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ABSTRACT

Students can make authentic contributions to the World Wide Web (WWW) and learn critical evaluation skills by publishing reviews of WWW resources. A project which served as a pilot study was implemented where high school students wrote and published reviews of resources they used as part of an inquiry-based science curriculum. Students were supported in writing reviews by specialized software and by in-class modeling of the review process. Findings supported the idea that high school students could critically evaluate sources and produce written analyses that synthesized their evaluations. Findings suggest, however, that student products were inconsistent and the project was not successful in helping students recognize separate types of critical evaluation (e.g. evaluation of source versus analysis of evidence). Future developments in both software and instructional support of WWW reviews are discussed. Reviews published in this project are available online. (Contains seven figures and eight references; a Likert survey sample form is appended.) (Author/CR)

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Student publishing of value-added contributions to a digital library

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Student publishing of value-added contributions to a digital library

Abstract

Students can make authentic contributions to the WWW and learn critical evaluation skills by publishing reviews of WWW resources. This paper will describe a project where high school students wrote and published reviews of resources they used as part of an inquiry-based science curriculum. Students were supported in writing reviews by specialized software, and by in-class modeling of the review process. We were generally pleased to find that high school students could critically evaluate sources and produce written analyses that synthesized their evaluations. However, student products were inconsistent, and we were not successful in helping students recognize separate types of critical evaluation (e.g. evaluation of source versus analysis of evidence). Future developments in both software and instructional support of WWW reviews are discussed. Reviews published in this project are available online from [<http://chs-web.neb.net/pollution>].

Introduction

K-12 students can 'give back to the library' by writing and publishing reviews of resources that they have found helpful in their research. There may be a wide range of interesting benefits to having students produce reviews and other 'value-added' contributions to a library. This paper will begin to explore those benefits by analyzing one set of reviews written by high school students in the context of a project-based science class (Blumenfeld, et al., 1991). Students located resources relevant to their topic, mostly on the WWW but also a few offline resources, and published 'reviews' of these resources on the WWW for the benefit of other researchers. We will describe both the methods we made to scaffold student-written reviews, and perform content analyses of the reviews that were published to determine what parts of this activity were successful and what challenges surfaced.

Benefits of WWW reviews

Student-published reviews have several possible benefits for both the students and the digital library. First, students can learn a range of critical evaluation skills by writing reviews of resources. Second, student-published reviews can add value to a digital library (e.g. the WWW), enabling other users to benefit from the searching and evaluating done by students. Third, value-added contributions represent an authentic publishing task which may help engage students, increase their ownership of the library, and help their understanding of how scientists evaluate and use information.

Critical evaluation of WWW resources

The WWW is a good place for students to learn how to critically evaluate source materials. This quality of the WWW is born of difficulty. As the other papers in this symposium will attest (Wallace, 1997), the WWW is a trying medium in which to conduct research, because of its vastness, its lack of central organizing features, the uneven and unpredictable nature of its content, and because it is ever-changing. We are not the first researchers to recognize that this difficulty also presents opportunity for teaching critical analysis and other 'information-age' skills.

Although we hope that the WWW will not always be as confusing a place as it currently is for K-12 students, the need for some critical evaluation skills is probably an enduring feature of the WWW, and of digital libraries in general. Distributed and decentralized digital libraries, by their nature, will always offer content that varies widely in source, reliability, technical level, media type, organizational structure and purpose. In order to move within these complex information spaces, students must have well-developed 'meta' level skills in evaluating resources and judging what is and is not relevant to their topic area. Therefore, it will be increasingly worthwhile to help K-12 students learn to critically evaluate materials.

What are the components of critical evaluation? Too often 'critical thinking' is thought to be a single type of analysis, when it actually involves a range of distinct types of analyses. In the project described in this paper, we asked students to evaluate sources according to 1) types of scientific claims made, 2) scientific credibility of those claims, 3) source of the published resource, 4) appearance of the resource and 5) the organizational structure of the resource. We also asked students to compose a synthesis of these separate analyses that would serve as a sort of abstract for other users. (More detailed description of the publishing task will follow.)

Benefits of value-added user contributions to the library

Student-published reviews are an example from a class of 'value-added' contributions by users that may serve a crucial role in digital libraries of the future. In a traditional library evaluation of content is done first by publishers and later by librarians, and users have essentially no role. The same is true for the various ways that content is organized and made accessible within the library. In a dynamic and distributed digital library, these traditional gatekeeping functions are harder to fulfill, and users may have an important role. No publishers, librarian, or government controls the content of the Internet-- even if they had the power, the content is too vast and changes too rapidly. Likewise, there are no centralized controls over how the Internet's content is organized, indexed, and accessed. In this environment, if a user takes the trouble to find and evaluate resources that are of use to them, it makes good sense that this 'value added' work persist in the library in some way, so that other users may benefit from it.

