

Application of student-centred strategies in teaching with computer aided instruction

Li Tao

Harbin Institute of Technology
Harbin 50001
People's Republic of China

Introduction

Nowadays, as computer techniques have developed to a high level, including both software and hardware, application of computers in education has appeared in most fields. Multimedia methods used in teaching practice, such as computer aided instruction (CAI), can supply much more information to the teachers and students than ever. The Internet can be used for distance education. It can also be used as a good way for teachers and students to communicate. And virtual learning environments and virtual laboratories are used to demonstrate simulations.

This paper presents works I have been putting into practice and some ideas coming from deep considerations after studying at the University of Sydney for four months. I have been studying in a program for 'Teaching Science in English' in the University of Sydney. I have learned a lot about contemporary teaching methods, such as student-centred teaching strategies, problem-based learning, case study methods and concept maps. In this paper, I will concentrate on how to use the student-centred strategies more in my future teaching practice, especially on the application of CAI in teaching, in order to encourage the students to be more interactive in their learning.

Currently used demonstration software

CAI has been around for many years, it is a very helpful and useful tool in teaching practice, to the extent that there are many kinds of CAI software used in universities all over the world. With the rapid development of computers, e.g. increase in calculating speed, memory and software, etc., we can do more than ever before. But there is still the problem of how to use CAI better and to make the computer a more efficient tool in our teaching.

One kind of CAI software has been used to show the deformation of beams under different loads in the course *Mechanics of Materials* at Harbin Institute of Technology. I will revise the use of this software, trying to make it more interactive and to encourage student thinking during lectures.

Most of the current use of CAI is for demonstrations in lectures. CAI can attract student (with many figures, words, cartoons, video and audio samples) and give more information than a general lecture. But it can also make for a more boring lecture for the student, if too much information is given and if the light of the classroom is too dim when using the projector, it may send students to sleep.

To solve these problems, a teacher should not overuse CAI. During the lecture when CAI is used, the lecturer should give students the opportunity for thinking and analysis. For example, you may set some points of pause in a CAI session. At these points, let the students think, analyze and create conclusions as to what will happen next. Alternatively some questions may be given to make the students learn interactively, and to establish connections between existing knowledge and the new experiences they are having. Students will gain very impressive knowledge from this kind of lecture.

In a CAI demonstration used in *Mechanics of Materials*, many kinds of deformations of a bar or a beam are demonstrated when different sorts of loads are applied. Figure 1 is a diagram showing a deformation of a beam when a couple is loaded on both ends of the beam. Before the couple is applied, some vertical and horizontal lines are shown on the surface of the beam. These lines are perpendicular to each other. After the couple is applied, we can see that the vertical lines haven't changed their lengths, and are still lines, just rotated a little. However the horizontal lines have changed their shapes to curves, whilst they are still perpendicular to the vertical lines, they have changed their length. The lines close to the top of the beam

are shorter and those on the bottom are longer. Because the deformation needed to be continuous along the vertical direction, a very important conclusion can be drawn: between the top and bottom lines, there must exist a point where the horizontal line doesn't change its length. We call this the neutral layer of the beam. This conclusion could be gained by a student according to the knowledge they have previously gained, so it is a good example to set as a pause point.

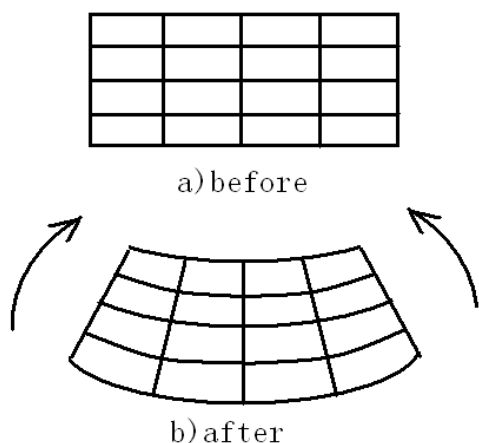


Figure 1. A diagram of deformation of a beam when a couple is applied

Virtual laboratory

Simulation is very useful in many fields. It may be used as a 'virtual laboratory'. You can do your experiment in a virtual environment, simulating steps of an experiment, selecting different types of experiments, controlling the process, dealing with the results you gain, and reaching

conclusions. In this way you can save a lot of time, money and resources because no equipment is needed other than a computer.

Figure 2 is a diagram of a test of one kind of material. In a virtual laboratory, an experiment can be started from the point when the load is zero ($F=0$), and as the load is increased, there will be some phenomena occurring (slipping lines, necking shrinkage and breaking). At the same time, a stress-strain diagram is drawn together with some key points on the curve relating to important concepts (such as proportional limit, yield stress, ultimate stress). Different kinds of materials have different mechanic properties. During the experiment, the students should observe these phenomena and record important data to use later in order to reach conclusions and for use in further discussion.

