Web Modules in the Emerging Areas of Chemical Reaction Engineering

Nihat M. Gürmen, H. Scott Fogler
Department of Chemical Engineering
The University of Michigan
Ann Arbor, MI 48109-2136

Abstract

We have developed web modules to present information in emerging areas and novel applications of chemical reaction engineering and linked with the appropriate chapters in the hybrid text to bring current research into the classroom. The modules are on molecular modeling, biochemical reaction engineering and computational fluid dynamics topics. They are encyclopedic in nature and are presented to students in an understandable and comprehensive manner keeping the Felder-Soloman learning styles inventory in mind. While the modules primarily target undergraduate students, they are layered so that parts of the web modules are a resource to high school students in an advanced chemistry course and perhaps also to graduate students in chemical engineering as a reference. Each module is a stand-alone unit that can be studied after the student has completed the chapter material related to the module. In addition to reviewing the fundamental principles of a topic, each module also contains living example problems, videos, photos, references and related links.

Introduction

It has been well documented that instructional technology enhances student learning [6], and that on-line students perform as well or better than the students in a lecture format [1,8,10,12]. The effectiveness of the inclusion of web based instruction in both asynchronous and synchronous courses has also been documented [2,7,9,11].

Research has also shown that not everyone learns the same way. One of the more cited ways to classify the different learners is the *Felder-Soloman Inventory of Learning Styles* [4] as listed in Table 1, which is based on a learning styles model formulated by Felder and Silverman [3].

Table 1. Felder-Soloman Inventory of Learning Styles

• Active Learners vs. Reflective Learners • Global Learners vs. Sequential Learners • Visual Learners vs. Verbal Learners • Sensing Learners vs. Intuitive Learners

Web modules provide us a powerful toolset to address virtually all the learning styles in the Felder-Soloman Inventory to supplement course material. Hence, we have developed web modules in novel and emerging areas of chemical reaction engineering to bring current research into the classroom. These areas include molecular modeling, biochemical reaction engineering and computational fluid dynamics. Each module is a stand-alone unit that can be studied after the student has completed the chapter material related to the module.

In addition to reviewing the fundamental principles of a topic, each module contains living example problems, videos, photos, references and related links. For example, the *Pharmacokinetics of Cobra Bites*, shown in Figure 1, is so complete and authentic that it is referenced on the Canadian Zoocheck Site [5] among suggested resource materials and is the definitive model for cobra envenomation and antivenin injection. This module is layered such that a high school student could obtain an understanding of the pharmacokinetics while at the same time an undergraduate could work with the coupled ODEs to learn various outcomes.

