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Helping Biomedical Engineering Students Develop Internet Literacy*

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This paper presents a novel approach to a class project in biomedical engineering that emphasizes both the most up-to-date knowledge in the field and the development of the Internet literacy required for the profession. Students work in teams on biomedical engineering projects that are published on the WWW. In the process of developing these projects, students gain Internet literacy and learn the basics of managing HTML, understanding copyright issues, determining how to take advantage of the unique nature of the World-Wide-Web, and learning from one another.

INTRODUCTION

ENGINEERING EDUCATION, including that of biomedical engineers, can no longer restrict itself to producing technically competent engineers but must also produce engineers who understand the context of the application of technology [1], can work in teams in a global environment [2], can communicate effectively [3, 4], and can keep up with rapidly occurring technological changes [5]. Each of these educational needs has taken on even greater urgency in the age of Internet technology.

The Internet is playing an increasingly significant role in the profession of engineering. Clearly, students need to become Internet literate to thrive in this changing world. The problem, however, is that while there are ample resources for helping engineering students find information on the Internet [6, 7], students receive very little actual instruction in and have few opportunities to create sophisticated forms of communication on the World-Wide-Web (WWW). Developing network literacy is much more than just learning Hypertext Markup Language (HTML). For example, network communicators must think of their audience in different ways, anticipating the needs of a wide variety of users. They must be able to manage the visual aspects of a web site, which is a far different medium from the page. They must be able to conceive of a text hypertextually, breaking it into appropriate components and helping users to find their way through them. They must be able to approach the communication task from the perspective of the usability of the final product.

These are just a few of the issues that set network literacy apart from print literacy. What we need, then, is a way of providing students with learning opportunities for developing network literacy related to their engineering curriculum. This is one of the goals for BAE 465: Biomedical Engineering Applications, a required course for students who are following the Biomedical Engineering Concentration in the Biological Engineering program at North Carolina State University.

Students in BAE 465 work in teams to produce a web-based project. While completing their projects, students learn how to:

1. find technical information on the assigned projects from the WWW as well as from more traditional sources;
2. make distinctions among the various types of sources according to authority, credibility, and value to the project;
3. prepare materials for presentation on the WWW;
4. produce original graphics for their web projects;
5. manage copyright issues that apply to web sites, such as publication of their own work and the use of web materials from elsewhere.

INTERNET PROJECT GUIDELINES

At the beginning of the term, the instructor assigns members to teams based on academic capabilities and other considerations. Each 3- to 4-member team is assigned at least one student with a high grade point average. Gender and ethnic background are also taken into consideration to provide balance and diversity within teams. Since these projects require a large amount of time to complete, student work and class schedules are collected and compared before final team assignments are made. Students are given the option of listing those members of the class with whom they would like to work and those members they would like to avoid. In addition to the Internet project, the teams must complete several homework sets during the semester.

Early in the 15-week semester, teams pick a project from a list of suggested topics. They may also suggest a topic that is not on the list and has

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not been covered recently. Each project is completed in two stages and is developed in common file space on the university's computing system. During the development phase, members of the class and the instructor are the only ones who can access the projects via the WWW.

Part I of the project involves writing approximately half of the technical material that is to be covered and developing it for web publication. Each project must include at least five links to images or relevant sites on the Internet, an original drawing, a bibliography, and a minimum of five references to peer-reviewed scientific research journal articles that provide historical information or represent early research on the topic. Projects that involve a specialized area in biomedical engineering must describe:

- the medical aspects of the biomedical engineering problem and why it is an important issue;
- the patient population that needs the device or measurement;
- the history of the development of engineering solutions before the introduction of the computer;
- the types of physiological signals that were measured and the transducers and biosensors used to make the measurements;
- patient safety issues;
- failures.

Projects that involve a body system must describe the anatomy, physiology, function, and medical relevance of the topic. In addition, each member of the group must write to at least one company that produces a product related to the project and request product literature, pricing information, and samples of the product. Many of these companies are now identified and contacted through the Internet.

