Mechanics of Materials Interactive Multimedia Labware

James N. Craddock, Lizette R. Chevalier, Kudzai Musumhi

Department of Civil Engineering
Southern Illinois University Carbondale
Carbondale, IL 62901-6603
PH: 618-453-6648 FAX: 618-453-3044
e-mail: craddock@ce.siu.edu, cheval@engr.siu.edu

Introduction

This paper concerns the development of a website and CD-ROM based laboratory manual for a Strength of Materials Laboratory. Similar work has been done for another component of the Civil Engineering undergraduate curriculum, the Introduction to Environmental Engineering Laboratory. The laboratory manuals for the two classes will have a similar interface and layout. The long-term goal of the project is to use the style and approach developed on this project as a template for other civil engineering laboratory courses. Common elements to all of these laboratories include modules on laboratory safety, report writing, statistics and proper use of units.

This work is being done as a collaborative NSF-funded project between the Civil Engineering and the Interactive Multimedia Department at Southern Illinois University Carbondale. Partial support for this work is provided by the National Science Foundation's Course, Curriculum and Laboratory Improvement Program under grant DUE-9952577. Southern Illinois University Carbondale College of Engineering, College of Mass Communication and Media Arts and the Materials Technology Center provide additional support. In addition, a faculty member from the College of Education is involved with the assessment of the project. In addition, assessment and development is supported through an industry partner. It is hoped that the final product will serve as a national model for a diverse range of university environments.

Strength of Materials or Mechanics of Materials is a second-semester sophomore or first-semester junior level engineering class, and is required for all civil engineering majors, as well as most other engineering majors. The laboratory component of this class includes experiments measuring bending stresses and deflections, buckling loads, compression of various materials, uniaxial tension and torsion of materials. The labware (laboratory courseware) was designed to present elements of theory, experimental procedure, data collection, data reduction, report writing, and statistics. The labware will combine simple text, illustrations, photographs, video-clips, sound, simulations, animations, hypertext descriptions, and links to the Internet, making it truly multi-media. The description of an individual experiment will include a section on the underlying theory upon which the experiment is based. A detailed description of the procedure involved in conducting the experiment will be presented, with video-clips as needed. This will include instructions on how to operate any equipment needed in the experiment. Several actual data sets resulting from the experiment will be provided for a variety of experimental parameters. A virtual simulation of the experiment will be provided whenever possible. With this information, it is thought that students will be able to completely familiarize themselves with the laboratory theory and procedures before coming to the laboratory.

The pedagogy promoted by our approach is to engage students in active learning, and to accommodate various learning styles. The labware (<u>lab</u>oratory course<u>ware</u>) is intended to enhance student learning through the exposure to richer learning tools, resources, and advanced technologies. Focusing on the development of an interactive multimedia web site for the laboratory component of the course will strengthen the bridge between application and classroom theory. The labware is designed to present elements of theory, experimental procedure, data collection, data reduction, report writing and statistics. It will combine text, illustrations, photographs, video-clips, sound, simulations, animations, hypertext descriptions, and hot-links to the Internet, making them truly multi-media. The final product will available on the World Wide Web.

Prior to attending laboratory, students will be expected to review the basic concepts of the associated theory and to experience a "virtual laboratory" prior to their actual hands-on experience. In addition to a multimedia presentation of the theory, experimental procedure and results, the labware will incorporate statistics through the use of multiple data sets. After the experiment, students can use the labware to understand data reduction and data analysis in addition to accessing additional sets of experimental data. This additional data will allow for the integration of statistics into the laboratory experience, as well as allowing the student to vary experimental parameters. This will further enhance the student's understanding of data reduction, data analysis and statistical analysis of real-world data.

For laboratories equipped with the appropriate equipment, the labware is designed with the expectation that students review the various aspects of the CD at different stages of the learning process. Prior to attending laboratory, students will be expected to review the basic concepts of the associated theory and perhaps to experience a "virtual laboratory" prior to their actual hands-on experience. In addition to a multimedia presentation of the theory and the experimental procedure and results, the labware will incorporate statistics through the presentation and use of multiple data sets. After the experiment, students can use the labware to perform data reduction and data analysis in addition to accessing additional sets of experimental data. This additional data will allow for the integration of statistics into the laboratory experience, as well as allowing the student to examine the effect of varying some of the experimental parameters. For example, different materials or geometries can be used in the Strength of Materials Laboratory experiments. This will enhance the student's understanding of data reduction, data analysis and statistical analysis of real-world data.

