Evaluating Web Sources in a Materials Engineering Course

Phillip J. Cornwell, David A. Stienstra
Rose-Hulman Institute of Technology

Abstract

An important part of engineering is knowing how to find, interpret and critically evaluate information. This skill is critical for life-long learning and for engineering practice. Unfortunately, we often do not adequately prepare our students for these tasks while the need to do so has increased dramatically due to the ease of access and the tremendous amount of information on the World Wide Web. To address this problem, a quantitative method was developed to help students improve their ability to evaluate sources of information. Students were asked to apply this method as part of an assignment in a course in materials engineering. In this paper, the proposed method for critically evaluating sources of information will be presented in detail. Assessment results will also be presented evaluating whether or not this method assisted students in evaluating sources.

I. Introduction

The World Wide Web is clearly affecting engineering education as is evidenced by the large number of papers dealing with the web presented each year at the Frontiers in Education Conference and the ASEE annual conference. Students now have at their fingertips a tremendous amount of information. In the area of materials science and engineering the number of web based resources is very large and is growing rapidly. A nice list of web sites with extensive materials information or lists of references to other materials related sites is presented in Reference 1.

One of the criteria associated with ABET 2000 is "The recognition of the need for, and an ability to engage in life-long learning." It is the authors' opinion that identifying, retrieving, and organizing information is an important aspect of life-long learning. One of the ways this criteria has been addressed at Rose-Hulman is by requiring students in the materials engineering class to research a material of their choice and to present their work in the form of a poster session. It has become clear that when asked to do research, students seem to prefer to go to the web than to the library. Unfortunately, students generally do not know how to critically evaluate the information they find and little or no peer review exists for web sources as it does for print published works. An assignment similar to the one at Rose-Hulman, that is, one that requires students to research a material as well as to evaluate the sources of information is described in Ref. 1. In this paper an assignment is described in which sophomore materials students select an engineering material to be researched using both conventional text resources and web resources. An important part of this assignment is that the students are asked to evaluate the quality of the data they find with respect to the following criteria:

- Is there any obvious bias in the data presentation?
- Why is the web page sponsor providing this information freely? (Any hidden agendas that need to be understood?)

- Does the data appear to be technically accurate?

In Ref. 1 it was observed that sophomore students had great difficulty evaluating the quality of the data they found. Their evaluation of site content was often based on their perception of the site sponsor rather than the actual information content. At Rose-Hulman we have observed a similar problem with students' ability to critically evaluate the quality of a data source. To address this problem, a quantitative method was developed as an attempt to help students improve their ability to evaluate sources of information. Students are asked to apply this method as part of an assignment in the materials engineering course.

II. The Rating Scales

The criteria used for this method are a modified version of those found for the general evaluation of web resources[2-4]. When evaluating a source of information on a material, students are required to use four criteria: 1) Is the source authoritative? 2) Is the information quantitative? 3) Is the source unbiased? and 4) Is the source thorough? A brief discussion and rating scale for each of these criteria are presented below.

II.1. Authoritative

If one wants to know the density of Osmium at room temperature, the *CRC Handbook of Chemistry and Physics* is more authoritative than Uncle Jake's web site. Authority in science and engineering comes from a history of accuracy and a reputation for knowledge in the field. This is the result of one of the most powerful controls in science, peer review. Consequently, handbooks published by professional societies and articles in refereed journals command considerable respect. Unfortunately, most practicing engineers must get the bulk of their information from trade journals, vendors, and web sites. Therefore, a method is needed for rating the authority of sources as shown in Table 1.

Table 1 – Scale for rating the authority of a source

Score	Authoritative
1	Authorship of information is unknown/unclear. Information is of unknown source.
2	Author is known but lacks recognized standing (student, sales people, experts outside their field). Author is not the origin of info and little or no reference to better authority exists. (Most small company web sites fall into this category.)
3	Author has reasonable recognition. Information is referenced to secondary sources. (Trade journal articles are often in this category.)
4	Author is recognized and reputable. Information is probably good, but is second hand and is inadequately referenced to a primary source. (Many textbooks fall into this category.)
5	Author is recognized and reputable. (May include college faculty, reputable corporations, and professional societies) Information was created by the author (GE test data on Lexan) or is adequately referenced to original source. (Refereed journals are in this category.)