Part I is worth 10% of the overall grade that a student receives in the course. It is graded on a 100-point scale with points assigned as follows:

- 40—technical content with appropriate sections;
- 10—spelling and grammar (0.5 points/error with a 10-point cap);
- 5—length (2 to 3 pages of single space Internet material per person);
- 10—scientific research articles;
- 5—original drawing;
- 10—WWW links;
- 5—reference format;
- 10—written in HTML or other languages used for web publications;
- 5—letters to companies.

Each student's grade is determined from the instructor's grade for the project and an evaluation by team members of each person's contribution to the project. Students who contribute an exceptional amount to the development of the project receive a grade that is higher than the team's score while students who fail to contribute their fair share receive a grade that is lower than the team's score.

Each team turns in an original and four copies of Part I. Each student selects a project from another team to review with each member of a given team selecting a different project so that every team will have the opportunity to look at two or three other projects. Detailed guidelines are provided for the peer review process, which serves two purposes. First, each team receives additional comments that are helpful for improving the overall quality of the project. Second, each team member sees at least one other project in detail and learns about the writing and web design styles of another group. Having to correct someone else's work helps students apply their writing skills and become better writers. Since the members of a team review different projects, they have the opportunity to learn different techniques used by others that they can then share with the group. This is a modified version of the jigsaw approach to team learning in which each member of a team learns different skills and brings them back to teach the group. Each student is given a grade (3% of the overall course grade) that is based on the quality of the review. Students who provide little feedback to the authors of a project receive poor scores on their reviews.

For Part II of the project, students must complete the rest of the technical material, correct the errors that were noted for Part I, and add this new material to their Internet site. All projects must also include five new links to images or sites on the Internet and five new references from peer-reviewed scientific research journals that were published within the last five years. Biomedical engineering projects must include a discussion of recent engineering solutions to the health care problem, technological innovations that have affected the specialized area, and future improvements that are needed. Projects that involve a body system must cover the topics that the biomedical engineering projects covered for Part I.

Part II is valued at 12% of the overall course grade. It is also graded on a 100-point scale with points assigned as follows:

- 40—technical content with appropriate sections;
- 10—spelling and grammar;
- 10—corrections made to Part I;
- 5—length (2 to 3 pages of single spaced Internet material per person);
- 10—new scientific research articles;
- 10—new WWW links;
- 5—reference format;
- 10—written in HTML or other languages used for web publications.

As was the case for Part I, individual student scores are based on the overall score for the project and an evaluation of the student's relative contribution.

At the end of the semester, each team presents its project to the rest of the class (5% of the overall grade). The oral presentations are expected to be presented from on-line material that the groups have developed. Presentations are graded by the instructor and other members of the class based on organization, quality of the A/V materials that are used, preparation, technical content, and ability to hold the audience's interest during the 5 min presentation given by each individual. Fifty percent of each person's grade for the presentation is based on the group's overall grade and 50% is based on the individual's presentation. This encourages the team members to work together to produce a high quality group presentation.

DISCUSSION

The web-based projects were first used in BAE 465 in 1994 after the Internet became more widely accessible and resources for biomedical engineering began to appear [8, 9]. Since that time, 131 students have completed 36 projects. Table 1 lists 4 projects from each of the 5 years the course has been taught. Figure 1 shows the home page, which includes an original drawing, for one of the projects that was completed in 1998.

One issue that must be addressed in helping students develop Internet literacy in a classroom setting such as BAE 465 involves the logistics of managing the basics of web site creation. Certainly, it is important for students to be able to understand and function in a web environment, but does a project like the one described here demand too much time on learning HTML and not enough time learning course material? Students taking the course in 1995 were asked to keep track of the time they spent working on the projects. They reported that they spent an average of 32 ± 14 (mean $\pm$ SD) hours working on the project with 28% of the time spent doing literature searches, 18% spent learning HTML and developing personal and group home pages, and 54% spent writing the sections of the project, finding relevant WWW links, writing letters to companies, and creating the original drawing. Thus, less than one-fifth of the time that was spent on the project was spent learning the mechanics of how to communicate via the Internet. The bulk of students' time was spent on more sophisticated forms of Internet literacy.

Another issue related to Internet literacy is the troublesome one of copyright. There are two major copyright issues involved with these projects:

1. fair use of material available on the Internet;
2. permission for publishing student work on the WWW.