Various research groups, including the University of Michigan Digital Library, are developing ways that users can give back to the library by having their search results, evaluations, or written comments persist in some way that other users can access them. The WWW reviews that are the subject of this research are but one example of class of value-added contributions that may become increasingly important to digital collections. (Birmingham, et al., 1996; Ibsen, 1995; Terveen, Hill, Amento, McDonald, & Creter, 1997).

Authentic publishing task

Composing and publishing resource reviews can be an authentic writing task where students can practice skills of synthesizing content and writing for an outside audience. It is sometimes difficult to convince students to invest energy in writing projects that do not have a real communicative purpose. It may be easier to motivate students to critically analyze resources, and synthesize these analyses, if WWW reviews have an authentic role to play in digital collections. Also, the task of writing for a real audience may cognitively benefit students, by making them more conscious of the information needs of scientific readers. (In fact, it was for this last purpose that WWW reviews were originally developed, as a means of instructional support for student publishing of other materials. See Bos, Krajcik, & Soloway, 1997).

Description of the project and instructional support

Setting

The setting for this study is the third-year cohort of an integrated science curriculum at Community High School in Ann Arbor, Michigan. This high school accepts students through a combination of lottery and first-come-first-serve signups each school year. The science curriculum in this school, called Foundations of Science (FOS), 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 three-year sequence focused on investigative science.

Three sections of eleventh grade students published WWW reviews as part of their assigned work for the beginning of a project on air pollution. The final product of this unit was a research report on students' local air quality monitoring efforts, which were also published on the WWW (Krajcik, Bos, and Soloway, 1997). Students published WWW reviews early in the project, as they were conducting the background research for their own reports. The WWW reviews were enhanced because students had an authentic purpose for finding and evaluating useful WWW sites. The stated audience for the published reviews was other high school students who might be conducting research on a similar topic.

Students were encouraged to work in groups, but were required to publish enough reviews to average one per person for the group (i.e. a group of three would be required to publish three reviews).

Software support for WWW reviews

Students published reviews by filling in an html form, [<http://chs-web.neb.net/pollution/reviews/contribute.html>] which solicited comments in seven categories. These categories were: scientific claim, evidence for claim, citation, source, organization of page, appearance of page, and overall description of resource. These categories will be discussed in detail in the analysis section. After students submitted a review, a cgi script parsed the student reviews and published sections of the review in two places. First, the script added summary information from the students' review to a table of the class' reviews (figure 1). Second, the script published the full version of each student review on a separate page, linked to the class table (figure 2).

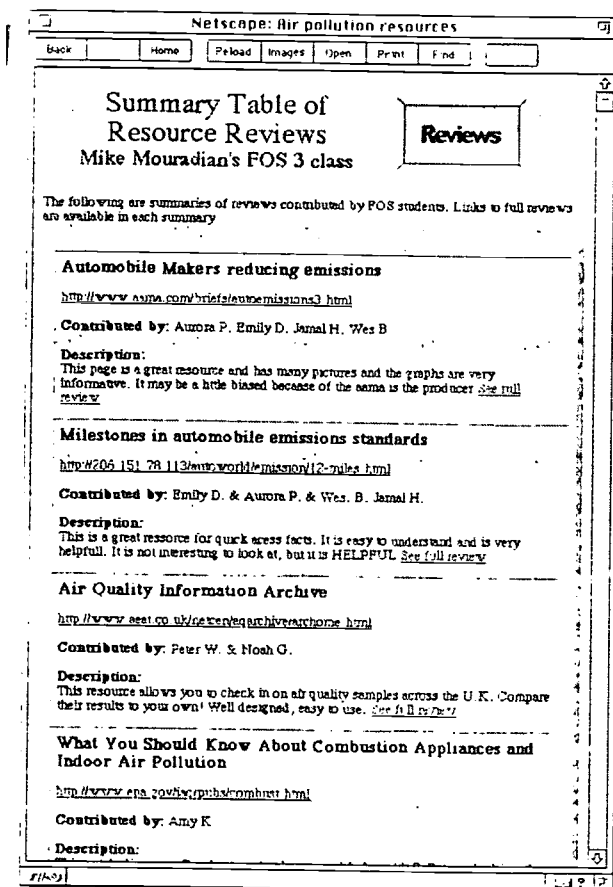


figure 1
Summary table of reviews published by one 11th grade class. Table entries show the description field along with 'hot' links to the full review and to the WWW resource itself.

