cal work, take time to discuss work habits when necessary. For example, most graduate students have not learned how to rapidly sort articles so that only the most important are read thoroughly. The professor can also be a cheerleader when groups feel that they will never be able to finish their projects. When the members of a group are not getting along, part of the meeting time can be used to help the students start processing group interactions. Do not try to solve their interpersonal problems, however. Make the students do this work or at least muddle through it.

The bane of grading group work is freeloaders. Delegate the responsibility of lowering the grades of freeloaders to the students. My grade assigned to each project is the highest grade students in the group can receive for the project. I require the students in each group to assign what percentage of this grade (ranging from 0 to 100%) each group member should receive. I then average these percentages for each group member and calculate their project grades. This procedure reduces freeloading and drastically reduces complaints from other group members when freeloading occurs.

This project-based paradigm is very efficient for professors. During the project work I typically spend a total of four hours per week on the course, with most of that time focused on the students. During project work the students spend much more time working on the course than the professor does!

Grading reports takes time, but since the reports are better than in other classes it is easier. The students learn their topic in depth, they learn how-to-learn, and they actually pay attention to the feedback on their writing.

A note of caution is in order, however. Most professors and students are inexperienced with project-based teaching. Professors need a certain amount of chutzpah to relinquish the normal control of a lecture course. They also need to know the material better than they would for a lecture class since it is impossible to prepare for student questions. Note that this method is not "turning the students loose." Students actually receive increased guidance and support. Despite the support, the freedom and responsibility may overwhelm immature students. Students, particularly those with high grades, may rebel. Other faculty may be skeptical and probably will not be supportive if the course flounders. Because of these risks, a graduate- or senior-level elective course is a good place to experiment.

IMPROVEMENT AND GROWTH

Master teachers may be born, not made; but good, efficient teaching is a learned skill. Sign up for a teaching workshop. Study and try out new teaching methods. After each class, reflect on what worked and what didn't, and tailor your future actions accordingly. Take notes, with the aim of improving the course next time. Find someone in your department with whom you can discuss teaching on a regular basis. Continual experimentation with teaching methods helps to prevent boredom and burnout, which can be major problems. Such experimentation can lead to teaching improvement and eventual recognition as a master teacher.

REFERENCES

1. Covey, S.R., *The Seven Habits of Highly Effective People*, Simon and Schuster, New York, NY (1989)
2. Lakein, A., *How to Get Control of Your Time and Your Life*, Signet Books, New York, NY (1973)
3. Wankat, P. C., "Effective, Efficient Teaching," Proceedings ASEE 1999 Annual Conference, CD ROM pdf file 000167, (1999)
4. Wankat, P.C. and F.S. Oreovicz, *Teaching Engineering*, McGraw-Hill, New York, NY (1993). [Out of print. Available free as pdf files at <http://unitflops.ecn.purdue.edu/ChE/News/Book/>
5. Boice, R., *The New Faculty Member*, Jossey-Bass, San Francisco, CA (1992)
6. Boice, R., *Advice for New Faculty Members: Nihil Nimus*, Allyn and Bacon, Boston, MA (2000)
7. Woods, D.R., *How to Gain the Most from Problem Based Learning*, D.R. Woods, Waterdown, Ontario, Canada, (1994). [Available from McMaster University Bookstore, 905-572-7160]
8. Wankat, P.C., "Learning Through Doing: A Course on Writing a Textbook Chapter," *Chem. Eng. Ed.*, **27**(4), 208 (1993) ❐

ChE book review

Multimedia Fluid Mechanics

by G.M. Homsy, *et al.*

Cambridge University Press (2000) $19.95

Reviewed by

Hossein Haj-Hariri

University of Virginia

The CD by Homsy, *et al.*, is a most welcome and timely educational tool for students (and instructors!) of introductory fluid mechanics. Fluid mechanics is a very visual discipline. To date, such visual accompaniment to the mathematical equations describing flow physics has either come from labs or from samplings of the fantastic movies put together in the 1960s. Whereas the material of those movies will never become outdated, the innovative multi-media approach adopted by Homsy, *et al.,* adds dimensions to the presentation that were simply not available forty years ago. This CD ROM is a true multi-media tool that has no paper counterpart. In other words, this is not a book typed on a CD—it is truly all that the box cover promises, and then some.

The approach is based on modules. Currently, there are three technical modules, with more promised. The current modules are dynamics, kinematics, and boundary layers. There is also a module on history, which should be studied by all students.

Continued on page 101.

"U-tube") downstream of the micro-metering valve before and after each trial as an alternative to obtaining the amount of naphthalene extracted in the experiment. The mass of the extracted naphthalene would be a more significant portion of the total mass of the sample and apparatus being weighed. In this manner, more accurate results may be possible.

If multiple groups complete the lab during the semester, another enhancement to the laboratory experience could be to have the different groups use different solute materials. At the end of the semester, a comparison of the correlation constants from each group could be completed and this could be used to create a generalized correlation. Possible alternative solutes include biphenyl and benzoic acid. Should this approach be taken, it is important to remember that the value of A, the surface-to-volume ratio in Eq. (1), must be provided for each system investigated.

