MoM, Dr. Beam, and Visual Mechanics: Direct Manipulation Software for Learning Mechanics of Materials

at the

University of Wisconsin-Madison

prepared for

The Institute on Learning Technology

part of the

Spring 2001

This quicklook also is available from the Learning Through Technology web site, http://www.wcer.wisc.edu/nise/ilt/
MoM, Dr. Beam, and Visual Mechanics: Direct Manipulation Software for Learning Mechanics of Materials

Gregory R. Miller
J. Ray Bowen Professor of Civil Engineering
University of Washington
Seattle, Washington
gmiller@u.washington.edu

Why use technology?
Like many instructors who teach mechanics of materials, I've experienced frustrating times when I feel that I've hit a wall in terms of what I'd like to communicate to our students and what I actually can communicate. This often involves something that would be much easier to understand if it could be animated or displayed dynamically, or I want to show better images than I can construct on the blackboard. But at the same time, I don't want to display a completely rendered, complex figure, because then it's not the same as seeing the figure evolve step-by-step during a blackboard lecture. Lectures can be effective for this—instead of seeing a complex figure in a textbook, with labels and lines all over it, students can watch the instructor demonstrate how the thing was constructed, so they see the sequence of how something came to be. It's like telling a story, really. I also wanted the figures to be as three-dimensional as possible, when appropriate, since we live in a 3-D world. I wanted to start with a 3-D model and use animation to show how we get to a 2-D view. I was trying to develop a wider set of avenues by which people could get to the material.

So my colleagues and I developed a system of computer-based tools for our classes—and for any engineering faculty to use—because we knew they would be really useful in giving the students a much richer, virtual, hands-on interaction with the concepts of the mechanics of materials.

The strategy
When I returned from sabbatical in 1990, a colleague came into my office and asked me if I'd like to participate in a new National Science Foundation project that the University of Washington was participating in: ECSEL, the Engineering Coalition of Schools for Excellence in Education and Leadership. The goal was to redesign and improve the learning environment in undergraduate engineering courses. We wanted to introduce sophomore-level students to real-world engineering practices, get them working in groups and learning effective communication skills, and retain them as engineering students.

At the start, we tried a lot of things, from technology to hands-on “gizmos.” The second year, a graduate student and I decided to teach a statics class with 100-percent computer projection. We used HyperCard—at the time, it was all that was available, but its simplicity was very effective in depicting evolving figures and equations. HyperCard provided monochrome figures and animations done essentially by flipping pages. This allowed us to construct figures line by line, focusing the students’ attention on the key points at each stage.
We also included four simulation programs, which we developed specifically for educational use, that give immediate visual and numerical responses when students manipulate the figures—students click and drag the mouse to rotate a figure or add stresses to a beam, for example. The software’s responses have an almost physical feel about them, which is very important in encouraging the students’ intuitive understanding of the material.

Because we were concerned about students taking what comes out of a computer at face value, we designed one of the programs to actually present them with incorrect results. We did this because we discerned that, even at the senior level, some students’ results are obviously wrong, and they have no idea what things should look like. No one had ever taught them a way of stepping back and comparing their results to some commonsense rules. By generating results that were incorrect, we were trying to teach them to inspect something according to the commonsense rules and say, “Well, no, that can’t be right, because it goes this way, and it should go that way.”

The course
I started developing these tools for Mechanics of Materials, a sophomore-level course of about 100 students. The nice thing about this subject matter is that the same concepts keep popping up even at advanced application levels—the course material opens up a lot of doors in a long hallway. I use these concepts all the way up into my graduate classes. And colleagues from other universities, like geologists and geophysicists, can download the whole package—it’s available for Macintosh and Windows. The class Website is http://octavia.ce.washington.edu/engr220.

The learning technology
HyperCard: We originally used HyperCard for our presentations, because it was really the only such program available at the time; but it was also easy to use and had unique capabilities. We still use it, adding color and more complex animations only as needed. With HyperCard, we organized the information in “stacks” of cards or pages that the students can move forward or backward through, using the navigation menu. HyperCard is still available from Apple Computer; the program is completely updated and compatible with multimedia and digital media: http://www.apple.com/hypercard.

MoM (Mechanics of Materials package): This package is the “freebie” version of the HyperCard stacks we created for the Mechanics of Materials class. MoM is a Macintosh application; Windows users can view the stacks using MetaCard, to which we provide a link at the course site. Both programs can be accessed at: http://octavia.ce.washington.edu/engr220.

The other four software packages that we developed for class are Dr. Beam, which allows the students to manipulate beam bending behavior; Dr. Stress, which lets students visualize and manipulate second-order tensors in three dimensions—these are mathematical abstractions that do not exist physically; Dr. Quack, which we used to give students both correct and incorrect answers that challenged their intuitive understanding; and Dr. Baldwin, which mimics lab experiments that the students do, allowing them to explore the experiments more deeply and repeat them as necessary.

Visual Mechanics: This is the commercial version of the MoM software; it’s offered through the commercial venture we founded: Dr. Software, LLC. The software offered here is real-time structural modeling software for architectural and engineering professionals, as well as
students. This software allows for direct manipulation modeling capabilities in real time, which enables users to explore the structures behavior rather than be bogged down in the details of the interface. Dr. Software offers two other packages: DrBeam provides direct manipulation for modeling and understanding beam bending behavior. DrFrame allows users to manipulate and model truss and frame structures. You can check this out at the Dr. Software Website: http://www.drsoftware-home.com.

The funding
The original funding for this project came from ECSEL, which was a National Science Foundation-funded project.

The results
We’ve tried to integrate the software pretty seamlessly into the course, to make it more transparent for the students. One comment we got was from a student who was amazed at how naturally the technology comes and goes during the lecture—it just seems like a natural part of what we do. All told, we provide material for 40 lectures. The material and software can be used fully, but I also use it in a less structures, more informal way in my other classes. My colleagues use these tools in any engineering or structural engineering curriculum.

I want to emphasize that technology might not be the answer if an instructor feels that his or her students do not seem to be engaged in the lectures. If that’s the case, putting stuff on a computer is probably going to make things worse. Nobody’s going to take notes; they’ll just sit there and watch it. The answer might be that you need to stop lecturing and do something else. The technology should be driven by a specific need or set of needs.

One of the best endorsements to me is that the students find this on their own, play with the software, and discover that it really enhances their learning. They find it and they use it because it works. If there’s some way that you can get the material straight to the students, that’s who your customer really is.

If you have any questions, you can contact me at gmiller@u.washington.edu.

<table>
<thead>
<tr>
<th>LINKS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanics of Materials course</strong>:</td>
</tr>
<tr>
<td><strong>Mechanics of Materials (MoM) Mac package for download</strong>:</td>
</tr>
<tr>
<td><strong>ECSEL</strong>:</td>
</tr>
<tr>
<td><strong>Dr. Software</strong>:</td>
</tr>
<tr>
<td><strong>Info on Dr. Beam</strong>:</td>
</tr>
<tr>
<td><strong>Dr. Beam demo version</strong>:</td>
</tr>
<tr>
<td><strong>Info on Dr. Frame</strong>:</td>
</tr>
<tr>
<td>Software</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Dr. Frame demo version:</td>
</tr>
<tr>
<td>Visual Mechanics:</td>
</tr>
</tbody>
</table>