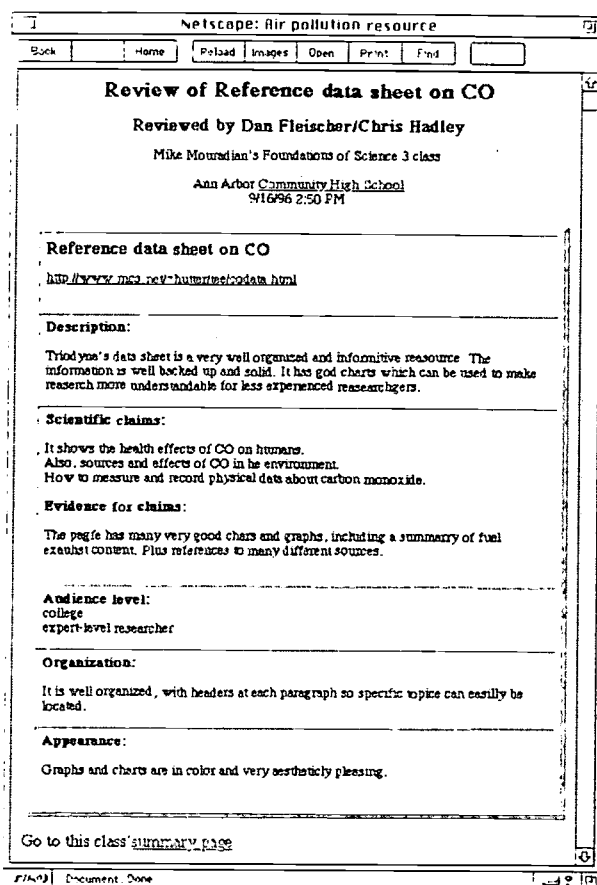


figure 2
Full review of a WWW resource published by one group of students in the air pollution project.

This review-publishing was supported on the high school's own Macintosh server, although it could as easily have been supported on another Macintosh server at a remote location. We used Maxum's Netforms software which allows non-programmers to parse the output of html forms and write the contents to WWW pages or other text files. The contents of the scripts that we designed and the basic file structure of the review pages are available on-line from the air pollution project site [<http://chs-web.neb.net/pollution/about/about.html>]. Supporting WWW reviews in this way requires purchasing of the NetForms software (\$136, available for trial download from <http://www.maxum.com>).

We are currently designing a more sophisticated software tool, ShaReview, which writes reviews to a database, from which student-published reviews can be searched, edited, and linked to student 'home' pages.

Instructional support for WWW reviews

We provided two kinds of instructional support for students writing WWW reviews. The first level of instructional support was in the design of the form itself, which directed students attention to different aspects of the WWW source, differentiated separate kinds of evaluations, and directed them to synthesize comments. The second level of instructional support was a modeling exercise, where students wrote a short practice review of a real WWW site and then compared their reviews to a model review of that site.

Design of form: Rather than present students with the daunting task of composing a free-form reviews, we instead devised a form divided into categories. Under each of the category titles were 'prompting' questions. We were hesitant about using questions, because we wanted to avoid presenting the task as an online 'worksheet' which would encourage students to use their well-practiced skills of dispatching series' of schoolish questions with minimal answers. We tried to present the reviews as a true composition task requiring some thought as to presentation of information, by stressing the need to write in complete sentences and to anticipate the needs of WWW readers.

The form was designed to support a set of high-level skills. By separating critical evaluation into six separate categories we encouraged differentiation--the conceptual separation of closely related categories. The form also prompted evaluation, which is a 'meta' level skill that is not often required of high school students. Writing a good review also required summarization, intelligently condensing an often-unwieldy amount of information into a few sentences. Finally, the form prompted a thoughtful synthesis of information from the first six fields into a single description field.

Practice reviews and modeling: Students were introduced to writing WWW reviews with a practice review activity. Students were given about 20 minutes in class to complete this sample review. After

students had some time to write their own reviews, the teacher displayed a sample review written by the researcher.

The practice site for this sample review¹ was chosen because it illustrates both the good and the bad of WWW resources. The site, "Breath Taking" provided extensive, relevant, and easily referenced data, but did not provide adequate explanation of the source or credibility of this information. Students could access particulate pollution figures from many US cities, along with estimated deaths from particulate pollution. However, the source of these figures was an unspecified "study by the American Cancer Society and Harvard University", with no accounting for data collection methods, and more seriously, no explanation of how the estimated death counts were obtained. Also, the site was not arranged into a recognized scientific format, so that students had to hunt for what information there was related to source and methods. Modeling a review of a resource with these difficulties, which are very typical of the WWW in its current state, would make students aware of the importance of evidence and citation, as well as serve to illustrate for students the importance of citation, evidence, and predictable organization structure in scientific reporting.

Analysis and discussion of student-published reviews

Students published 51 reviews in all, over a period of approximately one month. Average length of reviews published was 9.7 lines, approximately 100-150 words.

This project served as a pilot study for the WWW-publishing concept. All involved parties- teachers, students, researchers, and software developers, were unsure of exactly what the expectations for a high-quality student-published review should be, what sorts of resources students could find, and how well the software would work. The published products were, not surprisingly, inconsistent. Despite this, we were pleased to find that students could write worthwhile reviews, could analyze both content and evidence (to some degree), and could synthesized different categories of comments into short descriptions that could be genuinely helpful to other WWW users.

Summary versus review

One of the first questions we wanted to ask was, were the 'reviews' we asked students to write really different from any other school writing assignments? To study this we compared the published reviews from one class with a set of ten article summaries written by students in the same class. These summaries were assigned by the teachers at approximately the same time as the reviews, and were of articles similar in length and focus to the types of articles students were reviewing online.

