

# The Impact of the WWW on Engineering Education

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**Abstract** — The rapid growth of the World Wide Web is changing the way students learn and the way that they demonstrate their learning. Engineering educators are beginning to use the web as a vehicle for the presentation of both basic and supplemental materials for the instruction process. In addition, a wide range of engineering resources is available to students through searches on the Internet. Many students are being asked to use the Internet as a means of presenting their engineering designs and assignments. The graphical and non-linear format of the Internet provides many new ways of presenting and organizing data that could not easily be accomplished with conventional methods. A big problem that students and faculty are facing is that the ease of publishing on the web is creating data overload. No longer does one need to go through the process of finding a publisher and sending a book or article through a review process before publication. Students must address the issue of evaluating the worth of material that they find in their searches and must also consider the value of what they have produced for public dissemination. We have sought to assess the effect that publishing on the web has on the student's ability to critically interpret the materials that they gather from the web.

### I. INTRODUCTION

The growth of the Internet and the information resources available through it is changing the way that engineering education and engineering design is carried out. The student or practicing engineer is no longer limited to those books, articles and colleagues at their university or plant [1]. With the ability to rapidly communicate anywhere in the world, collaboration can take place and resources can be shared easily and rapidly. The development of the Internet in its current form and the changes it has made in the communication are well documented in *The Internet Book* [2]. Through classroom exercises and assignments, we have sought to make our students aware of these changes and the effect that it can have on the engineering design process. We have sought to make them aware of the engineering design resources available to them and of the ability to collaborate electronically.

### II. STUDENT RESEARCH ASSIGNMENTS

Students in a number of Materials Science classes have been asked to search the Internet for engineering design data. After selecting an engineering material or group of related materials, they were to research engineering properties, proc-

essing and applications available from any web sources. The only restriction on their searches was that the sources which they referenced needed to provide information that was freely available to anyone with web access and that did not require a payment or special access privileges. They were then asked to submit an annotated bibliography describing the resources that they had found. An important part of this bibliography was an *evaluation* of the data available at each web resource. The students were first asked to evaluate the usefulness of the data in carrying out the design of an engineering product or process. They were then asked to evaluate the quality of the data:

- Is there any obvious bias in the data presentation?
- Why is the web page sponsor providing this information freely?
- What is the environmental impact of using these materials or process? (In line with the Padnos School of Engineering's emphasis on environmentally responsible design - <http://engineer.gvsu.edu/pse-info/mis&val.html>)
- Does the data appear to be technically accurate?

The annotated bibliography was then submitted electronically as a hypertext document with active links to each of the web resources. In addition, many of the students posted the bibliographies to their personal web pages. The hypertext submission of the bibliographies not only makes the information found more useful because of the active links provided, but also greatly aids the instructor in verifying their research sources and conclusions. They also allow a compilation of the students' resources to be made available for future student use in their classes - <http://engineer.gvsu.edu/courses/250/materials.html>.

The Internet can also be a source of creative ideas. In a senior design course, students were asked to identify a problem they had seen during their co-op work terms. They were then asked to search available patents on the Internet for a potential solution. Through their searching they uncovered a number of sites that offer patent information. These sites al-

low searches of current patent information for no fee, and provided abstracts, reference information and claim lists. Fees are only charged for complete copies of the patents. Previously this process would have required hundreds or thousands of dollars and help from a patent agent. In their submitted homework (on-line) the students included actual links to the specific patents. This made it possible to give this worthwhile assignment that would have been otherwise impossible.

#### *A. The Advantages of Research Assignments*

Engineering programs throughout the country have been criticized for ineffective usage of computers in engineering education [3]. These assignments provide a demonstration of the effective application of computers to engineering design in a way that is quite different from the more common application as a computation tool. Students use the Internet to find design data, to communicate with the instructor and to collaborate with other students on their research assignment. By being able to electronically link to remote engineering resources, students can broaden the scope of their knowledge beyond what is available at any particular campus. By tapping into the resources of companies, libraries, professional and trade organizations and universities worldwide, it is possible to get a much broader base of information than is available at any one location.

#### *B. The Disadvantages of Research Assignments*

Web based information resources still have many problems which need to be overcome before they are truly useful for engineering design applications. Students often complained that they were deluged with an overload of information as they performed their searches. A web search on a simple engineering topic often lead to many thousands or millions of hits. It became impossible to sort out those that were truly applicable to the topic they were researching. Surprisingly, another strong response from the students was that there was a lack of information available. Often this response came from the same students who had complained of an overload of information. Although there were lots of 'hits', it was often difficult to find any truly useful information.