Students are told that Internet images and other materials, e.g. audio clips, may only be included in projects as direct links. Most importantly for encouraging fair use, students are instructed to request permission before including links in their projects. Since software is readily available that allows students to capture images from other sites and save them as files in their own space, they are reminded that doing this represents a violation of the originator's copyrights. Projects lose points if copyrights are violated.

Because student projects are to be published in public lockers on the WWW, students are asked to give the copyright for the project to the instructor. Getting permission to publish raises some important but often overlooked points. One is that the students' work will be truly in the public domain, available to anyone in the world with a web browser. This encourages them to consider the implications of what they are doing in this wider realm—something unusual for a class project. Another point is ownership of a group project. In this case, since each section of the project has an identifiable author, sections written by students who refuse to give permission to have their part of the project published will be removed before the project is made available to the world. The final point concerns what it means to give up copyright of one's own work, how that material will be used, and what rights the authors have over it. Students in this class face the problems associated with copyright and the Internet—problems they will likely encounter as professionals.

Table 1. Selected student projects currently available on the WWW. (http://www.bae.ncsu.edu/bae/research/blanchard/www/465/textbook/projects.htm)

Engineering Topics	Anatomy and Physiology Topics
Artificial Limbs, 1994	The Body's Senses and Artificial Replacements for Them, 1997
Artificial Organs, 1996	The Cardiovascular System, 1994
Assistive Devices and Mobility Aids, 1998	Exercise Physiology, 1998
Bioimplantable Materials, 1996	The Muscular System, 1994
Bioinformatics and Medical Informatics, 1998	The Nervous System, 1997
Biomedical Applications of Textiles, 1995	The Respiratory System and Mechanical Ventilation, 1998
Cellular and Tissue Engineering, 1996	The Skeletal System, 1994
MRI: Magnetic Resonance Imaging, 1996	
Clinical Engineering, 1997	
Neonatal Monitoring Devices, 1995	
Pacemakers and Defibrillators, 1995	
Rehabilitation Engineering, 1997	
X-rays, 1995	