¹ "Breath-taking: premature mortality due to particulate air pollution in 239 American cities" [<http://www.nrdc.org/nrdcpro/bt/tableGu.html>]

We were particularly interested in how much science content information was in each type of writing assignment, (we would expect more in the 'summaries'), and how many 'meta' level statements were in each (we would expect more in the reviews.) By 'meta' level statements we mean statements that in some way go outside the scope of the immediate article, and put the article into a larger context by evaluating it or comparing it with knowledge from other sources.

We were correct in our expectations for the relative occurrence of content statements and 'meta' statements. On the average, the summaries were longer and contained more content-specific information. The 'reviews' were shorter, contained less content information, but contained more 'meta' level statements about the articles. A few striking differences: in the ten article summaries, the source of the article itself was never mentioned. By contrast, 9 of 20 of the class' reviews at least mentioned the source (and in the future we hope this will be much higher--see next section.) Many of the summaries did contain some 'meta' level statements, such as student commentary about issues in the articles. However, none of the ten summaries included any commentary on the article itself, (e.g. "this article give good basic information about carbon dioxide") while almost all (19/20) of the reviews did include some commentary at this level.

The WWW reviews, then, demanded less detailed content engagement by the student, but encouraged more high-level evaluation. What is the value of this higher 'meta' level of engagement? We believe that putting the content of a WWW page into a larger context has several possible benefits. First, it may help students form a larger and more accurate picture of the scientific world, which goes beyond isolated facts from nameless scientists, and envelops the researchers, government workers, and private enterprises that use scientific information for disparate purposes. Second, a larger picture is necessary for students to move in the complex information landscapes of the WWW. For example, students who have only ever been taught to process textbook knowledge are easily lost when presented with a list of hundreds of search engine 'hits' which must be rapidly classified and evaluated. Third, taking a 'meta' view of scientific information can help students learn and remember new information by connecting it with their personal opinions and their knowledge from other domains.

Content analysis of reviews

We will now separately analyze each category of the review form. Along with analysis of each section, we discuss issues which arose in this project that may be broadly applicable to student-published reviews.

'Claims' field

Students summarized the scientific content of a WWW resources using the 'Claims' category. On the average, students wrote about two lines of text summarizing claims. To determine how well students were identifying the claims of the WWW pages we were reviewing, we conducted a content analysis of one class' published reviews (n = 14). We accessed the original WWW pages they had reviewed and rated what the students had written about the claims in three categories: accuracy, centrality, and comprehensiveness, with results presented in figure 3.

| Accuracy | Centrality | Comprehensiveness |
|-----------------------|---|---|
| 6 completely accurate | 4 identifies central claims | 1 comprehensive description of important claims |
| 7 accurate | 6 partially identifies central claims | 11 partial description of important claims |
| 1 not accurate | 4 poor identification of central claims | 2 poor description and coverage of claims |

figure 3 Accuracy, centrality, and comprehensiveness of claims (n=14)

Most of what students wrote as claims were accurate, with only one student reporting a claim that was actually inaccurate. Given the variability and high technical level of some of the sites reviewed, we were encouraged by this result.

Students had more difficulty identifying what were the most central claims of a WWW source. This difficulty is not unexpected, given that students were at the beginning of a project, working in a content area that was mostly unfamiliar to them. When content is unfamiliar, it is more difficult for students to identify which claims are new, and which are common-knowledge background information.

Nevertheless, students sometimes missed central claims that we felt should have been discernable, such as one instance where the central claim appeared in the resource title. We expect that with more practice, students should be able to get better at identifying the central claim of a resource, even when working in unfamiliar content areas.

We also felt that students could do a better job of covering the breadth of claims at the sites they reviewed. Often, students would give only high-level overviews of the claims at a WWW site, (e.g. "This site makes claims about the health effects Carbon Monoxide") when they should have gone into more detail (e.g. "This site describes how carbon monoxide robs the blood of oxygen, tells what the symptoms are, and tells how carbon monoxide poisoning can be prevented.") Again, this is partially due to students' unfamiliarity with the content. If students does not know that carbon monoxide has health effects, then that claim alone is a revelation and the rest may seem mere detail. By contrast a teacher or research

reading the summary is well aware that carbon monoxide is poisonous, may consider that fact too obvious to be considered a claim, and will want the student to delve into more detail. Students in this project were almost surely capable of describing claims in more detail, if pushed to do so. Future WWW-publishing projects will give more specific guidelines, perhaps in the form of length requirements, of how much claim coverage is expected.

'Evidence' field

One of the key skills necessary for using resources in an uncontrolled environment such as the WWW is the ability to evaluate credibility of sources. This is not a skill that most high school students are required to practice, because most information they are exposed to comes from carefully screened sources such as textbooks or school library collections. WWW reviews can give students an opportunity to develop savvy and skills in evaluating credibility.

