AC 1998-392: Molecules Moving through Monoliths: Is this Civil Engineering?

Marilyn Barger, Hillsborough Community College

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FAMU-FSU College of Engineering

Abstract

There are three equal and extremely important attributes of all engineering science concepts as presented in an ABET approved engineering curriculum. They are fundamental, immutable, and the essence of every engineering discipline. One such fundamental concept is molecular diffusion. Although traditionally a hallmark of chemical engineering education, historically, civil engineering education has presented diffusion concepts as a "just in time" tool to solve particular problems. However, a change in this presentation paradigm is necessary if the discipline is to meet one of the major challenges of the 21st century. It is anticipated that tomorrow's employers will give junior engineers assignments that require an expanded experience and knowledge base of such concepts so that they will be able to immediately relate to and work effectively within interdisciplinary engineering and science teams.

It is relatively easy for civil engineering programs to extrapolate the role that important engineering science principles like the diffusion concept play in the various aspects of its diverse courses. In fact, this fundamental concept is introduced in most freshman chemistry experiences and, therefore, is available as a topic for discussion and development in any civil engineering course. Topic areas where diffusion's role can be expanded or further explored include construction materials, corrosion phenomena, and the fate of chemicals in the environment. The goal, however, is not just to extend the role that such phenomena plays in a given course or even a curriculum, but to use it as a topical tool to broaden engineering student's minds to encompass the role global phenomena like diffusion play in the creative aspects of all engineering decision.

This presentation will present possibilities for exploring, expanding, and extending the use of the diffusion concept as a means of providing information and background for civil engineering students to see its applicability in many diverse domains and dramas. Possibilities include the total immersion in a multi-disciplinary course, the integration of interdisciplinary diffusion-related problems into appropriate courses, and the utilization of the underlying mathematical models as the common link. Resources for each of these avenues will be provided.

Interdisciplinary Courses

Why not take the spirit of the ABET 2000 to its ultimate task and offer an interdisciplinary course co-taught by professionals in different fields? Such a course, Chemical Fate and Transport in the Environment, was first offered in the fall semester of 1997. Several novel and exciting course components made it challenging to develop and present, but ultimately rewarding to the students. First, the course has an instructional team consisting of one chemical and one environmental engineer. Second, these teaching resources are not in the same department. Third, these resources are not even in the same university or city. Fourth, it has students enrolled in two separate courses that are offered separately and independently by the Civil Engineering Department at the FAMU-FSU College of Engineering in Tallahassee and the Chemical Engineering Department of the University of South Florida in Tampa. Finally, the course is conducted in a technically demanding, multi-site, and completely interactive media.

The course materials for Chemical Fate and Transport in the Environment were coordinated by the two instructors and relate directly to the educational paradigms of both environmental and chemical engineering. The course also has as one of its fundamental components, the diffusion phenomena. The course begins by reviewing the principals of chemical equilibrium and bulk and molecular transport. It continues to cover specific applications integrating transport and equilibrium ideas for contaminant chemicals introduced into a variety of environmental situations. It ends with students predicting the ultimate fate of an organic chemical contaminant in a multi-phase natural environment.

The course production aspects were coordinated by the Distance Learning Offices of the two universities. The courses at both universities were scheduled for the same time slot on Tuesday and Thursday afternoons. The classes met independently on Tuesday afternoons, and via a bridge connection donated by the State of Florida's Department of Management Services on Thursdays. This connection linked television studios at both universities where the classes took place. Although there were occasional technical problems with the visual or audio connections and the video screens were sometimes difficult to read, students and faculty who regularly engage in distance learning adapt to these situations by using down time for classroom management issues or tutorial help.

There are several general but genuine benefits gleamed from such an energetic endeavor. Although course development and class preparation required a significant time investment, the stress of such task related choices and decisions was tempered by the cooperative nature of the project. Both instructors were involved in the development of all lectures and assignments, even for those that each was not specifically responsible for presenting or preparing. Additionally, having a colleague as a ready reference and coworker with whom one could share the assignment preparations, quizzes, tests, and solutions sets duties, made the large investment in preparation time for the new course more amicable. Both faculty learned from each other and integrated each other's expertise and experience with their own. The students received two perspectives of the same material, gained insight of another engineering discipline, and the opportunity to watch professionals with different skill sets work together. Students asked either or both faculty questions, and the faculty asked opinions of and solicited comments from any student in either class, or each other during the course of a lecture.

This particular interdisciplinary, interdepartmental, and inter-university class was a new elective course for both faculty and both departments. The two faculty members worked together to develop the material to assure that it would be appropriate to students in both disciplines. For example, a strong emphasis on the theory of mass transport was appropriate for chemical engineering students, but might initially overwhelm environmental engineering students unless it was balanced with concrete applications and examples of site remediation, pollution prevention, and risk assessment. Both student populations appreciated a strong emphasis on problems dealing with natural, i.e., nonhomogeneous systems.