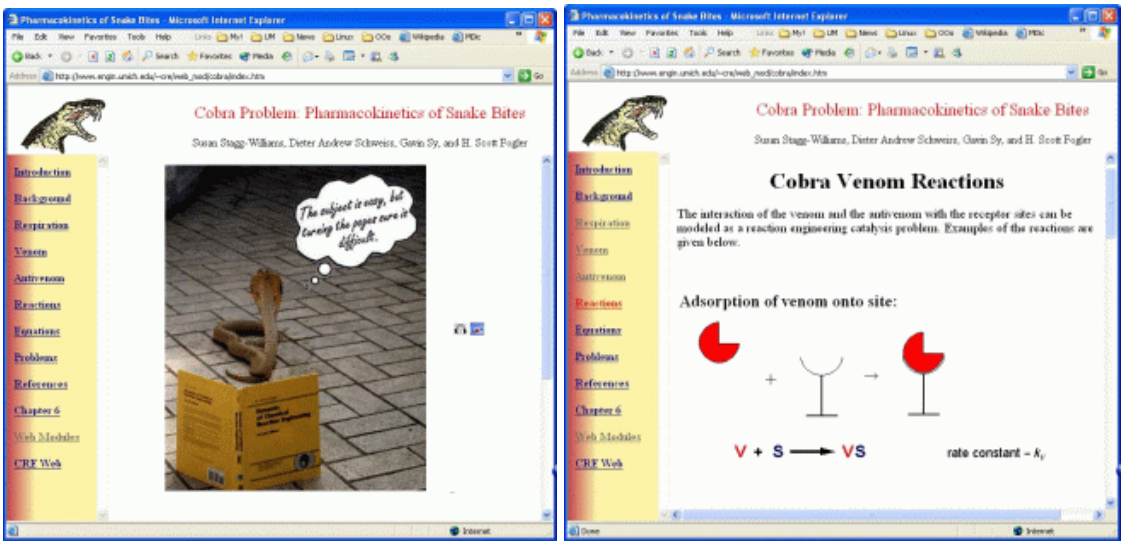

Figure 1. Cobra web module opening and reactions pages

Web Modules

The modules are mostly developed with the help of undergraduate researchers. Table 2 shows the general format in use. Standard HTML for layout and well-tested JavaScript code for interactivity are utilized to maximize the compatibility across different operating systems and browsers.

Table 2. Web Module Format

I.	Introduction
	a. Description of Process/Phenomena
	b. Background
	c. Significance/Relevance
II.	Presentation of Fundamentals
	a. Text, videos, photos, derive type, hot buttons
	b. Links to tutorial (e.g., lecture notes) in CRE related to the material
	c. Links to related material
III.	Living Example Problems/ICMs
	a. Change variables
	b. Add equations
	c. Suggestions how the problem might be explored/extended.
	– What if …
IV.	Interactive Self Tests of Material
V.	Homework Problems with Solution for Instructor

Quantum Web Module on Molecular Modeling

Quantum web module provides students with an introduction to the use of computational quantum *chemistry* to estimate reaction rate parameters. High school students can visualize processes through animations of the various reaction steps. Undergraduates can couple the computational software packages with transition state theory to estimate equilibrium and rate constants for elementary gas phase reactions. Most importantly, all students will gain experience with quantum chemical methods in chemical reaction engineering that will enable them to pursue potentially more complex computations in their future careers.

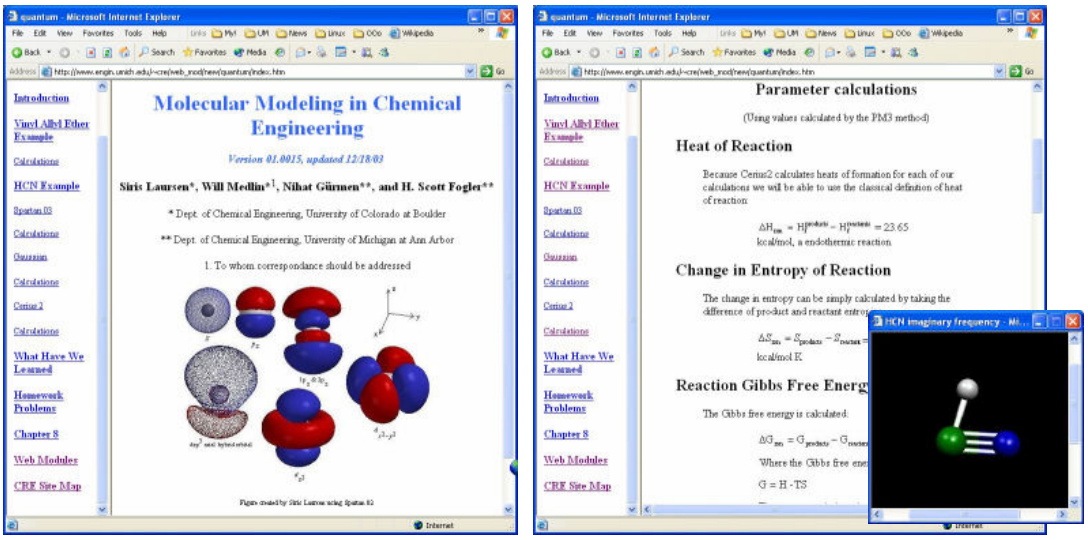

Figure 2. Quantum web module opening and reactions pages

Radial Effects Web Module on Computational Fluid Dynamics with FEMLAB™

Radial effects web module highlights the radial effects in a tubular reactor that are usually neglected to simplify the calculations. Also, the effects of parameters such as inlet temperature and flow rate are investigated. These effects can be readily studied using the software program FEMLAB™ in a very user friendly environment. The module is based on an example problem of Elements of Chemical Reaction Engineering (E. 8-8) where propylene oxide reacts with water to form propylene glycol.