Analyzing the reviews published in this pilot project, we saw that students were able to do some evaluation of credibility. However, students seemed unable to draw distinctions between different methods of establishing credibility. We wanted students to evaluate source credibility in three related but distinct categories: evidence, citation, and source. Our intention was that in the 'Evidence' category students would report whatever they could find about the scientific data-collection behind the information presented, or notice and report the absence of such evidence. In the 'Citation', students were to look for references to published academic studies, and in 'Source', students were to report the author or group responsible for putting the information on the WWW. Instead of recognizing these separate categories, students used 'Evidence' as a catch-all for any evaluations they made of the resource's credibility. In their published reviews, every student collapsed the three categories of 'Evidence', 'Citation', and 'Source' into a single category, and reported their evaluation of credibility using the 'Evidence' field. This, despite the fact that we had gone to some pains to make the distinctions clear, including modeling of the separate kinds of analysis, and inclusion of an on-line glossary linked to the WWW form. Helping students recognize different methods of establishing credibility will be a key challenge for future WWW reviewing projects.

Ninety percent (46 of 51) of student reviews contained something under the evidence category. We coded those 46 responses to see what students were writing in response to the call for evidence. Many evidence fields contained more than one of the categories below.

26% (12 of 46) gave information about scientific studies supporting claims in the WWW resource.

41% (19 of 46) reported that there was no evidence (i.e. description of methods available).

15% (7 of 46) provided elaboration of the claims.

35 % (16 of 46) referred to the source of the information.

Evidence in WWW pages: While only 26% of student-published reviews described scientific evidence, another 41% did report on the absence of evidence. We knew beforehand that many WWW pages did not contain enough information about evidence (the practice review site was one such) and felt that helping students notice this absence was important. As preparation for their own air pollution studies, we wanted students to be conscious of the role of methods in supporting claims made about air pollution.

Elaboration versus evidence: Another difficulty for students was in separating what we would consider 'evidence' from mere elaboration of claims. A number of students (15%) made the error of providing content elaboration in the place of scientific evidence. For example, reviewing a WWW page on carbon monoxide poisoning, one pair of students reported as evidence the typical concentration levels of CO₂ found near gas stoves. Although this is relevant to the claim, and this information does tangentially add to the credibility of the claim, this information is not 'evidence' the way we have defined it. This mistake is not as foolish as it may seem, because in non-scientific settings, elaboration often does suffice to establish credibility. In a composition class, for instance, students are frequently instructed to 'support your points' through elaboration, rather than scientific methodology. It is the somewhat unique epistemology of science that requires description of methods. Teaching high school students to look for and critique scientific evidence may be a worthy purpose for student-published WWW reviews.

Source versus evidence: The most frequent confusion about the evidence category, as mentioned before, was students putting information in the evidence field that we had wanted them to put in the 'source' or 'citation' fields. In 35% of the reviews students used the 'Evidence' field to report who conducted the studies rather than describing the scientific studies themselves. Again, this confusion is understandable when we consider that this is the normal way that high school students (and almost everyone else, unless expert in a field) have for establishing scientific credibility of source material.

Our favorite example of reporting source information instead of evidence, (from a student who apparently did understand the difference) was this one: "They don't have any evidence for that claim, they just have the facts written down. They're the EPA, they can do that." This is a somewhat circular claim ('because the EPA presents them, they are facts') that nevertheless has some truth to it. Even if the EPA was somehow fabricating data or using unsound methods, it is highly unlikely that a high school student, or any other non-expert would be able to detect this. (This same student wrote, in their description field, "If hopefully they are not telling any lies then this is an excellent resource.") In the future we may emphasize identifying the source of information as the primary means of establishing

credibility, although we will continue to ask students to at least notice when methods are or are not described.

Overall, in examining the 'evidence' section of the published WWW reviews we are encouraged that students did conduct some critical evaluation of WWW pages, a skill which, as noted before, is not frequently demanded of high school students in science. In the future, the main challenge will be to separate distinct ways of establishing credibility.

'Source' field

Although the separate Source 'field' was universally ignored by the students this project, it is still valuable to examine who the publishing sources of student documents were, and discuss some of the emergent issues of evaluating sources.

Students wrote reviews of WWW pages from a nicely balanced collection of sources, including government, commercial, and nonprofit-sponsored pages (figure 4). The diversity of sources shows the richness of the WWW, and also highlights the need for critical evaluation skills.

| Government (USA) | Government (foreign) | University | Nonprofit organization | Commercial | Commercial information provider (magazine or reference) |
|------------------|----------------------|------------|------------------------|------------|---|
| 18 | 6 | 8 | 7 | 9 | 3 |

figure 4 Distribution of sources reviewed by students.

A few issues related to this variety of sources seem worth discussing in some detail.

Ambiguity of sources

it is often very difficult to correctly attribute the source of information found on the WWW. Often, scientific information is given with no attributed source. Sometimes, even the publisher of a WWW page is difficult to determine. Students also may be confused when there are multiple sources that they need to report. For instance, the sample review page used in this project gives information from a study by the American Cancer Society and Harvard University, published on the WWW by a private nonprofit environmental advocacy group, giving three potential 'sources' for this information.