The course was organized such that the two classes followed the same schedule, covered the same material, and were evaluated by the same assignments and exams. The joint completely interactive Thursday lectures were given alternately by the two instructors throughout the semester. The independent Tuesday class periods were also coordinated for the material covered. Tuesdays were used for quizzes, tests, and local management issues.

Although the connection between chemical and environmental engineering might seem to be an obvious one, there are other aspects of civil engineering curriculum that will easily lend themselves to a similar interdisciplinary course offerings model. The area of materials used for civil engineering might well be connected to a course in chemical or mechanical engineering dealing with the properties and management of materials used for process equipment, fluid conduits and system metering devices. Although different disciplines use many of the same materials processed in the same manner, they are normally taught with a narrow discipline-specific vocabulary and examples. The generation, transfer, and control of heat also offers potential as the basis of an interdisciplinary course that might not have such a vocabulary constraint.

Other Interaction Avenues

There are, of course, several other not-so-immersive models for increasing student awareness of engineering's global presence and implications. Examples of the same phenomenon from different disciplines can be introduced. Faculty can also teach the mathematical tools and models underlying the principals of the phenomena with emphasis on universal applicability to a variety of problems. They can also emphasize and encourage development of analogous reasoning skills and problem solving strategies to further broaden students' horizons outside the usual civil engineering domain.

For the diffusion phenomenon example, assignments that emphasize diffusion in different disciplines can easily be created. As in the civil engineering curriculum, diffusion concepts are found in many aspects of material sciences, to address the development and processing of materials to adjust or enhance their physical properties. Corrosion concepts, in whatever course they find themselves, also use diffusion to predict the movement of chemical species through the media or material of interest, such descriptions are of vital interest and applicable to civil engineers. There are also examples in the environmental area, including the movement of contaminants in various compartments of the environment and the variety of separation technologies used to treat polluted air, water, and soil.

The "just-in-time" teaching approach to the diffusion phenomenon introduces Fick's Laws of Diffusion and its common solution algorithms as a quick "how-to" recipe to solve specific but limited problems. An example in civil engineering materials might be the carburation of steel. Subsequently, the class moves on to the next topic, leaving the concepts and problem solution techniques for molecular diffusion implanted as an isolated idea related to the production of steel. Unfortunately, in the minds' eye of students, this tact myopically compartmentalizes the topic and solution algorithm to the particular course, problem and/or text. To reinforce the mathematics of the solution and the problem solving strategy, and to force a focus on the conceptualization of the phenomenon and where else it is observed in modern technology, it is vital to include examples from other engineering disciplines both in class discussion and homework assignments.

The list of interdisciplinary diffusion examples can be very long. A few examples that might be pursued include the doping of semiconductors, which is just one of an inexhaustible set of examples related to surface science, an area upon which, all engineering disciplines extensively interacts with. Specialty gas mixtures are generally produced by gas diffusion through a variety of membranes, which is but one of many examples in the chemical processing industry where diffusion plays a major role. In the area of water treatment, be it for drinking, process feedwater, or remediation, controlled convective and diffusion transport of water and its components through polymeric membranes is the basis of the many new and preferred treatment technologies. Drug delivery systems, in which the phenomena of diffusion plays an important role, is an exciting area found in bioengineering and biomedical engineering.

Conclusions

Faculty of all engineering disciplines are currently challenged to increase the effectiveness of their "products" in the emerging global society. Many issues are at hand, including making students aware of sustainability, giving students the disposition to life-long learning, and preparing them to work effortlessly in multidisciplinary teams and/or confidently on interdisciplinary problems. Civil engineering faculty, along with faculty of all science and engineering disciplines, must enhance student leaning experiences by broadening the scope of information transferred with interdisciplinary, all encompassing, and multi-perspective applications. Molecular diffusion is just one of many fundamental phenomena that can easily be used to attain this goal in civil engineering courses and curricula. It is just one of many excellent vehicles for expanding a civil engineering student's experience to meet the expectations of their 21st century employers.

In the past decade, an expanded arsenal of tools have been made available to enhance traditional learning techniques. Increased use of these aids will increase the likelihood of successfully motivating students in Civil Engineering. Historically, civil engineering programs have used case studies, demonstration, homework sets, and lecture examples within the confines of the traditional employment base as a means to motivate students to apply themselves to successfully master challenging problems. The advent of multimedia, computer models, and virtual engineering experiences, provide additional avenues of pursuing this traditional approach. Although many faculty are using these new techniques to teach civil engineering ideas, these same tools can and must be implemented to teach students to cross-connect civil engineering ideas to other disciplines. Development of such cross discipline skills is vital for the creation of a disposition for life-long learning and a critical foundation for implementing important 21st century professional survival skills..

Author

MARILYN BARGER is a registered professional engineer and an assistant professor in the Civil Engineering Department of the FAMU-FSU College of Engineering where she is developing research programs in waste management, reverse osmosis, and environmental fate and transport. She has a B.S. in Chemistry from Agnes Scott College, a B.S. in Engineering Science and Ph.D. in Civil Engineering from the University of South Florida.