In the case of equipment failure or poor experimental controls and/or data collection by the students, the additional data will allow students to complete data reduction and data analysis critical to the link between theory and application. In the event that a particular piece of equipment is unavailable, the multimedia presentation of the labware, together with the virtual laboratory simulation and the actual experimental data, should provide a reasonable substitute. This will allow institutions such as community colleges, which do not have the financial resources to have a complete laboratory facility, to offer their students a suitable laboratory experience in these classes.

An overall product survey will be prepared to judge the students' and the faculties' opinion of the format of the labware as compared to traditional printed laboratory manuals. This survey will be a critical link in the formative assessment and development of the labware during initial site visits, and will continue to improve the product.

The development of the labware represents a large and comprehensive piece of work developed with cross-discipline and industrial collaboration. This partnership has provided a distinctive experience and opportunity for all of the developers. It has also presented some interesting problems, which were attacked with constructive and viable solutions.

Background

There has been a significant amount of work done in the area of multimedia and/or web based interactive learning modules in science and engineering [1,2]. This work ranges from basic courses such statics [3,4], dynamics [5], and strength of materials [6]; to advanced topics such as finite element analysis [7]. Interactive courseware and online courses have also been developed in civil engineering fields such as construction management [8,9]. In the Civil Engineering area, the development of a multimedia soils mechanics laboratories have been pursued [10-14]. Some work has also been done in the area of environmental engineering, including a look at some aspects of an introductory environmental lab [15-17]. Other work in the area of environmental laboratories looks at an interactive multimedia lab manual [18-20]. There has also been work done in the use of multimedia in a strength or mechanics of materials laboratory [21-23]. Developments have also taken place for creating "Virtual Laboratories" for engineering education [24]. Distance learning is also a topic of interest [25].

Development

A variety of software was used to develop the web site. Macromedia and Adobe publish the two major families of software for this type of project. An abbreviated list of these software titles used includes:

1. Macromedia Dreamweaver – overall web development
2. Macromedia Flash – web enhancements
3. Macromedia Premiere – video editing and development
4. Macromedia Director – initial prototype development
5. Macromedia Fireworks – web enhancements

6. Adobe Photoshop – graphic editing and development
7. Adobe After Effects – video enhancement
8. MediaCleaner – video/audio compression
9. Camtasia – screen capture videos

Each of these programs has a substantial learning curve. It was deemed a more efficient use of time for the graduate students in multimedia to master and use these programs. The engineering faculty provided the general concept, overall direction, and technical content.

The Strength of Materials Laboratory is part of a larger project. The main navigation menu shown at the top of Figure 1 illustrates this. The six links across the top of the web page take the user to the main pages of a general topics section, the Introduction to Environmental Engineering Lab page, the Strength of Materials Lab page, and to dummy pages for Soil Mechanics, Fluid Mechanics, and Construction Materials Lab pages. These last three links are included to accommodate future work in this area that will include similar sites for all civil engineering labs. Under the pictorial logo for the page is a list of links to individual experiments and topics. For the Strength of Materials Lab, the links include a glossary of terms and tables of material properties in addition to several experiments. The experiments include tension, torsion, column buckling, beam bending, and set of three experiments in compression. The navigation scheme is consistent throughout all pages in the site. It is possible to access any of the six main pages from anywhere, and any of the sub-topics from anywhere in the Strength of Material site. Under the page for an individual experiment, a new navigation border appears on the left of the page as illustrated in Figure 2. This is a set of links to topics individual to the individual experiment, including introduction and application pages discussing the general experiment and it context within engineering, a materials page describing the materials used in the experiment, a page giving a detailed description of the procedure for the experiment, a page discussing the analysis of the data collected, a page detailing the contents of the report for this experiment, a sample data sheet, a set of references, and any supplementary data sets that may be provided. This list of topics may be expanded to include some discussion of the theory.

In Figure 3, the page showing the procedure for the tension experiment is shown. Video clips are used to present some complex topics. This video clips can be accessed from the video icon shown in this Figure 4. Also shown in Figure 4 are icons for data sets, Excel tips, and sample calculations. The use of these icons is consistent throughout all Lab Sites and pages. This demonstrates the efforts being made to achieve a consistent look and feel for the entire project.