A fairly simple skill, that of truncating the URL, should probably be taught to students using the WWW. Often, students will follow a link from a page of search hits, and are deposited into the middle of a WWW site, with no easily-perceived source. The source can often be found by following truncating the URL. This technique is helpful for finding the WWW publisher of information, although the problem of attributing scientific data often remains.

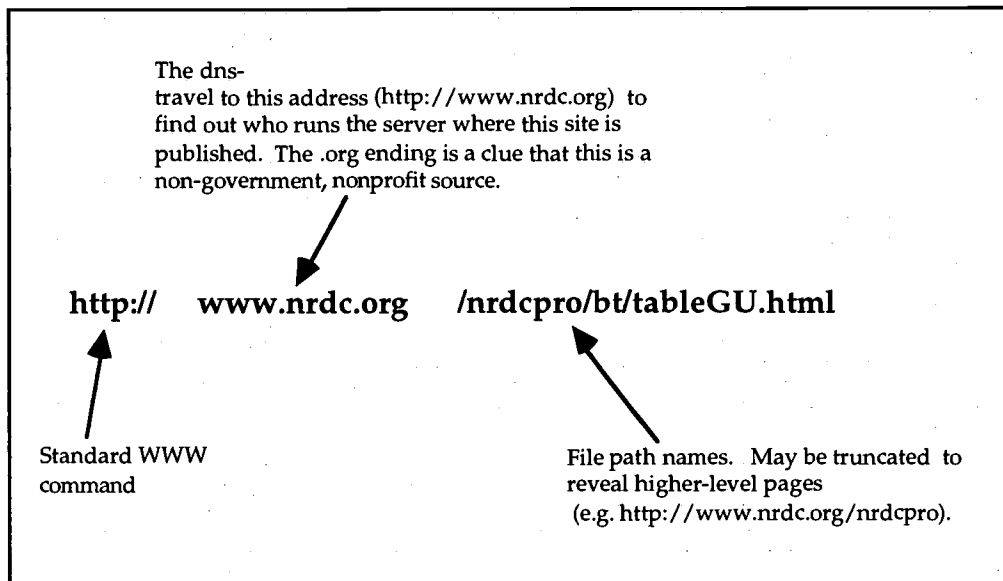


figure 5 Truncating URLs can be a key methods of finding the source of a WWW page

Bias of sources

How should high school students judge the potential biases of the information they find? This is perhaps most easily done when the source is commercial. One good site reviewed by students in this pilot project was a fact sheet about carbon monoxide published by the American Automobile Manufacturers Association² (AAMA). The information was helpful, but it was also good for students to realize that the publisher of this source has a vested financial interest in environmental regulation.

It is more difficult to judge the potential biases of a nonprofit agency. It is helpful for students to spend time in an agency's WWW site trying to get an overall sense of what the agency's mission and goals are. If possible, it is also good for students to try to pin down a nonprofit's source of funding (although this is often not possible on the WWW.)

Most difficult, perhaps, is describing the potential biases of a government source. Should we tell students that government agencies are 'bias-free'? If not, what are it's biases? Most citizens would recognize that a

² <http://www.aama.com/briefs/autoemissions3.html>

government agency does have biases towards perpetuating its own bureaucracy and keeping its mission in the public eye. However, it is not clear how this subtle bias might relate to the routine data collection and analysis done by government agencies.

In general, in this pilot study project, our goal was to simply have students notice that information on the WWW was published by sources with potential biases. We did not spend much time examining how these potential biases might affect the information presented.

In other situations where more time is available, WWW reviews may be an excellent vehicle with which to study how biases affect scientific information. Students may come into such projects with the idea that bias is important only if a source has fabricated data outright-- otherwise, scientific information is just 'facts'. We suspect that outright fabrication by legitimate organizations is somewhat rare, however. Most bias show up in different ways, which students may learn to recognize. Students can learn to think in sophisticated ways about bias by discussing how information may be politicized, and how it may be selectively presented. Some nonprofit organizations seem especially prone to politicization, or haphazard mixing of political and scientific claims in the same article or page. Students can learn to recognize this and should probably learn to treat these sources skeptically. The other biasing tendency is selection of information. An agency or company will naturally tend to present information that supports its position. The AAMA fact sheet on automobile emissions mentioned earlier is a good example of this. The information presented, showing that most air pollution comes from cars built before current regulatory standards, is factual and helpful, but also tends to support a political position beneficial to the AAMA (that further regulation won't reduce air pollution much until older cars are scrapped). An information-savvy student should not necessarily assume that the AAMA 'made up' this information (we expect that they didn't) but should suspect that there may be other information to support other opinions on this matter, and should use other sources to find those opinions.

Organization and appearance

The next two categories of review comments are organization and appearance. As with previous categories, we wondered beforehand whether students would be able to make distinctions between these two similar concepts. In this case, our concerns were unfounded, as students were quite willing and able to evaluate organization and appearance as separate concepts. However, they did not seem to have a lot to say about either of them. 82% (42 of 51) of reviews contained an entry for appearance, and 82% (42 of 51) contained an entry for organization. The typical entry was quite short, averaging 1.4 lines of text for 'appearance' and 1.6 lines of text for 'organization' fields.