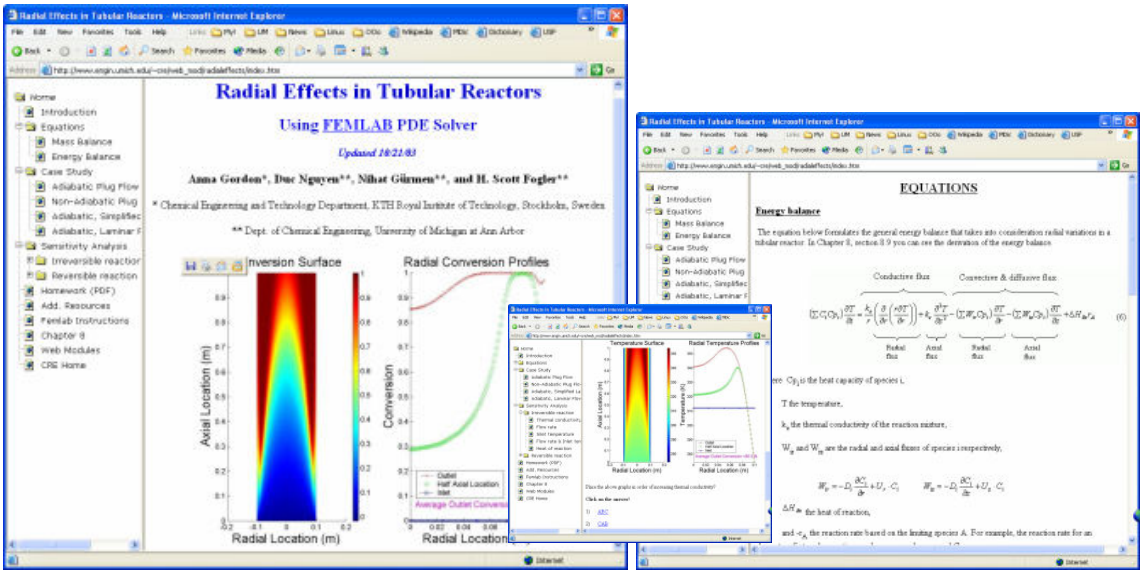

Figure 3. Radial Effects web module opening and energy balance pages

Russell's Viper Web Module on Biochemical Reaction Engineering of Venom

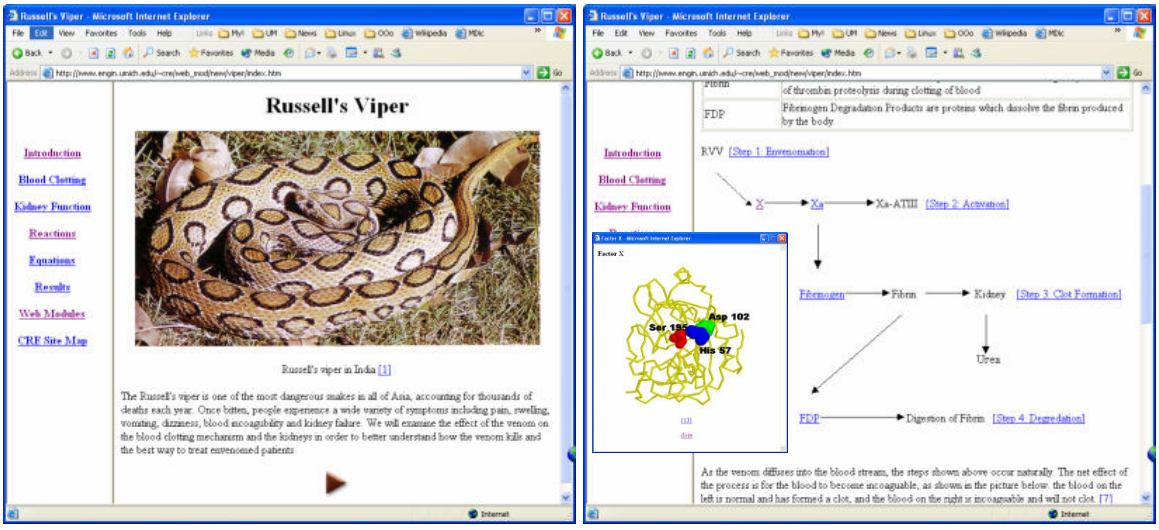

Figure 4. Russell's viper web module opening and reactions pages

The Russell's viper is one of the most dangerous snakes in all of Asia, accounting for thousands of deaths each year. Once bitten, people experience a wide variety of symptoms including pain, swelling, vomiting, dizziness, blood incoagubility and kidney failure. The Russell's viper web module examines the effect of the venom on the blood clotting mechanism and the kidneys in order to better understand how the venom kills and the best way to treat envenomed patients.