Student cannot be expected to perform many real experiments on different kinds of materials in one semester. A virtual laboratory can save time and supply students with opportunities to learn about many kinds of materials in a relatively short time, especially with some typical materials. The virtual laboratory can also be used for preparation of a real experiment. It can be put on the Internet as a shared resource for all students, teachers and engineers.

We can establish a virtual laboratory for structural analysis. In this laboratory, students can design their own structures using a series of standard members supplied in the laboratory. Students can work together or individually. They can be creative during the experiment. Imagination is very important here. After comparing different designs, they can develop an optimized one. The final design should have the maximum strength, stiffness and stability, and use the least material.

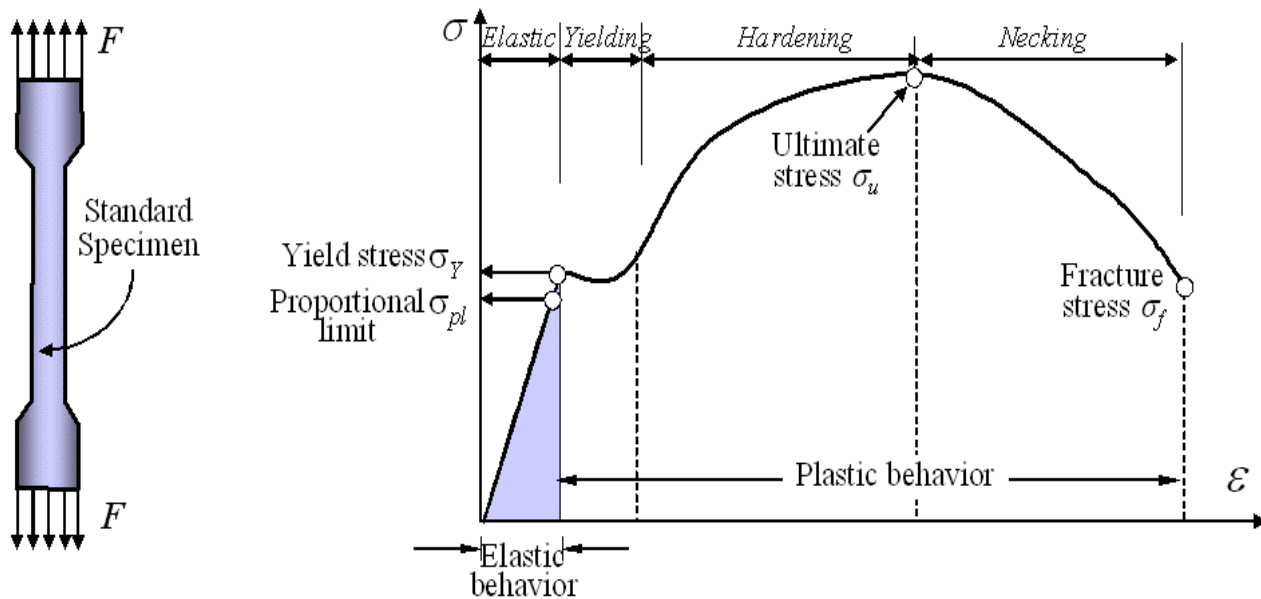


Figure 2. Material test and stress-strain diagram

Student designed programs

Mechanics of Materials is a course in which many engineering problems are solved and calculated. Students should learn how to use analyzing methods and to apply calculating skills. You cannot solve a complex problem using a mini-calculator. Nowadays, computers are very powerful. They are suitable for solving complex problems, and they are very efficient tools for conducting an engineering analysis.

In the course, *Mechanics of Materials*, it is appropriate to encourage students to design their own calculating programs using one kind of computational language in one semester. There is a lot of excellent software tools that could be used as design platforms. Students may have learned to use them in previous courses or by themselves. If they have, this is not a problem. It should be the first time for them to solve an engineering problem using a modern computer. Students need to have the integrative ability to use interdisciplinary knowledge. This course gives students a good opportunity to practice and develop their skills of utilizing computers.

The following are some steps for students to design calculating programs, assisted by teachers.

Processes of design programs

1. Analyzing problems

Once an engineering problem is given, the students should analyze it carefully using disciplinary knowledge. They should try to find a suitable way to

solve it. Some mathematical formulae and original data should be prepared before the program design.

2. Selecting a platform

A suitable platform for designing a program should be selected. It must be easy to learn and use (such as *Visual Basic*, *Visual C++*, *Matlab*). It should have functions of mathematical calculation, and an easy way to input data and post software for dealing with output (both final data output and figure output).