Appearance. We expected appearance would be one of the easiest review categories, because students generally already have some opinion about the aesthetic value of the WWW pages they are looking at.

We also expected that students' evaluation of appearance would depend largely on the amount and quality of graphics, (as opposed to subtler features of layout) and we were correct on all counts. Overall, students were unimpressed with the graphical quality of the pages they viewed, but typically viewed this as an acceptable feature of scientific articles. The comment from one student pair "it isn't amazingly gorgeous, but it gets the job done" echoed the sentiment of many students.

One way to increase the sophistication of students' graphics evaluations may be to separate graphics more clearly by function. Some graphics serve a purely decorative function, some serve to reinforce or illustrate the text content, and some (such as graphs) present original content. In the future we hope to help students become more sophisticated in identifying these characteristics.

Organization. This category asked students to focus on how the information on a WWW page was arranged and made accessible. 'Organization' is a much less common category of critique for a high school student to make. However, the group of students participating in this pilot did have some experience because the topic was covered in class a year before, in a project where students created WWW pages. Perhaps due partly to this previous experience, students were able to make some good critiques of organization, commenting on the use of headers, length, hyperlinks, and other relevant features.

Description

The description field represents the most interesting writing task in the WWW reviews. Having analyzed a source according to a series of distinct categories, students were asked to then synthesize these comments into a description of the resource which would appear by itself on the class' summary page. (see figure 1, previously displayed).

The description is thus part of the review, but also could stand alone as a 'mini' review, similar to an abstract. A user reading the description can select one link and go directly to the reviewed resource, or select a different link to read the full reviews (figure 2).

Although the description is the first part of a student review that digital library patrons would read, we arranged the html form so that students composed the description last. By the time that the students wrote the description they would hopefully have thought critically about the other aspects of the resource, and could synthesize these separate analyses into a few well-chosen sentences. The features that we hoped to see in the descriptions were syntheses of two or more evaluation categories (e.g. both content and credibility), 'meta' level evaluation of the source, and a writing style that indicated they were thinking about potential audiences for their review.

Student review descriptions did contain some synthesis and evaluation. Thirty percent (13/43) of the review descriptions synthesized information from two or more review categories. The descriptions that did not synthesize content tended to be either content summaries or simple evaluative statements. Fifty-eight percent (25/43) of reviews containing descriptions included at least one evaluative statement. Evaluative statements were often the first line of the reviews ("this was a very good resource"), or close paraphrases of their own review comments ("This page had attractive graphics").

The most difficult evaluation/synthesis task seemed to involve evaluating content. Even the best of the students' descriptions tend to contain either content summaries or evaluative statements, but rarely do a good job of both summarizing and evaluating content. In the future, helping students write such syntheses will be a pedagogical goal.

A high-quality description does more than simply synthesize and evaluate. The review writer should select information very deliberately, based on the needs of an intended audience. We are still developing methods, including interview and 'think-aloud' studies, for determining to what extent students consider the needs of their potential WWW audience and how these considerations play out in their written products.

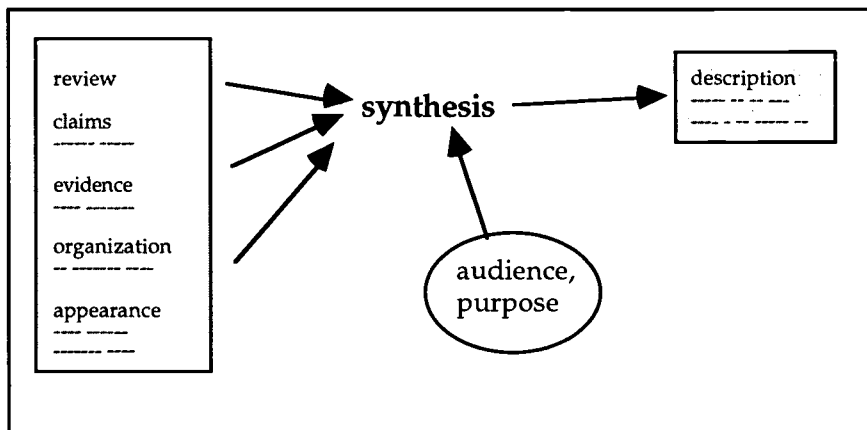


figure 6 Conceptual model showing how comments from six categories are synthesized, with an audience in mind, into a single description

Student opinions of WWW reviews

Survey results on WWW reviews- some students reported that writing reviews madethem more conscious of use of evidence in their lab reports.

Students' opinions on the WWW reviews activity was split. We asked students six likert survey items (Appendix A) about whether they thought writing WWW reviews was valuable, and whether they

thought the learned from it. We found something of a bimodal split (figure 7), with some students quite positive about all aspects of the review-writing, and some quite negative. We have not yet found any variable that seems to account for this split.