As was observed in a previous Internet research assignment several years ago, the students had a great deal of difficulty evaluating the quality of the data they found. Their evaluation of site content seemed to often be based on their perception of the site sponsor rather than the actual information content. Surprisingly, government and academic sponsored sites were perceived most favorably, while commercial sites (anyone having a product or service to sell) were perceived with a great deal of skepticism. Part of this skepticism concerning commercial sites may be related to the limited information provided at many of these sites. This limitation

may be due to concerns about the compromise of proprietary data or to the potential for lawsuits due to the misuse of data.

The students also found that many of the sources of data that they perceived to be the best were not available without some form of payment. The effort to find some way to make access to information electronically a viable commercial exercise has led to restricted access at many sites. A small amount of information is often provided as an advertisement, but the user is required to pay through a subscription fee or a per use credit card charge in order to get detailed information about materials and processes.

### III. STUDENT AUTHORED WEB PAGES

The Internet allows students to go beyond being simple consumers of information. The ability to create and post the results publicly now makes the students producers of technical content. We offer multiple courses where students are required to submit their work by adding hypertext links from their home pages to assignment files. The files are then available for anybody world wide to download (<http://engineer.gvsu.edu/courses/> and <http://claymore.engineer.gvsu.edu/students.html>). This has been done for a number of courses,

EGR 209 Statics and Solid Mechanics  
EGR 250 Materials Science  
EGR 255 Materials for the Electrical Sciences  
EGR 352 Kinematics and Dynamics of Machinery  
EGR 367 Manufacturing Processes  
EGR 450 Manufacturing Control Systems  
EGR 470 Product and Process Design  
EGR 474 Integrated Manufacturing Systems  
EGR 485/486 Senior Engineering Project

Consider that problems that are solved on paper often contain transcription and calculation errors (as well as scribbles). Software based solutions encourage the students to focus on the creative aspects of the solution, while decreasing the need to tend to detail. There is an obvious tradeoff here, but when carefully planned the student will benefit.

To increase student success when doing electronic publishing it is necessary to discourage the use of scanned pages. Instead we encourage the use of programs such as Microsoft Word to allow typesetting, and other programs such as Excel, Mathcad, Working Model and Labview to allow problem solving support and simulation. As an example, consider the use of Mathcad for simple matrix based calculations such as circuit mesh analysis or truss analysis. The student will first spend time setting up calculations, but then spend less time finding matrix inverses. Overall the assignments are more accurate, and errors are focused on the equation formulation. A few examples of work that students have submitted on the web include:

- static truss solutions done in Mathcad and simulated in Working Model
- analysis of a bicycle frame for forces, deformation and strength
- kinematic and dynamic analysis of four bar linkages with Mathcad and Working Model
- design of rotating cams done using Mathcad, Autocad and Working Model.
- Labview programs to do PID control of a motor
- estimates of cutting forces and efficiencies in HTML
- process plans in HTML and Word documents
- final project reports for a number of courses using varied formats

The use of commercial software to present the students' work on the web poses some unique issues. The use of proprietary software packages requires that the remote reader has the required software or a browser plugin. To make the materials more universally readable we encourage the use of HTML whenever possible. Most HTML publishing software is easy to use and readily available (even free).

The Internet also raises questions of privacy and integrity. When a student posts their work, their achievements and mistakes stand for all to see. This encourages students to put in greater effort and take greater pride in their labors. But, work that has been evaluated and marked is returned privately. A stated concern is that when work is available publicly it makes it possible for copying to occur. Casual observation has revealed that students share results, but copying is a rare occurrence.

As expected, work that has been submitted electronically can be marked and returned electronically. The nature of electronic documents is such that the student no longer needs to be physically present to deliver or retrieve the marked work. In addition, solutions for suggested and assigned problems can also be posted. If the problems are based on assumptions, it is easy for students to modify the solution assumptions to check their own work. As for marking the electronic versions, most software allows the addition of text with color or font changes to make it stand out. The marked files can be returned to the students either by electronic mail, or by placing them in a private directory.

#### *A. The Advantages of Student Authoring*

Our opinions are shaped by the depth and breadth of our experiences. In the pre-information age these opinions were heavily influenced by commercial printers. In particular we are accustomed to resources that appeal to broader audiences. Examples of these printed works include books, magazines and journals. In general these are subject to constraints such as:

- publication length (100+ pages for a book and 5-20 pages for a journal)
- perceived market – personal values often transcend financial returns
- publication costs
- a linear consistent document – the depth of information must be complete
- a high level of correctness and completeness
- printable on ink and paper
- released as editions

A complement to mass publication is the individual publication that we tend to find on the Internet. A large portion of the technical content on the Internet is created by individuals. They post a variety of individual facts with personal interest. Consider that on the Internet an individual is likely to post a single value, but in printed books we are more likely to get tables of those values. Understanding this difference helps clarify the source, quantity and quality of the Internet based information. After posting assigned work to the web the student is better prepared to differentiate between Internet based resources and more traditional printed matter. This is accompanied by a greater understanding of the source of the content.