II.2. Quantitative

To be most useful to a designer, engineering information should be quantitative. A vendor can say their new plastic is "better" but it is more useful to know that it is 30% stronger than nylon. Even better is knowing that the material has ultimate tensile strength of 12,000 psi when tested according to ASTM D638. The best information is reported as quantitative values referenced to known engineering standards. In Table 2 is a scale that can be used to rate the degree to which a source is quantitative.

Table 2 – Scale for rating the degree to which a source is quantitative.

Score	Quantitative
1	Information is in the form of adjectives (better, stronger, lighter)
2	Adjectives have vague reference (lighter than Kevlar, stronger than steel)
3	Information is well defined in a relative sense (material is 30% stronger than cold rolled 1020 steel)
4	Information is numeric without reference to standards (UTS=12,000 psi)
5	Information is numeric and referenced to specific standards. (UTS=12,000 psi per ASTM D638)

II.3. Unbiased

As anyone who has ever sold or bought a used car knows, sales people are not always forthcoming with all the details, especially the disadvantages of a product. Consequently, **no** commercial source can be considered unbiased. A scale for evaluating the degree of bias for a reference is shown in Table 3.

Table 3 – Scale for evaluating the degree of bias for a source.

Score	Unbiased
1	Commercial web sites, press releases, and most short articles in trade journals such as *Machine Design* are simply some form of advertising.
2	The work of only one person or company, rather than information that has been independently verified by other individuals or groups.
3	Comparison articles in trade journals such as *PC Magazine* would fall here. There may be some bias toward reviewing only products that advertise in their magazine, but comparisons are usually quantitative to minimize reviewer bias.
4	Non-commercial sources that still have an ax to grind (Consumer Reports is less biased than Motor Trend because of a lack of advertising, but may be biased towards gas mileage and against horsepower as to important comparisons.)
5	Includes non-commercial web sites and journals that accept no advertising. The article **must** discuss competitive products and be specific about advantages **and** disadvantages of products. Most handbooks, textbooks, and refereed journals are here.

II.4. Thorough

Thoroughness is hard to rate without significant experience. Therefore, for the student, the scale presented is a relative rating scheme, and students are required to look at a lot of sources before giving a high rating. Two questions that can be asked are "Would you recommend that the readers of your work seek out this source?", and "Would you link it to your own web site on the topic?"

Table 4 – Scale for rating the degree to which a source is thorough.

Score	Thorough
1	Sketchy information/ no other comparisons/ would not link to my own web site
2	Best of at least 3 similar sources, probably would not link to my own web site
3	Best of at least 5 similar sources, may link to my own web site
4	Best of at least 7 similar sources, would probably link to my own web site
5	Best of at least 10 similar sources, listed on other people's "best of" lists, would definitely link to my own web site.

III. The Assignment

Each quarter the materials science course is offered, students are assigned a project in which they are required to apply material science knowledge to a problem of material selection and then to communicate their findings to an audience. Each small group selects an engineered object or device of interest to them. (Examples have ranged from bicycle frames to hip implants). They then determine the design requirements such as strength to weight ratio, cost, and ease of manufacture that are subsequently used as the basis for comparing the alternative materials. The student group then selects a "best" material from the quantitative comparison of the alternative materials with respect to the design requirements. The results of this material selection are presented as a poster session that is open to all students on campus. All students in the course are required to evaluate each poster.

A reference list is required of the students that lists all of the sources used in a proper reference format. Accompanying each reference, students are required to rate the source in each of the four categories discussed in Section II. For example, a rating for General Electric's web site for information on Lexan may garner ratings of 5 each for Authoritative, Quantitative, and Thorough, but could not get better than 1 or 2 for Unbiased. If all of the sources are biased, at least one was required to be oppositely biased to the others. For example, if they are reviewing the relative merits of Spectra and Kevlar for body armor, Allied Signal and DuPont would be good references that have opposite biases. A rating for material properties from the ASM Metals Handbook may earn a five in all categories. A typical feature article in Machine Design would probably get a rating of (Authoritative-3, Quantitative-3 to 4, Unbiased-2 to 3, Thoroughness-3).

