Alternatives to Matrix Methods

How to Teach Structural Behavior

By Marc Hoit, Ph.D.

Education versus Training

I would like to add my voice to what Professor Graham Powell has stated in his previous STRUCTURE® magazine articles (November and December 2008): the NCSEA definition of what is needed in specific courses in order to educate a structural engineer is misguided. In my opinion, the detailed listing of specific courses and outlines of the content of each course is fundamentally in conflict with how to specify educational objectives and what we want our educational institutions to achieve. What is needed is to develop a set of educational objectives that define the skills and abilities of a graduate in order to be a successful structural engineer. It is not about which specific method or formula a graduate needs to know, but how to creatively solve a problem using the mathematical, social, and engineering tools at their disposal.

There is an inherent conflict between what a university should provide as education and what an industry needs a graduate to be able to accomplish in the workplace. University education is about helping a student build the knowledge, skills and, most importantly, problem solving ability to know how to attack and solve a problem they have never seen before. In educational theory, this is the highest level of learning; the ability to compare, contrast and evaluate the issues and come to a solution. This is the type of individual we want to educate so that they can continue to learn and create throughout their career.

On the other hand, there is the need of industry to have an employee be productive and meet the demands of the current workplace. In the modern structural engineering workplace, this means being familiar with analysis, concrete, steel and timber design, including the codes and the specifications that allow them to create a final design which can be signed, sealed and built. AISC performed a study a number of years ago that found the average engineering company provided additional education for a new graduate for 14 months before they reached full productivity.

With our modern educational constraints of reduced credit hours, increased general educational requirements and the explosion of information in all of the traditional Civil Engineering disciplines, the conflict of how to teach both the educated mind and the specific skills becomes untenable. As one solution, ASCE has declared that the first professional degree be a BSE plus 30 hours through their Body of Knowledge.

ABET understood this problem over 10 years ago and developed their outcomes assessment model of accreditation. This model allows each program to create a mission and a set of goals for their degree. These goals are then met through their individual curriculum and by developing appropriate outcomes that each student must achieve. The program must then measure these outcomes for each student to prove they are meeting the requirements.

We are also in an era where our students have a different view of education and learning. The millennial student comes with a different set of expectations about how to acquire information. They have grown up with instant access to a Web full of visual, interactive and highly customizable information. They use technology to help them multi-task their learning. This is a fundamental change and must be accommodated if we are to reach a new generation of engineers and provide them the tools to compete globally in our industry.

A Possible Solution

So, we know the problem; but, what is the solution? Professor Powell's suggestion is right on target, and from all educational research and learning theory offers an ideal solution. While I firmly believe that is the case, I also understand that getting there will require smaller and more varied changes. Some of these changes are already happening. Many schools no longer require a traditional computer programming language (e.g., Fortran, C, Java), but use things like Mathcad and MatLab to teach structured problem solving using analytical tools. Other schools have restructured their Indeterminate Structures course to reduce the hand methods and emphasize computer tools. However, we have a long way to go in order to achieve an ideal learning environment.

Many programs still teach a very detailed Matrix Methods course at the undergraduate level. I was guilty of this and wrote a text book (now out of print) that covered this material. If I re-wrote the book now, I would take a larger step towards the objective of teaching structural behavior and cover fewer of the details of how to form a matrix and solve equations. While we clearly need people to understand and do these detailed matrix operations, it is the domain of the software developers and researchers, and more for the PhD level courses.

If I had to teach the course tomorrow, what would I do? I would only teach virtual work, and that would be for two weeks as an introduction and refresher. I would cover one week of matrix math and stiffness operations in order to show the connection between hand methods and computer techniques. I would then spend the rest of the time covering structural behavior, and do that through assignments using a structural analysis computer program. I would craft my assignments in much the way Professor Powell describes, by giving structural problems and behavioral questions to solve using a computer tool. I would demand the students also validate their answers by simplified analysis with both hand methods (virtual work) and using computer tools with simplified models.

There is one definite step that is needed to achieve these objectives: Organizations and industries need to partner with universities to help set the objectives for a graduate, and then shoulder their share of the responsibility to provide part of the education towards those goals. This is also an ABET requirement, so it should be an easy step once we agree to share the educational effort.▪

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