Abstract

This paper describes efforts to develop a curriculum delivery approach for the classroom that overcomes limitations inherent in the standard blackboard lecture and that more fully integrates the teaching of engineering science with the teaching of concrete engineering practice.

Simple, HTML-based modules are under development that incorporate text, still images, and video clips to more closely couple concepts in mechanical engineering design with practical examples of their implementation. Two-dimensional dynamic simulation software will be used to help students visualize and analyze the motion of mechanisms, and mathematical software will be used to go beyond what can easily be presented on the blackboard.

Results from preliminary work have been encouraging and suggest that incorporation of practical examples using computer-assisted multimedia will help students build connections between theory and practice.

Introduction

Two Important Challenges

Two critical challenges for undergraduate education in mechanical engineering design are:

• how to exploit currently available computer technology to improve the teaching and learning process.

• how to integrate engineering science and design practice into the curriculum so that graduates are fully grounded in the theoretical fundamentals and can apply their knowledge practically.

Underlying the first challenge is the fact that the computer is a very powerful tool that enables the seamless integration of a variety of media for conveying information and combines the ability to perform rapid computation into a single platform. Many educators have begun to recognize the potential that computer technology offers to the educational process and have developed computer assisted courseware. By-and-large the results so far seem to indicate that computer-assisted multimedia can improve the educational process and that it will become more a part of education in the future [1, 2].

Mechanical design education has much to gain by incorporating the use of computers in the traditional classroom environment. Nisbett, et. al., articulated well that the standard technique of blackboard lecture is inadequate for demonstrating and modeling dynamic systems such as those encountered in courses on dynamics, mechanisms, vibrations, etc [3]. Unfortunately, the most prevalent approach to mechanical engineering in the classroom is still the blackboard lecture. Interactive computer graphics have been recognized to aid substantially in visualizing dynamic concepts, and many computer assisted instructional (CAI) packages have been developed. However, CAI packages have mostly been used in self-paced, tutorial settings. It is only recently that computers have begun to be used extensively in “lecture”. There is tremendous opportunity to pioneer new paradigms involving computer assisted curriculum delivery in the mechanical engineering classroom.

Underlying the second challenge is the idea that design education is not as well off as it was fifty years ago, because abstract engineering science has been emphasized at the expense of concrete engineering practice [4]. This perspective seems to be confirmed by other educators who have observed a trend of declining practical experience in engineering students [3,5,6]. A common complaint from employers of engineering undergraduates is that they “don’t have any practical experience.” Additionally, and more seriously, “lack of motivating engineering relevance in lower division courses has been hypothesized as a major factor for undergraduates deselecting engineering as a career” [7]. The Accreditation Board for Engineering and Technology (ABET) has responded to the need for more balance in the last five years by becoming more specific with regard to the design content in undergraduate programs, however, there is still a long way to go to
integrate design and concrete engineering practice into the curriculum.

The next section will discuss my initial efforts to address the two challenges and the remaining sections will discuss my current work on developing a computer-assisted classroom learning environment that moves beyond the standard blackboard lecture.

**Toward the Un-lecture**

**My Initial Attempts at Addressing the Two Challenges**

My first attempts have been to develop several computer-assisted classroom instructional modules and hands-on laboratory experiences for ME 154, Mechanical Engineering Design, a one semester required course for upper division ME undergraduates at San José State University. ME 154 is a 4 unit class that combines the subjects of mechanism design and basic design of machine elements. The modules cover an introduction to mechanisms and the fourbar linkage. They utilize PowerPoint presentation software to present textual information and Working Model simulation software to present animations of linkage kinematics. The hands-on experiences involve mechanical dissections and a term design project, and are described more fully in an earlier paper [8].

The feedback I’ve received from students by formal survey and casual interview has been overwhelmingly positive on the use of the computer in “lecture” in general, and the use of Working Model, in particular, to help visualize the motion of mechanisms.

As the instructor, I am very encouraged with what the computer has allowed me to do in class. I used a notebook computer and an LCD projection panel in a standard classroom. The PowerPoint slides I used in lecture (minus a few key words) were made available to students in hardcopy for notetaking. One of the key benefits I found, and the motivation for the title of this paper, is that “lecture” became much more interactive and engaging, more like a dialog rather than an information dump. I was able to face the students throughout the period, only needing to glance occasionally at the screen of my computer instead of spending a substantial amount of time with my back toward them while using the chalkboard. The students were able to spend more time grappling with the concepts than trying to copy what I would normally have written on the board. The 2D dynamic simulations of linkages with Working Model helped the students grasp concepts in mechanism design more rapidly and completely than could have been done by my using the chalkboard.

