher in the second project than in the first (71% versus 42% for identifying features, 83% versus 63% for connecting to accessibility). This may be because the prompting form was more explicit on these points, because students were writing reviews for a second time, or because students had been more given in-class preparation on hypermedia organization as part of the larger HyperStudio design project. In any case, these two iterations offer a model for student evaluation of organization, and baseline data on how 11th grade students may perform with this model.

### **How Do Students Evaluate Appearance and Use of Media in Web Resources?**

The Web offers a variety of new media types that may be aids for learning. However, students must be prepared to recognized and critically evaluate different media representations for them to use it effectively. This paper examines data from two projects where students were asked to critically evaluate the media used in scientific Web resources.

As with organization, the Web resources that students reviewed were not as rich with new types of information such as diagrams, flowcharts, scientific illustrations, video, sound, animation, or interactive simulations as we may have hoped (Table III). Consequently, students’ reviews of graphics and organization did not afford much chance for students to critique new representational forms (Table IV). The paucity of interesting representational types probably explains the low levels of connections to content understanding made by students in their reviews. These findings present a challenge to developers to Web resources for student use, to make more thorough and creative use of the Web’s multimedia capabilities. Further research on more media-rich source materials are needed to examine how students critically evaluate this new media when they are available.

### **How Do Students Evaluate Bias in Web Resources?**

Addressing the third form of perspective taking, which is taking the perspective of the publishers, students were asked to identify bias in Web resources. There was an interesting contrast visible between two student reviews of pages that the researcher felt had a clear bias. In one case, a commercial source of vitamin supplements, student reviewers correctly and thoroughly discussed the potential biases. In the other case, a page sponsored by a fundraising group, student reviewers entirely missed the potential biases. These two incidents lead to the hypothesis that students may be more well prepared to identify bias in commercial resources than in charitable advocacy groups or other nonprofit organizations. Further research on a more controlled set of pages might be worthwhile to study how students respond to different kinds of biased information.

### **Future Directions**

This research suggests a number of potential extensions for further study of student-published reviews of Web resources.

#### *Value of Student-Written Reviews*

This research focuses on the students’ role as writers of reviews. A logical next research step would be to study how students use critical reviews, and whether they truly are value-added contributions to the Web. Would other high school students find them valuable for research? Would younger students or the general public use these reviews? Would student-written reviews be considered more useful for finding information than the output of widely used search engines? Some pilot work on these research questions has begun within the context of the University of Michigan Digital Library Initiative. The next section discusses this implementation.

#### *Technological Implementation of Reviews*

Implementation of reviews as a usable aid to information seeking is dependent on the development of new technology to support this. What software support would be optimal for supporting student-written reviews? Ideally, student-written reviews should be

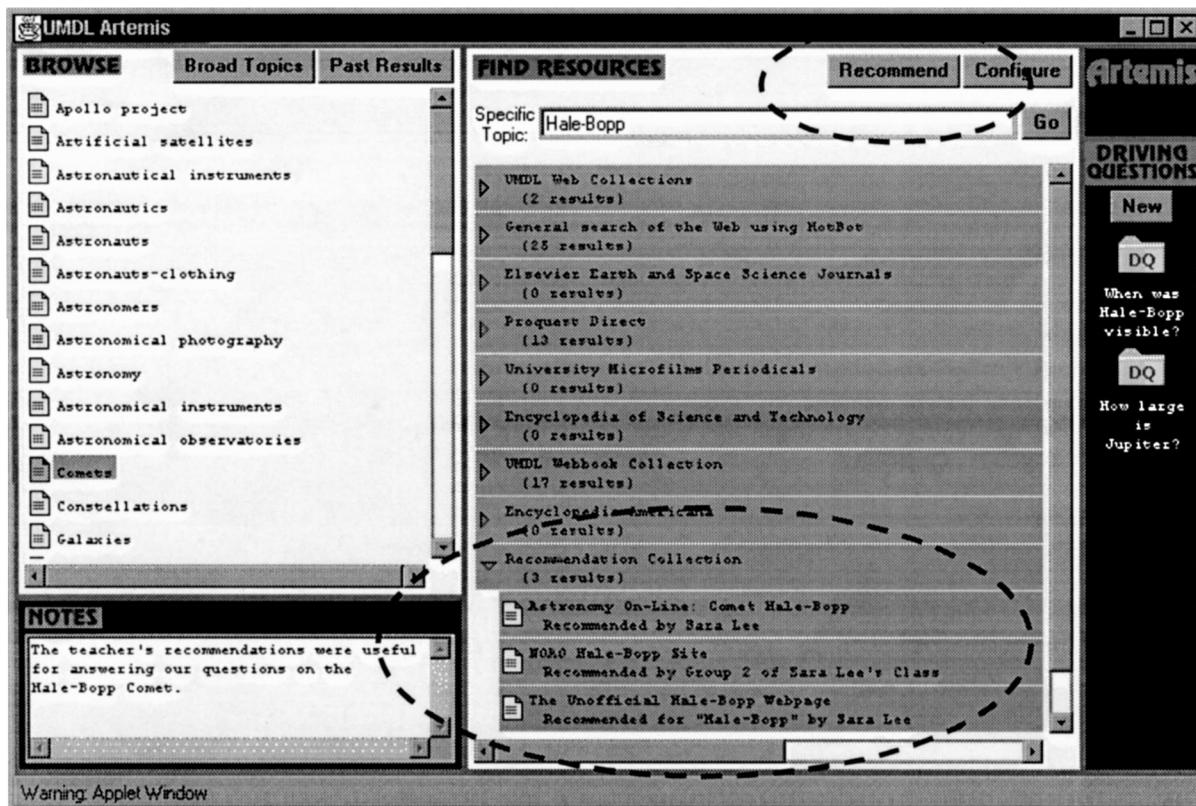


Fig. 1. The Artemis interface to the University of Michigan Digital Library, with recommendation feature.