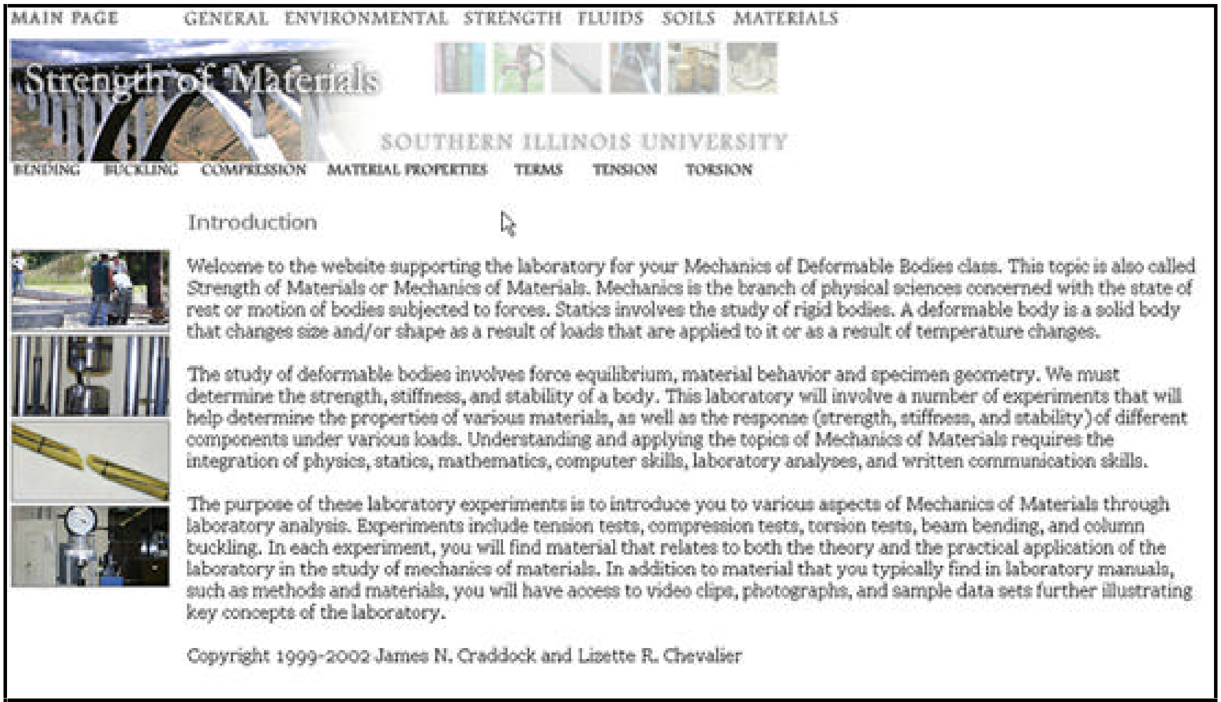

Figure 1. Layout of Main Page for Strength of Materials Lab

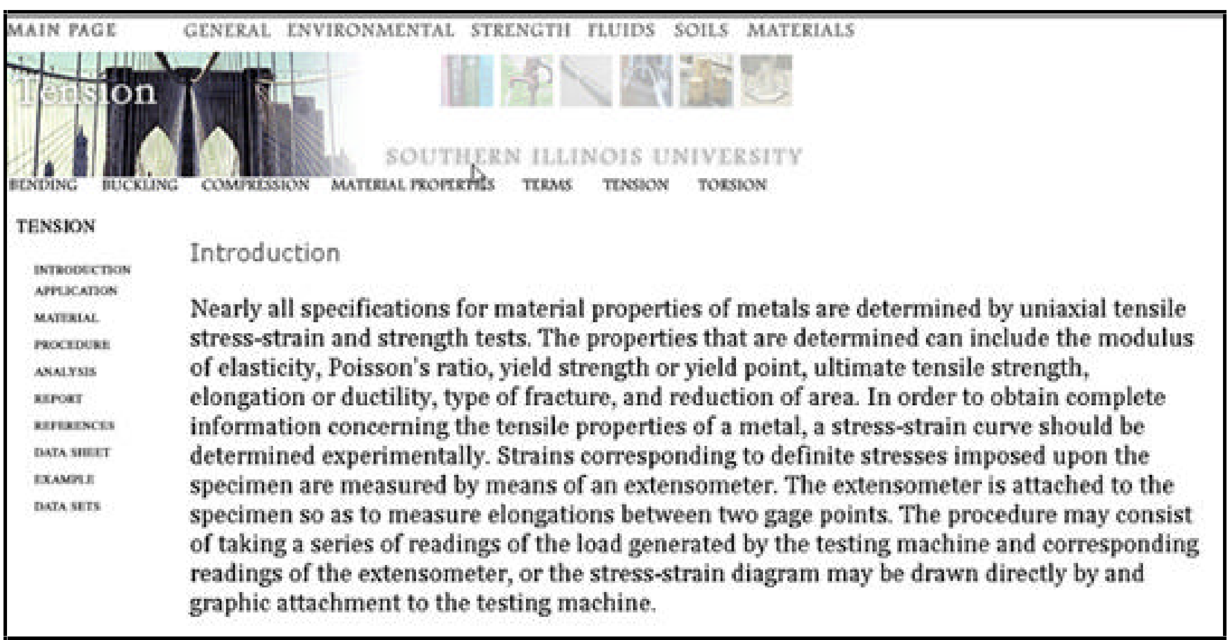