#### *B. The Disadvantages of Student Authoring*

Although the Internet is quickly becoming ubiquitous [4], it is still not universally accepted. In this time of transition we find varying levels of ability and comfort. For the student that is not yet comfortable there is a significant perceived barrier. This barrier can be extremely distracting, and will reduce the value of the experience. This is overcome with individualized help (although this need is diminishing).

### IV. CREATING EDUCATIONAL RESOURCES

If students are to participate in the information exchange of the Internet, faculty should be contributing as well. We can characterize the information created by students as inconsistent, incomplete and possibly incorrect. As educators, we can provide a point of stability to students by providing content that is consistent, complete and correct. We have done this previously through our course notes presented in lectures. By placing course notes on the web we now present a needed body of knowledge that is condensed, has suitable levels of detail, and is not driven by commercial and individual interests alone. Other similar developments are occurring at other universities [5].

To date we have placed full sets of course materials online for a number of courses. By themselves these materials number hundreds of pages, and can still be bulky and tedious to the casual reader. But, on the web, details are easily found using search engines. The web site ([www.eod.gvsu.edu](http://www.eod.gvsu.edu)) has

been set up with search capabilities for some of the posted course notes, as well as for the student directories. Students can use the search engine to quickly find topical information from a variety of sources, and related topics, before needing to venture to outside sources. The popularity of this site has seen a rise in use from fewer than 10 transaction per day last year to well over 100 per day this year (measured by telnet and ftp sessions).

## V. CONCLUSIONS

Most students who have used the World Wide Web to research materials topics have been very successful. Research materials are plentiful and reasonably easy to access with the fast search engines and well researched starting points pointing the way. The students continue to have difficulty, however, with the evaluation of the material obtained through their searches. Often the information that they find is intended only to sell a product or to persuade the reader of a particular point of view rather than to provide objective technical information. Particularly on issues where technical and social concerns mix together, many of the students seem to have great difficulty synthesizing a personal viewpoint. They often seem to be swayed by the last (or most persuasive) web site that they visited rather than by an objective evaluation of the opposing views. As with the evaluation of documents in the print media, students need to be guided to carefully analyze the biases of the author and synthesize a supportable viewpoint of their own.

Some students continue to have difficulty finding appropriate data on the web. These students, who generally have had very little Internet experience, have indicated the need to include detailed material on web research in engineering courses. Through the exercises in our courses, we have sought to make our students aware of the many aids available to engineers on the Internet to assist in the design process. This information includes legislation and regulations, case studies, materials properties and process data.

Engineering students need to be taught to effectively use the Internet resources and to glean the valuable information from what is provided while understanding that the level of review afforded most traditional publications is not yet applied to the Internet. They must also understand that the data provided on the Internet is often isolated and incomplete rather than an exhaustive compilation on the subject.

Used effectively, the Internet can supplement classroom instruction and provide valuable resources for developing senior design projects. One of the biggest difficulties, however, is that with the proliferation of information, little has been done to ensure the quality of that information. It has become very difficult to search through the enormous volumes of data to find that which is truly valid and useful. Since anyone can publish on the Internet without peer review

or other oversight, much of the information is of questionable value. It is essential to understand the source of the information and to use it in context with other information sources, online or otherwise, in order to ensure proper application. Some mechanism of electronic peer review seems to be desperately called for to ensure that the checks and balances which have been applied to print media are also applied to electronic media. The professional societies need to lead the way in providing mechanism for the review process, but many seem reluctant to enter this field since it is not at all obvious how the costs can be recovered or money can be raised when the documents are so freely distributable.

## VI. BIOGRAPHY

Paul D. Johnson is Associate Professor of Engineering in the Padnos School of Engineering at Grand Valley State University where he has taught since 1986. Although a materials engineer, he has been active in the development of the computer engineering program and the integration of web resources into the engineering curriculum. He is system administrator and web master for the school of engineering's Internet server. Prior to his appointment at Grand Valley, he was a Staff Engineer at the Kansas City Division of Allied-Signal Aerospace and Assistant Professor of Mechanical Engineering at Montana State University. He also spent four years in the USAF as an instructor of computer electronics technology for the U. S. Air Force and the Federal Aviation Administration. He received his BA in Physics and Mathematics from Houghton College (NY) and his MS and Ph.D. in Metallurgical Engineering and Materials Science from the University of Notre Dame.

Hugh Jack is an Assistant Professor on Engineering in the Padnos School of Engineering at Grand Valley State University. His background includes a Bachelor's in Electrical Engineering and Master's and Ph.D. in Mechanical Engineering. He has been teaching courses in Manufacturing, Mechanical and Electrical Engineering on a variety of topics. Areas of interest include Robotics, Process Planning, Parallel Computing, Internet Applications and Education. Much of this work can currently be seen at (<http://www.eod.gvsu.edu/>).

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