stored in a database that is searchable by keywords, and also browsable. Teachers should be able to customize the database with their own review categories, and should be able to add their own hotlists of reviewed sites. Finally, reviews should not be in a separate database, but rather should be integrated with other kinds of Web searching, so that reviews are returned as the result of searches in the same way that other Web pages are. One pilot system, implementing all of these features except teacher-customized review forms is called Recommender, and was developed as part of the University of Michigan Digital Library research project (Wallace *et al.*, 1998). Figure 1 shows the Artemis interface, with the Recommender button showing in the upper right corner.

In the Recommender system, students can write reviews of documents they have found on the Web and, by writing a review, add this resource to the library's collections. Once added, these student-written reviews become a part of a recommendation collection that shows up with all other library collections in keyword searches of the library. As an initial pilot test

of this system, some of the student-written reviews from project #1 (air pollution) were made available within the Artemis system. We returned to the same high school where a different class of students were beginning the same air pollution project (project #1). We put a selection of the previously published reviews into the Recommender system, and students were given access to them. Initial anecdotal evidence indicates that students are both willing to use reviews written by other students, and sometimes even chose reviews written by fellow students ahead of other resource collections available in the UMDL system.

## CONCLUSION

This paper presented data from two design studies, exploring the idea of student-written reviews as a means of teaching critical evaluation and getting students involved in publishing contributions in the distributed hypermedia resources of the World Wide

Web. This research provided data on what kinds of resources students may find when conducting scientific research on the Web, provided a model and data about critical evaluation of Web resources, and also explored the potential of student-written reviews fulfilling the function of social filtering of Web resources. Data presented here may provide grounding for further development of the technical and pedagogical scaffolding of students' use of this vast and exciting new resource.

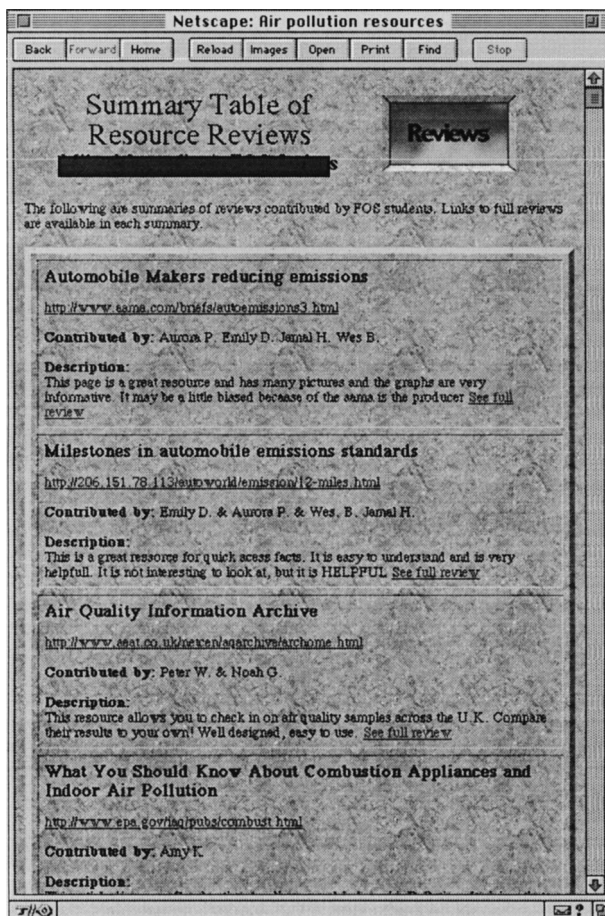
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**Appendix A.** Appearance and layout of published review from project #1.

**Resource title:** Hantavirus illness in the United States  
<http://main.street.net/hantavirus.html>  
 Reviewed by: [redacted]  
 Review written 3/7/97 9:29 AM

**Abstract**  
 The information includes how to prevent the hanta virus and stuff on the last Hantavirus outbreak in the United States as well as some information on what systems in your body the hantavirus attacks. This site is not written in a language that is too technical and would be okay for High School age people.

**Source**  
 The Center For Disease Control and Prevention published this page. There are no obvious biases in the article.

**Organization**  
 The page is well organized with bold headings seperating the information. Information is easy to find. The page is small enough that it does not need a good central page.

**Appearance**  
 There is nothing flashy about the appearance of this page and it has no graphics. The page is well divided by different font sizes and bullets for the lists. The layout and text work together to effectively communicate.

**Appendix B.** Appearance and layout of sample review from project #2.

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