Figure 2. Introductory Page for Tension Experiment

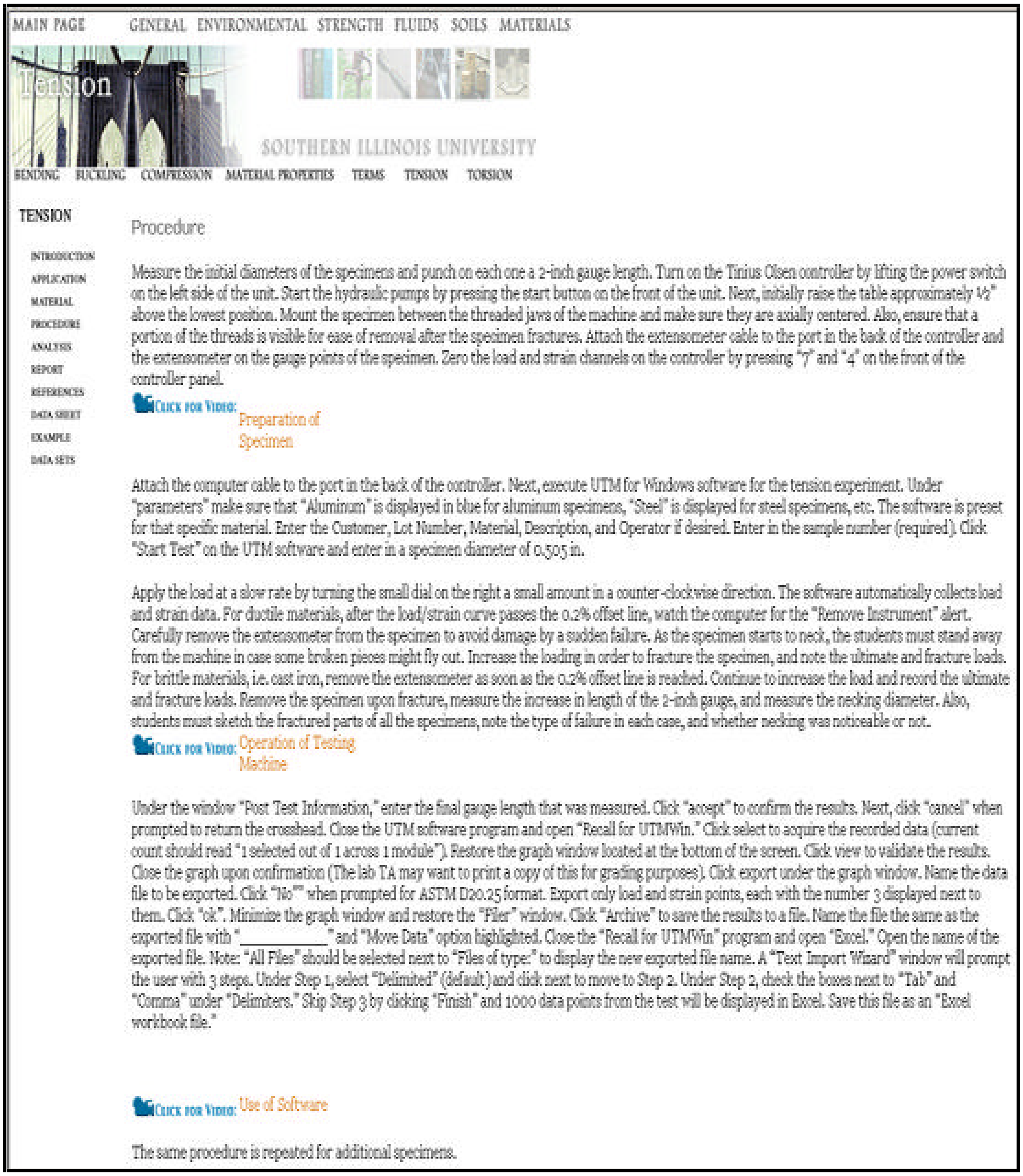

Figure 3. Procedure Page for Tension Experiment Showing Use of Icons.