3. Optimized design

A good design should be an optimal one. It should have the following components:

1. be easy to input original data;
2. give clear data and output imaging;
3. change different images between input and output smoothly;
4. should allow easy choice of factors for calculating;
5. have the most concise program;
6. should calculate correctly;
7. should occupy the smallest amount of memory of the computer; and
8. should have the highest calculating speed; and so on.

4. Group work

The program requires more homework for the students. If students work together, they will get a very good design and learn to co-operate with others. Figure 3 is a concept map for program design.

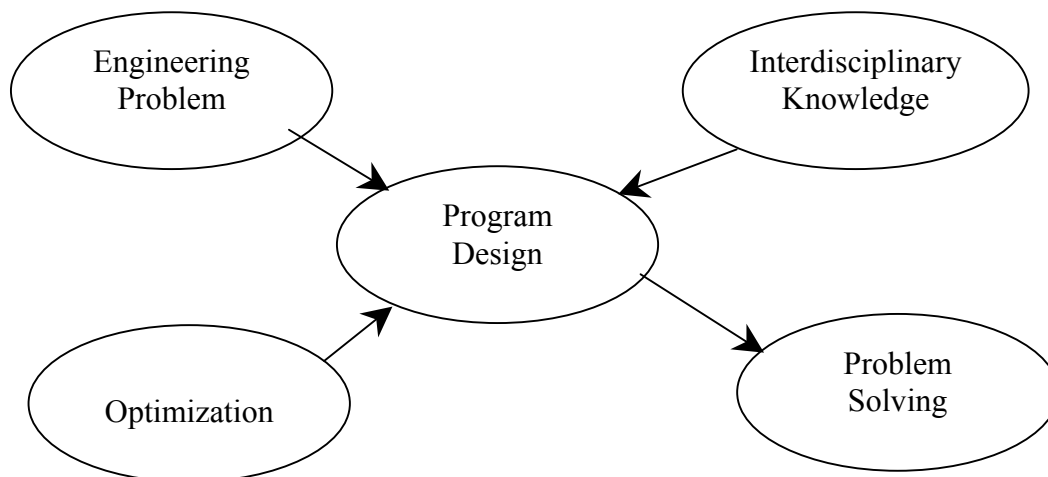


Figure 3. Concept map of program design

Assistance from teacher

1. Selecting problems

A teacher should select a suitable engineering problem for each student. The problem should come from real engineering practice. This should attract their attention, and make them interested in solving the problem and designing their program.

2. Testing programs

The teacher should test the students' programs, to certify their correctness.

3. Instructions

During the process of designing a program, the teacher should give instruction to students, so that students can revise their program continuously.

4. Competition

A competition can be held at the end of the course. It will aim to encourage the students in program design, for example a small prize can be awarded, or extra marks assigned for excellent program design.

5. Database

A database of excellent program designs can be established. It could be used as a sample for students of the following year and could also used as software in real engineering analysis.

Example

Figure 4 is a diagram of a beam with a circular cross section subjected to three kinds of simple deformation. The

stress distributions and formulae for calculating stress are listed.

Problem: Calculate the stress of a beam with a circular cross section, and find where the position of maximum stress occurs and the value of the stress.

Input: d ---diameter of the beam;
 F/P ---load;
 l ---length of the beam

Output: σ_{max}/τ_{max} ---maximum value of normal stress or maximum value of shearing stress

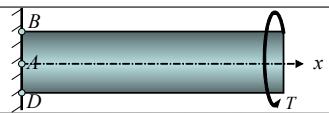
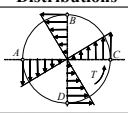

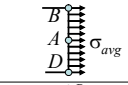

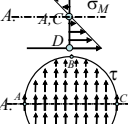
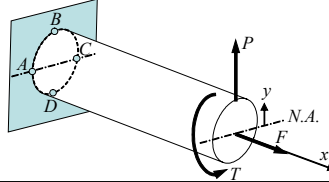
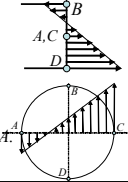
	Stresses Produced by Each Load Individually	Stress Distributions	Stresses
Torsional Load (Torque T)			Torsional shear stress $\tau_T = T\rho/J$
Axial Load (Force F)			Tensile average normal stress $\sigma_{avg} = F/A$
Bending Load (Transverse Force P)			Bending normal stress $\sigma_M = -My/I$ Transverse shear stress $\tau_V = VQ/It$
Combined Loads			Total normal stress $\sigma = F/A - My/I$ Total shear stress at N.A. $\tau = VQ/It \pm T\rho/J$

Figure 4. Different types of deformation

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