Discussion

The web modules are linked and integrated with the existing material on the fundamentals, yet they are stand-alone lessons that show different emerging areas and novel applications of chemical reaction engineering material. They bring current research into the classroom and are layered such that high school students, undergraduate students and graduate students can learn something critical from each lesson. Each lesson include background material, photos, videos, discussion of the fundamentals, simulations, self tests, hot buttons (e.g., derive, links). These modules serve as a well documented resource for those students from other disciplines searching the web for information, as was the cobra module. Because the topics are modularized, the instructors can pick and choose the ones they want to include in any particular term

Acknowledgements

The funding of this project is provided by NSF under the grant DUE-0126497. We would like to thank our collaborators Prof. Will Medlin, Siris Laursen, Dr. Duc Nguyen, Anna Gordon and Michael Breson.

References

1. Dutton, J., Dutton, M. and Perry, J. Do on-line students perform as well as lecture students. *Journal of Engineering Education* 90, 131-136 (2001).
2. Edwards, C. and Fritz, J. H. Evaluation of three on-line delivery approaches. Paper presented at the 1997 Mid-South Technology Conference, (1997).
3. Felder, R. M. and Silverman, L. K. Learning and teaching styles in engineering-education. *Journal of Engineering Education* 78, 674-681 (1988).
4. Felder, R. M. and Soloman, B. A. Index of learning styles. http://www.ncsu.edu/felder-public/ILSpage.html, accessed on June 2003.
5. Haji, R. Venomous snakes and snake bite. http://www.zoocheck.com/programs/exotic/venom/snake.shtml, accessed on June 2003.
6. Kadiyala, M. and Crynes, B. L. A review of literature on effectiveness of use of information technology in education. *Journal of Engineering Education* 89, 177-189 (2000).

7. Linser, R. and Naidu, S. Web-based simulations as teaching and learning media in political science. Paper presented at the 1999 Fifth Australian World Wide Web Conference, Lismore, Australia, (1999).
8. McCollum, K. In test, students taught online outdo those taught in class. In *Chronicle of Higher Education* (1997).
9. Nachmias, R., Mioduser, D., Oren, A. and Ram, J. Web-supported emergent-collaboration in higher education courses. *Educational Technology and Society* 3 (2000).
10. Schutte, J. G. Virtual teaching in higher education: The new intellectual superhighway or just another traffic jam? , http://www.csun.edu/sociology/virexp.htm, accessed on June 2003.
11. Vargo, J. Evaluating the effectiveness of internet delivered coursework. Paper presented at the 1997 Third Australian World Wide Web Conference, Lismore, Australia, (1997).
12. Wallace, D. R. and Mutooni, P. A comparative evaluation of world wide web-based and classroom teaching. *Journal of Engineering Education* 86, 211-219 (1997).

Nihat M. Gürmen received his B.S. degree in chemical engineering from Bogazici University, Istanbul, Turkey. He received the M.E. and the Ph.D. degrees in chemical engineering from the University of South Florida, Tampa. He is currently a postdoctoral research fellow at the University of Michigan, Ann Arbor. His research interests include numerical modeling and simulation of physiological systems; critical thinking and creative problem solving techniques with interactive computing.

H. Scott Fogler is the Vennema Professor of chemical engineering at the University of Michigan, Ann Arbor. He has graduated 30 Ph.D. students from his research group and has published more than 180 research publications. His research topics include: flow, reaction, precipitation; kinetics of wax deposition; fused chemical reactions; gellation kinetics; asphaltene characterization and remediation; colloidal phenomena; catalyzed dissolution of minerals; pharmacokinetics of acute toxicology; critical thinking and creative problem solving.