Figure 4. Icons Used Throughout Web Site.

Assessment

Assessment of this project is being conducted on several levels. Student assessment is one of the primary tools being used. A survey based on a six point Likert scale is being used with five or six questions on the Educational Objectives, the Web Site Quality, the Web Site Content, and the overall Concept. Additionally, off-site review by faculty and students is being planned. A wide range of institutions has agreed to participate. These include public and private universities, a two-year community college, an engineering technology program, and institutions in small medium, and large cities. This should provide a wide range of input, which will shape the final product.

Conclusions

This project represents the two different aspects of civil engineering laboratory curriculum as well as a unique collaborative effort with the College of Mass Communication and Media Arts. Overall, the project is developing into a beneficial activity for both colleges, supplementing the educational needs of both the undergraduates and graduates. The use of the web for presentation of a laboratory manual is very promising. The use of multimedia elements and hypertext links allows the presentation of much more information than a traditional printed lab manual. By planning a common site for all lab classes in the civil engineering curriculum, continuity is maintained. The use of multiple data sets allows the integration of statistics into the laboratory. While more work needs to be done; this is a very encouraging development and has been well received by the students. The development of the labware represents a large and comprehensive piece of work developed with cross-discipline and industrial collaboration. This partnership has provided a distinctive experience and opportunity for all of the developers. It has also presented some interesting problems, which were attacked with constructive and viable solutions.

Acknowledgement

This project is funded in part from the National Science Foundation (DUE - CCLI Project Number 9952577), the College of Engineering at Southern Illinois University Carbondale (SIUC), the Department of Civil Engineering at SIUC, the Materials Technology Department and the College of Mass Communication and Media Arts at SIUC.

Bibliography

1. Kohli, G., Maj, S. P., and Veal, D., "Multi-media Technology - An Opportunity for Modern Engineering Education," American Society for Engineering Education Annual Conference Proceedings, St. Louis, MO, June 18-21, 2000.
2. Yew, Tze-Leong, and Gramoll, Kurt "Teaching Multimedia Development to Engineering Students through Web-Based Modules." American Society for Engineering Education Annual Conference Proceedings, St. Louis, MO, June 18-21, 2000.
3. Holzer, S.M., and Andruet, R.H., "Learning Statics with Multimedia and Other Tools," American Society for Engineering Education Annual Conference Proceedings, Seattle, WA, June 28 - July 1, 1998.
4. Berreen, T., "Development of an Interactive Learning Resource in Engineering Mechanics," American Society for Engineering Education Annual Conference Proceedings, Seattle, WA, June 28- July 1, 1998.
5. Flori, R.E., Koen, M.A., and Oglesby, D.B., "Best Engineering Software for Teaching ("BEST") Dynamics, Journal of Engineering Education, (85), January, 1996, pp. 61-67.
6. Rais-Rohani, M., and Young, K.A., "Development of an Multimedia Structural Mechanics Teaching Tool on the World Wide Web," American Society for Engineering Education Annual Conference Proceedings, Washington D.C., June 23 – 26, 1996.
7. Milton-Benoit, J., Grosse, I.R., Poli, C. and Woolf, B.P., "The Multimedia Finite Element Modeling and Analysis Tutor," Journal of Engineering Education, (87), Supplement, 1998, pp. 511-517.
8. Strenth, William J., "Developing 'Civil Construction,' An Internet Class Using Electronic Blackboard," American Society for Engineering Education Annual Conference Proceedings, Albuquerque, NM, June 24 - 27, 2001.
9. Mendes,Ricardo Jr., Vargas, Carlos Luciano S., and Heineck, Luiz Fernando M., "A Web - Based Environment for Construction Planning Courses," International Conference on Engineering Education Proceedings, Rio de Janeiro, Brazil, August 17-20, 1998.
10. Kemeny, John, and Zeitler, Bryan, "An Online Geo-mechanics Course with a Virtual Rock Lab Based on Streaming Audio and Vector Graphics," American Society for Engineering Education Annual Conference Proceedings, Albuquerque, NM, June 24 - 27, 2001.
11. Aleni, Morteza, and Barnes, Robert, " A Multimedia Soil Mechanics Laboratory Software Development for Teaching and Learning Purposes," International Conference on Engineering Education Proceedings, Ostrava, Czech Republic, August 10 - 12, 1999.
12. Masala, Srloljub, Biggar, Kevin, and Geissler, Colin "The Geotechnical Virtual Laboratory," American Society for Engineering Education Annual Conference Proceedings, St. Louis, MO, June 18-21, 2000.
13. Budhu, Muniram, "A Multimedia Geotechnical Laboratory test Courseware," American Society for Engineering Education Annual Conference Proceedings, St. Louis, MO, June 18-21, 2000.
14. Budhu, Muniram, "An Interactive Virtual Geo technical Laboratory," American Society for Engineering Education Annual Conference Proceedings, Albuquerque, NM, June 24 - 27, 2001.