**My Current Work**

Under the support of a fellowship from the San Jose State University Institute for Teaching and Learning, I am attempting to enhance the computer-aided classroom instructional modules I’ve created in two ways:

1. Incorporating practical examples of mechanism and mechanical design into the un-lectures through the multimedia capability of the computer (e.g., still photographs, video, and 2D simulations)

2. Incorporating the computational power of commonly available mathematical analysis software into example problems and guiding students in its use.

With regard to the first area, students who have not had significant exposure to mechanical systems while growing up, often have trouble visualizing the motion of mechanisms and designing mechanical systems. This is often the case for females who are usually not encouraged to play with mechanical toys while growing up. There are two primary problems for students with limited background:

- They simply don’t have the experiential data base to build upon.
- The standard blackboard technique of drawing kinematic diagrams (stick figures representing the links and joints of a mechanism) is too abstract and static to allow students to easily visualize motion and relate the abstract representations to real devices.

By incorporating practical examples into the un-lectures using computer-assisted multimedia, I can expose students with limited experience to many practical examples in a relatively short time. The practical examples will enable students to build bridges between conceptual understanding of mechanisms and real-world design practice. Other educators have similarly realized the potential of bringing real-world examples into the classroom through computer-assisted multimedia in the fields of architectural engineering and construction technology [9, 10].

With regard to the second area of enhancement, the standard blackboard lecture is inadequate to go beyond much more than simple analyses, because it is tedious and time consuming for both teacher and student to copy down many lines of equations. There is tremendous opportunity to encourage exploration, in-depth analysis, and optimization of mechanical systems through the judicious use of analysis software. Student engineers need training in how to use mathematical software tools in order to become marketable and productive in today’s work environment. Without proper guidance, students are prone to pitfalls of blindly believing results of
computer-aided analyses or forgetting about fundamentals and choosing an approach that is unnecessarily complex to solve a simple problem. The emphasis here is not on any particular software, but rather on the approach, applicability, limitations, and applications of available software tools to solve practical mechanical design problems.

Methodology

Text, still images, and video clips in the enhanced un-lectures will be HTML-based and presented using a browser such as Netscape Navigator or Mosaic. I am exploring this approach instead of using standard presentation software, like PowerPoint, for several reasons:

- It is a very straightforward way to create the modules (short learning curve)
- It is low cost (Netscape Navigator and Mosaic are free!)
- It allows non-linear presentation of information (hypertext links instead of sequential slides)
- It will allow students to easily participate in creating additional curriculum material
- It is readily adaptable for use on the Web

At least six practical examples of mechanism applications, such as a desk lamp, garage door linkage, etc. have been photographed or videotaped. The mechanism examples will be used to provide a practical context for the presentation of conceptual information. For example, students will be introduced to kinematic diagrams by seeing them superimposed on photographs of actual mechanisms. Video clips will show how the actual mechanism moves. Dynamic simulations of the same mechanisms will be used to interactively determine quantitative information such as joint angles, velocities, forces, etc.

The database of examples will be continually expanded by involving students from the course to create examples through class assignments. The database may be of use to other educators and could be made available on the Web.

Analysis examples corresponding to the practical examples will be developed using MathCad, TK Solver, or a spreadsheet program.

Future Plans

I intend to expand the un-lecture modules to cover the second half of the course dealing with the design of machine elements. There is less need for dynamic visualization, but perhaps more need for analysis and optimization in this part of the course.

Summary

Currently available computer technology has the potential to improve the teaching and learning process in mechanical engineering design education by allowing practical examples to be integrated into the classroom lecture environment. There is a need to more fully integrate the teaching of engineering science and design practice so that graduates are fully grounded in the theoretical fundamentals and can apply their knowledge practically.

I am developing an approach for teaching mechanical engineering design in the classroom using HTML-based modules that incorporate text, still images, and video clips that will more closely couple concepts in mechanical engineering design with practical examples of their implementation. Two-dimensional simulation software will be used to help students visualize and analyze the motion of mechanisms corresponding to the practical examples. Mathematical software will be used to go beyond what can easily be accomplished on the blackboard to expose and to guide students in its judicious use.

Feedback from preliminary work suggests that the use of the computer in the classroom will enhance the teaching and learning environment and will help students grasp concepts more rapidly and completely. I expect that the incorporation of practical examples using computer-assisted multimedia will help students build connections between theory and practice.

References

4. Smith, C. O., “A Fifty Year Perspective on Design Education,” ASEE Design in Engineering


Link to an example for HTML lessons