After a rating is made for each of the four categories, the total rating, that is the sum of individual category ratings, is then calculated. For this assignment all of the categories were given equal weightings, but clearly it is possible to give them different weightings depending on

what is believed to be more important. The reference list was evaluated on format and overall "quality". An example of how sources might be rated by a student is shown in Table 5.

Table 5 – Sample rating of various sources.

	A	Q	U	T	Tot
Ashby, M.F., *Materials Selection in Mechanical Design*, Oxford, Pergamon Press, 1992, pp. 123-127.	4	4	5	5	18
Haberle, J.G., and Matthews, F.L., "The Influence of Test Method on the Compressive Strength of Several Fiber-Reinforced Plastics", *Journal of Advanced Materials*, Vol. 25, No. 1, 1993, pp. 35-45.	5	5	5	2	17
Stienstra, David, Personal interview, 21 March 1995.	3	2	3	1	9
www.chaseelastomer.com, Chase Elastomer Corporation on Hypalon Rubber Products	4	3	1	2	9

A - Authoritative
Q - Quantitative
U - Unbiased
T - Thorough

IV. Assessment

The students were surveyed both before (Survey 1) and after the assignment (Survey 2) to determine if the assignment affected how they viewed sources. These surveys are included at the end of this document. The surveys addressed:

- Students' level of experience with research and references
- Student' opinions on the different aspects of references
- Types of sources (print vs. Web) preferred by students
- A quantitative evaluation of three sources

The students surveyed were primarily junior mechanical engineers who reported writing an average of 5-6 papers over the past three years in which they used at least 3 references. There were no statistically significant differences (95% confidence level) due to the assignment in the students' opinions of what factors were important in selecting a reference. The responses after the assignment were more scattered than before the assignment. The general trend was that the student ratings on the importance of the factors were all lower after the assignment.

A significant difference was seen in the students' view of what mix of sources (Web vs print) they were likely to use in the future. Before the assignment 12% of the students expected to use all Web sources in future work while after the assignment, no students expected to rely entirely on the Web.

The most remarkable result was that the quantitative rating of the three sources did not change significantly from before to after the assignment. The GE Web site went from a rating of 12.0

before to 12.5 after. The ASM rating went from 17.9 to 18.2 and the Machine Design rating was 14.2 before and 13.3 after. This is remarkable because the measuring methods were so different. In the first case, the students rated each reference on a scale 0 to 20 based on their personal view of quality. In the second case, they rated each reference with respect to four categories using a 0-5 scale (with specific criteria) and summed the result. Either this is coincidental, or the collective wisdom of 50 junior mechanical engineers is similar to that of the author of the survey. Since the 50 students reported researching an average of 5-6 papers apiece over the past 3 years, they collectively may have similar experience and opinions.

V. Conclusions

In this paper, a quantitative method to help students improve their ability to evaluate sources of information has been discussed. The method requires students to evaluate their sources according to four criteria: 1) Is the source authoritative? 2) Is the information quantitative? 3) Is the source unbiased? and 4) Is the source thorough? The surveys indicate that students are less likely to rely entirely on Web sources after the assignment. This indicates some increase in critical thinking with respect to sources. Student ratings of source "quality" appeared to be unaffected by the assignment. This may be because of significant experience with use of references.

Bibliography

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PHILLIP J. CORNWELL

Phillip Cornwell is an Associate Professor of Mechanical Engineering at Rose-Hulman Institute of Technology. He received his B.S. from Texas Tech University in 1985 and his M.A. and Ph.D. from Princeton University in 1987 and 1989 respectively. His present interests include structural dynamics, structural health monitoring, and undergraduate engineering education. Dr. Cornwell has received several awards including the 1990 ASME Aerospace Division Award, an SAE Ralph R. Teetor Educational Award in 1992, Teacher of the Year from a Rose-Hulman student group in 1994 and the Dean's Outstanding Teacher award in 2000.