In summary, this laboratory experiment provides a valuable introduction to a modern unit operation in the chemical process industry while at the same time it encourages creative thinking in the synthesis of concepts from disparate areas of chemical engineering.

NOMENCLATURE

A	Surface area per unit volume of a packed bed (m^2/m^3)
a,b,c,d	Correlating equation parameters
C_1	Average concentration of naphthalene in exiting carbon dioxide (kg/m^3)
C_1^{sat}	Concentration of naphthalene in carbon dioxide at saturation (kg/m^3)
ΔC_{LM}	Log mean concentration driving force (kg/m^3)
D	Column diameter (m)
D_{AB}	Diffusivity (m^2/sec)
d	Particle diameter (m)
g	Acceleration due to gravity (m/sec^2)
k	Mass transfer coefficient (m/sec)
P	Pressure (bar)
P^{sat}	Vapor pressure of solute (bar)
R	Ideal gas constant ($m^3bar/molK$)
T	Temperature (K)
V	Molar volume of fluid phase (m^3/mol)
V^{sol}	Molar volume of solute (m^3/mol)
V^0	Empty column superficial velocity (m/sec)
z	Packed bed length (m)
ρ	Density (kg/m^3)
μ	Viscosity (kg/m sec)

Dimensionless Numbers

N_{Gr}	Grashof number $\left(d^3 g\rho\Delta\rho / \mu^2\right)$
N_{Re}	Reynolds number $\left(DV^0\rho / \mu\right)$
N_{Sc}	Schmidt number $\left(\mu / D_{AB}\rho\right)$
N_{Sh}	Sherwood number $\left(kz / D_{AB}\right)$

REFERENCES

1. Hannay, J.B., and J. Hogarth, "On the Solubility of Solids in Gases," *Proc. Roy. Soc.*, **29**, 324, London (1879)
2. McHugh, M.A., and V.J. Krukonis, *Supercritical Fluid Extraction, Principles, and Practice,* 2nd ed., Butterworth, Stoneham, MA (1994)
3. Eckert, C.A., J.A. Van Alsten, and T. Stoicos, "Supercritical Fluid Processing," *Environ. Sci. Tech.*, **20**, 319 (1986)
4. Maddocks, R.R., J. Gibson, and D.F. Williams, "Supercritical Extraction of Coal," *Chem. Eng. Prog.*, **49** (1979)
5. McHugh, M.A., and M.E. Paulaitis, "Solid Solubilities of Naphthalene and Biphenyl in Supercritical Carbon Dioxide," *J. Chem. Eng. Data,* **25**, 326 (1980)
6. Gabbard, R.G., "The Development of a Senior Unit Operations Laboratory on the Supercritical Extraction of Solid Naphthalene with Supercritical Carbon Dioxide," M.S. Thesis, New Jersey Institute of Technology (1993)
7. Debenedetti, P.G., and R.C. Reid, "Diffusion and Mass Transfer in Supercritical Fluids," *AIChE J.*, **32**, 2034 (1986)
8. Lee, C.H., and G.D. Holder, "The Use of Supercritical Fluid Chromatography for Obtaining Mass Transfer Coefficients in Fluid-Solid Systems at Supercritical Conditions," *Ind. Eng. Chem. Res.*, **34**, 906 (1995)
9. Jossi, J.A., L.I. Stiel, and G. Thodos, "The Viscosity of Pure Substances in the Dense Gaseous and Liquid Phases," *AIChE J.*, **8**, 59 (1962)
10. Funazukuri, Y., Y. Ishiwata, and N. Wakao, "Predictive Correlation for Binary Diffusion Coefficients in Dense Carbon Dioxide," *AIChE J.*, **38**, 1761 (1992) ❒

Multimedia Fluid Mechanics

Continued from page 95.

The CD is neither a book nor a collection of movie clips. It is truly a seamlessly integrated multi-media tool. The user can read some brief text describing the phenomenon, can look at the equations and see the meaning of each term, and also look at some movie clips that will drive the point home. Most importantly, there are a number of very simple, but cleverly designed, interactive experiments where the user can take data off of a running movie clip and process the automatically tabulated data in order to investigate the dimensional relationships and gain valuable insights. These interactive experiments constitute very nice classroom demonstrations to supplement lectures. An equation feature that is used cleverly is a roll-over feature where as the mouse pointer is dragged over each term of the equation, the term is magnified and highlighted, and its meaning pops up in a small text box.

I cannot overemphasize how well this CD is done. The selection of the topics, the level of coverage, and the actual presentation are all superb. There are many hyperlinks throughout the CD; however, unlike some other CDs where the user can hyperlink his/her way into a digital purgatory, on this CD one can always return to the page of interest using the small navigation map at the top of the page.

Congratulations to Professor Homsy and his colleagues for undertaking the much-needed task of creating a new tool for aiding students of fluid mechanics. Also, congratulations for holding the line on the price, which is extremely reasonable in an environment of skyrocketing textbook prices. ❒