15. Hart, H., and Kinnas, S.A., "Developing Web-Based Tools for Environmental Courses," American Society for Engineering Education Annual Conference Proceedings, Seattle, WA, June 28 - July 1, 1998.
16. Robinson, R. B., "Multimedia Tour of a Wastewater Treatment Plant," American Society for Engineering Education Annual Conference Proceedings, Seattle, WA, June 28 - July 1, 1998.
17. Katz, L.E., Weather, L.J., Kozlowski, R., Scott, M. and Manion, W., "A Multimedia Based Laboratory Course for Environmental Engineering," American Society for Engineering Education Annual Conference Proceedings, Seattle, WA, June 28 - July 1, 1998.
18. Chevalier, L.R. and Craddock, J.N., "Interactive Multimedia Labware For Civil Engineering Curricula," American Society for Engineering Education Annual Conference Proceedings, Albuquerque, NM, June 24 - 27, 2001.
19. Chevalier, L.R., and Craddock, J.N., "Formative Assessment of Interactive Multimedia Labware for Environmental Engineering Laboratory," International Conference on Engineering Education Proceedings, Oslo Norway, August 6-10, 2001.
20. Craddock, J.N., and Chevalier, Lizette R., "Web Based Laboratory Manuals in Civil Engineering," International Conference on Engineering Education Proceedings, Taipei Taiwan, August 14-16, 2000.
21. Rais-Rohani, Masoud, and Brown, Debbie T., "Development of a Virtual Laboratory for the Study of Mechanics," American Society for Engineering Education Annual Conference Proceedings, St. Louis, MO, June 18-21, 2000.
22. Craddock, J.N., and Chevalier, Lizette R.," Interactive Multimedia Labware for a Torsion Experiment," American Society for Engineering Education Annual Conference Proceedings, St. Louis, MO, June 18-21, 2000.
23. Chevalier, L.R., Craddock, J.N, Riley, P.C., and Trunk, B.J., "Interactive Multimedia Labware for Strength of Materials Laboratory," Computer Applications in Engineering Education V8, No.1, 2000.
24. Mosterman, Pieter J., Dorlandt, Marcel A.M., Campbell, J. Olin, Burow, Craig, Bouw, Rene, Brodersen, Arthur J., and Bourne, John R., "Virtual Engineering Laboratories: Design and Experiments," Journal of Engineering Education, pp. 279 – 285, (83), July, 1994.
25. Smith, Kjetil, Strandman, Jan O., Berntzen, Raymond, Fjeldly, Tor A., Shur, Michael S., and Shen, Hong "Advanced Internet Technology in Laboratory Modules for Distance Learning." American Society for Engineering Education Annual Conference Proceedings, Albuquerque, NM, June 24 - 27, 2001.

Biographical Information

DR. JAMES CRADDOCK received his B.S., M.S., and Ph.D. degrees in Aeronautical and Astronautical Engineering from the University of Illinois. He joined the faculty at Southern Illinois University – Carbondale in 1980. His main interest is solid mechanics with an emphasis on composite materials and the finite element method. He is also active in innovative engineering education using the internet and multimedia.

DR. LIZETTE CHEVALIER received her B.S. degree in Civil Engineering from Wayne State University, and her M.S. and Ph.D. from Michigan State University. She joined the faculty at Southern Illinois University – Carbondale in 1995. Her main interest is environmental engineering with an emphasis on soil remediation involving nonaqueous phase liquids. In addition she is active in engineering education using modern technology.

MR. KUDZAI MUSUMHI is an International Graduate student from Zimbabwe at SIUC in the Interactive Multimedia Program. Upon graduation, he plans on pursuing a career in Multimedia. He plans to get into full time Christian Ministry and to use Multimedia as a means of communicating the message of the gospel.