DAVID A. STIENSTRA

David Stienstra is an Associate Professor of Mechanical Engineering at Rose-Hulman Institute of Technology. He received his BSME from Iowa State University in 1978, MSME from University of Iowa in 1982, and PhD from Texas A&M University in 1990. His interests include all aspects of engineering materials, fracture mechanics, fatigue and failure analysis and undergraduate engineering education.

Survey 1
Responses are in bold face below question
49 students responded

1. In the past three years, how many times have you researched a topic in which you used at least three references?
   a) 0 b) 1-3 c) 4-6 d) 7-10 e) >10
   (0%) (18%) (51%) (16%) (14%)
2. In the cases where you researched a topic in the past, what proportion of the sources came from the web (articles not previously published in journals) versus from print sources (books, journals)?
   a) 100% Web b) 75% Web c) 50% d) 25% e) 0%
   (0%) (18%) (37%) (41%) (4%)
3. If, as a future company employee, you had to do research and had equal access to all sources (well-stocked technical library and fast internet connection), from where would you prefer to get your sources?
   a) 100% Web b) 75% Web c) 50% d) 25% e) 0%
   (12%) (27%) (39%) (22%) (0%)
4. When selecting a reference, how important are each of the following
   1= Very important 2= Important 3= Neutral 4= of little concern 5=of no concern

Source is easy to access	1	2	3	4	5
	55%	**16%**	**5%**	**2%**	**0%**
Source is easy to read	1	2	3	4	5
	45%	**51%**	**2%**	**0%**	**2%**
Source is free of bias	1	2	3	4	5
	31%	**24%**	**20%**	**2%**	**2%**
Source will impress reader	1	2	3	4	5
	22%	**27%**	**31%**	**12%**	**8%**
Source is believable	1	2	3	4	5
	73%	**25%**	**2%**	**0%**	**0%**
Source contains quantitative information	1	2	3	4	5
	39%	**27%**	**12%**	**0%**	**2%**
Source contains a lot of information	1	2	3	4	5
	20%	**53%**	**20%**	**4%**	**2%**

Suppose you are researching polycarbonate plastic. Please rate the following sources based on a scale of 1-20 in which 20 is what you believe to be the highest level of quality. Note that GE is the manufacturer of Lexan, one of the brand names of polycarbonate, ASM International is a professional society of materials engineers, and Machine Design is a trade journal focused on the mechanical design area.

(12.0)_____ General Electric Web page
(17.9)_____ ASM Engineered Materials Handbook excerpt
(14.2)_____ Article on use of polycarbonate in Machine Design

Survey 2
Responses are in bold face below question
51 students responded

1. If, as a future company employee, you had to do research and had equal access to all sources (well-stocked technical library and fast internet connection), from where would you prefer to get your sources?

a) 100% Web	b) 75% Web	c) 50%	d) 25%	e) 0%
(0%)	**(32%)**	**(44%)**	**(24%)**	**(0%)**

2. When selecting a reference, how important are each of the following

1= Very important 2= Important 3= Neutral 4= of little concern 5=of no concern

Source is easy to access	1	2	3	4	5
	41%	**37%**	**6%**	**12%**	**4%**
Source is easy to read	1	2	3	4	5
	25%	**45%**	**21%**	**6%**	**4%**
Source is free of bias	1	2	3	4	5
	20%	**41%**	**24%**	**8%**	**8%**
Source will impress reader	1	2	3	4	5
	11%	**17%**	**34%**	**28%**	**9%**
Source is believable	1	2	3	4	5
	46%	**31%**	**6%**	**13%**	**4%**
Source contains quantitative information	1	2	3	4	5
	35%	**37%**	**12%**	**10%**	**8%**
Source contains a lot of information	1	2	3	4	5
	13%	**33%**	**40%**	**8%**	**6%**

Suppose you are researching polycarbonate plastic. Please rate the following sources based on a scale from the attached page. The total is the sum of the other four columns. Note that GE is the manufacturer of Lexan, one of the brand names of polycarbonate, ASM International is a professional society of materials engineers, and Machine Design is a trade journal focused on the mechanical design area.

A	Q	U	T	Total	
				(12.5)	General Electric Web page
				(18.2)	ASM Engineered Materials Handbook excerpt
				(13.3)	Article on use of polycarbonate in Machine Design