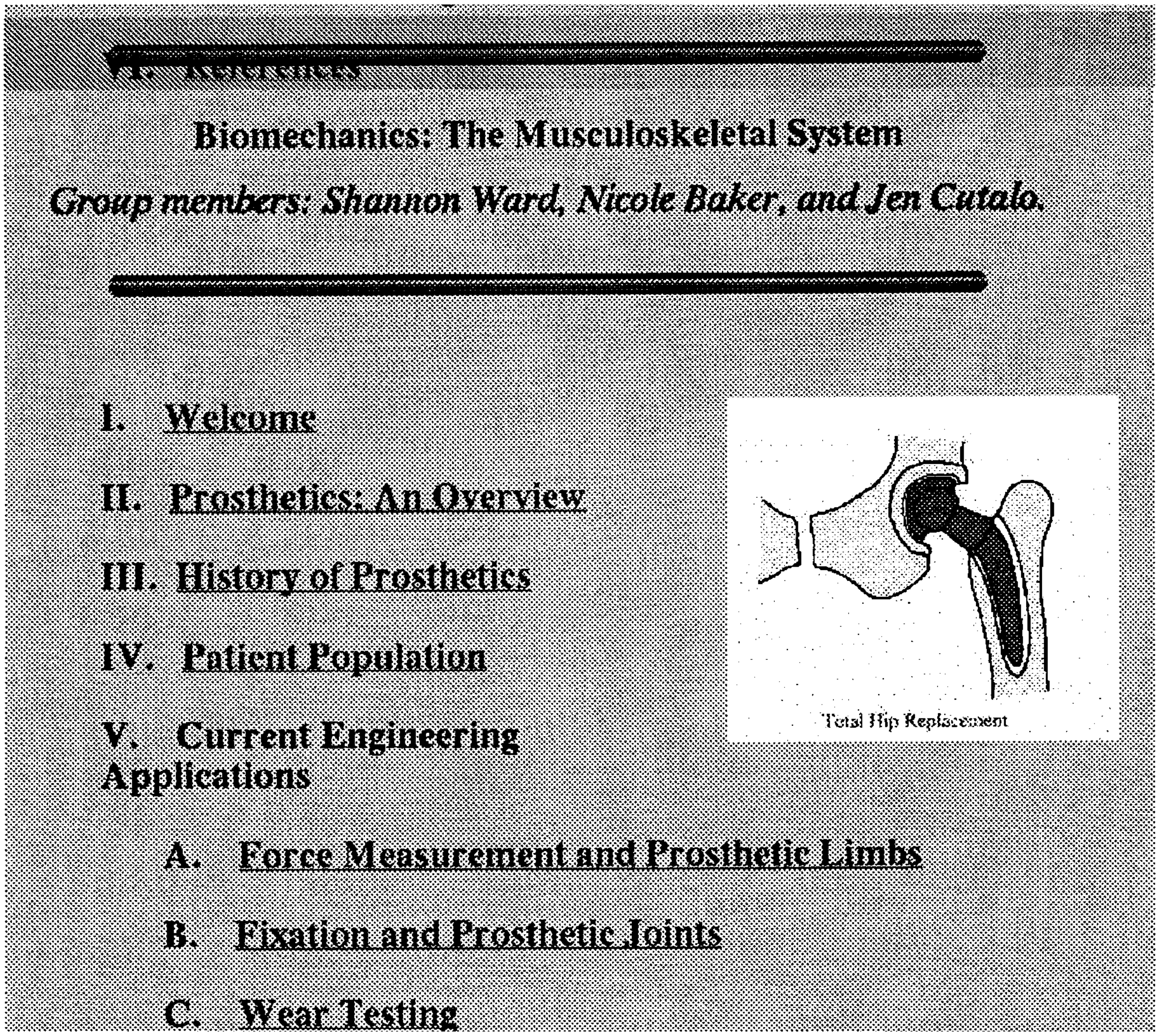

Fig. 1. Example of a student project with an original drawing.

Since Internet literacy offers special challenges not found in print literacy, it is necessary to provide special oversight of the students' projects. The process of dividing the project into two parts with the first part being graded and returned for revisions before the second part is due has been followed for all five offerings of the course. Each semester, every project improved markedly after Part I was evaluated. Students learn from the intervention in the project. Breaking it into two parts also made the project more manageable. The work of the students was spread across the entire semester instead of allowing them to procrastinate until the very end.

Another issue, peer review, takes on an added dimension in the development of Internet literacy. In 1997, 69% of the students who responded to a survey about the course indicated that the peer review process helped them create a better project. Those who responded that peer review had not helped indicated that the problem was not the review itself but that their reviewers gave them little feedback. Several among this group of students indicated that it was still valuable to see how people reacted to their project and that they learned from reviewing someone else's project. Those who indicated that the peer review process was useful mentioned that they got ideas from seeing what other groups had done and that it was beneficial to have a student's view of the project so that the group could see how clear the project seemed to others. There is considerable support in the literature for the effectiveness of students learning from each other [10], but such interaction may be even more crucial in Internet projects. This form of education is so new that students could be the best source of ideas and help for each other.

Beyond the development of Internet literacy, these WWW-based projects have provided two additional benefits for students. Many students report receiving e-mail from people who have read their projects. Most of the letters ask technical questions based on what they read in the project or thank the authors for providing information about a condition that affects them or a member of their family. Finally, WWW-based projects provide an excellent venue for students to show their work to potential employers or graduate school administrators. Employers, especially, want to know that potential employees can communicate effectively, work in teams, and use the Internet. What better evidence is there than a well-written, team-based project that is accessible to the world.

CONCLUSION

The amazing growth of the WWW is changing the face of society and is also changing the way biomedical engineers do business. It is incumbent upon us as teachers to give our students the tools to succeed in this changing environment. In addition to using the Internet as a formal teaching tool [11], we need to help our students learn to use the Internet as a medium of communication. Like every new medium, the WWW demands its own principles of literacy.

The project described in this paper offers students the opportunity to develop the skills of Internet literacy. Beyond merely finding, synthesizing, and evaluating web sources, students in BAE 465 publish the results of their research on the WWW. In doing so, they encounter such issues as who the audience is, how to take advantage of the visual potential of a web site, and how to arrange the material in hypertext form so that it makes sense. They also encounter other issues of Internet literacy from learning how to manage HTML to the implications of copyright. An Internet project like this one engages students in learning both the most recent knowledge related to biomedical engineering and the foundations of communicating on the Web.

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