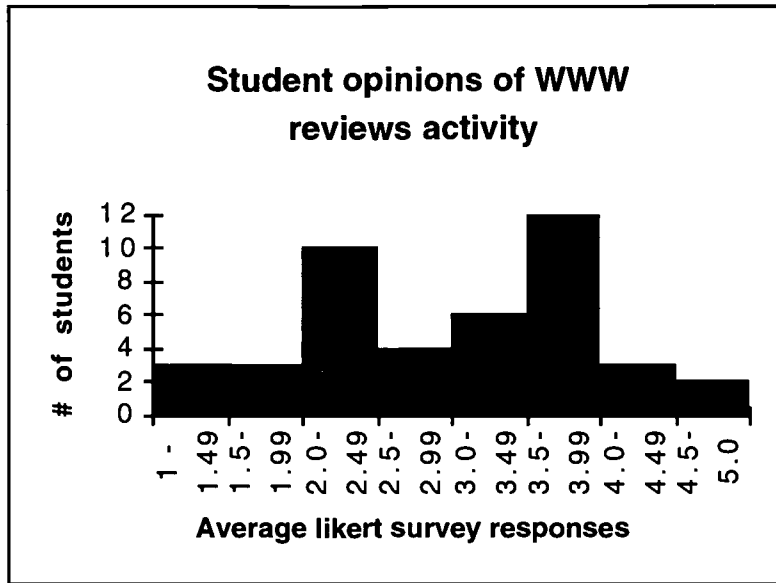


figure 7 Bimodal distribution of student responses, averaged across six likert items, to questions about the worth of writing WWW reviews. Higher responses are more positive.

Examining the average responses, we found slightly positive responses on two items. Students thought that writing WWW reviews made them more conscious of their own use of evidence and citation, (3.1 on 5 pt scale) and said that in designing their own WWW pages they tried to avoid some of the mistakes or bad features of resources they had reviewed (3.2 on 5 pt scale).

Discussion

This project was a pilot study of students-published resources reviews. These reviews were an exercise in critical evaluation, as well as being an authentic 'value-added' contribution to the WWW. We provided an online html form to allow publishing of these reviews, as well as instructional support in the form of modeling and a practice review.

Reviews differed from summaries that were composed by the same class in the same time frame. The 'summaries' contained more content summary, while the 'reviews' contained more 'meta' level statements.

A key difficulty for students was in separating three closely-related categories of 'Evidence', 'Citation', and 'Source'. Students reported all of these in the 'Evidence' field, along with some 'evidence' which was actually mere elaboration, and ignored the other two fields.

Future plans

At this writing, the WWW reviews have already been used a second time by the same cohort of students, [<http://chs-web.neb.net/diseases/reviews/>] although these reviews have not yet been analyzed. For this second project, we collapsed the three fields related to credibility into one field, 'Source'. Although it would be worthwhile to teach students to separate different ways of establishing credibility, that goal did not fit the overall goals of this project. We did take on the challenge of helping students evaluate 'Appearance' and 'Organization' in more depth, by giving them direct instruction about different design principles.

We are also in the process of developing software, called ShaReview, which will take WWW reviews to the next level of technological sophistication. ShaReview writes student-composed reviews to a FileMaker Pro database, where they can be edited by students, and searched by outside users. ShaReview also links each student-written review to a student 'home page'. This feature, along with the editing capability, we hope will allow students both more control and more ownership over what they have written. ShaReview is also being designed so that it can be easily modified by teachers for disparate purposes, and we hope to distribute it free to K-12 teachers.

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Appendix A

Six likert survey questions about WWW reviews, asked of students after the air pollution laboratory reports project

WWW reviews

A. Do you think that writing and posting WWW reviews online was a worthwhile part of this project?

5 (definitely yes) 4 3 2 1 (definitely no)

B. Did reviewing other WWW pages help you become more analytical in your reading of scientific sources?

5 (definitely yes) 4 3 2 1 (definitely no)

C. Did any of the WWW pages you reviewed influence the way you designed your own WWW page?

5 (definitely yes) 4 3 2 1 (definitely no)

D. After reviewing other pages on the WWW, were you more conscious of your own use of evidence and citation (in your project reports)?

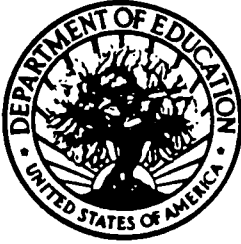
5 (definitely yes) 4 3 2 1 (definitely no)

E. After reviewing other pages on the WWW, were you more conscious of how other people might read the report your group was publishing?

5 (definitely yes) 4 3 2 1 (definitely no)

F. In designing your own WWW page, did you try to avoid some of the mistakes or bad features you saw on other WWW pages that you reviewed?

5 (definitely yes) 4 3 2 1 (definitely no)



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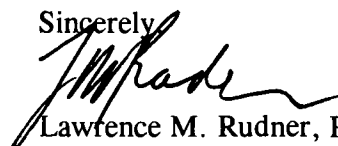
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