ROLE OF COMPUTER TECHNOLOGY IN CIVIL ENGINEERING EDUCATION

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ABSTRACT: The development of powerful and affordable microcomputers and computer software will have an impact in the delivery of instruction in higher education. This is especially true for civil engineering education where the computer has started to be appreciated as a useful tool in civil engineering analysis and design. This paper presents the use of computers as tools in the classroom and the author’s experience of integrating computer usage in some civil engineering courses.

KEYWORDS: education, civil engineering, computer, software

1. INTRODUCTION

The rapid development of computer technologies which include powerful and affordable microcomputers and reliable and user-friendly software has started to change the delivery of instruction in higher education. Computers have greatly increased the ability of students to perform calculations and to process large amount of data. As a result, the type and nature of problems and mathematical techniques taught in school may have to be changed or modified so that the usefulness of the computer can be maximized in the teaching-learning process. This is especially true for civil engineering education where the computer has started to be recognized as a useful and important tool in civil engineering analysis and design.

In what way can computer usage be introduced in the curriculum? How can we increase the awareness of students on the importance of computers in the solution of various problems in civil engineering? These are some questions that will be addressed in this paper.

2. TEACHING AND LEARNING USING COMPUTERS

Computer software, specifically for engineering, have become more powerful, robust and user friendly. Consequently, it has become clear that integrating the use of computer software in the curriculum will be to the advantage of the students who will become future civil engineers. However, before adopting the computer in teaching, the professor needs to determine whether five prerequisites for instructional use of computers have been met. This is summarized by Wankat and Oreovicz (1993).

1. Accessibility of hardware and software to both students and faculty.
2. The software must be reliable, robust and easy-to-use.
3. The faculty must have sufficient interest with the software.
4. There must be an advantage in the use of the computer software.
5. Students must be given some background on the use of the hardware and software.
If computers are adopted in engineering education, the learning objectives will depend on the type of software being used. These software may be classified into three groups: (a) generic application software; (b) specialized engineering application software; and (c) programming software.

2.1 Generic Application Software

Generic application software include spreadsheets and equation solvers. They represent the useful middle ground between hand solutions and computer programming. Spreadsheets such as Microsoft Excel are easy to use and learn. They are structured and data are presented in tabular form. Debugging is easy since errors are immediately displayed. Input and output are easy since any cell can be changed or displayed at any time. The inclusion of graphics capabilities makes it easy to prepare presentation-quality graphics and trends can be seen visually. Furthermore, spreadsheets are easily documented since each cell can be labeled.

Equation solvers, on the other hand, include MathCAD, MATLAB and Mathematica. With an equation solver, the user lists equations, gives values for the known variables and asks for a solution. The program then finds a direct solution or iterates to find a solution after the user supplies initial values. MathCAD worksheets are easy to create and results are immediately displayed as shown in Figure 1 which is a portion of a MathCAD worksheet for the matrix analysis of a plane truss.

![Figure 1. A MathCAD Worksheet](image-url)
When spreadsheets or equation solvers are used, students can do “what if?” calculations. These software are, thus, easily adaptable to discovery learning methods. Students can explore the effect of changing parameters, thereby gaining a feel for the magnitudes of parameters in problems. These generic application software may be easily incorporated in engineering courses as a tool for the students, for example, in the solution of graded homework. Lenox (1997), for example, integrated MathCAD in a reinforced concrete design course by requiring students to use MathCAD on every written requirement or homework. Homework problems for new lessons were most efficiently solved by supplementing MathCAD solutions from previous homework assignments. The final project which is a comprehensive design of a building is accomplished by combining previous MathCAD worksheets related to design of beams, slabs and columns.

2.2 Specialized Engineering Application Software

Specialized engineering application software are commercial programs developed for specific problems in engineering. These programs are extremely powerful and realistic since they are written for practicing engineers. They are, however, not very user friendly and expensive to license. Available software at DLSU include STAAD – a comprehensive structural analysis and design software, MicroFEAP and GRASP for two-dimensional analysis of structures, BATS – a three-dimensional analysis program for buildings, and GEAR – a software with various modules including the design of concrete members. Specialized software on other civil engineering applications are also available such as PRIMAVERA - a program for construction management and EMME/2 - a program for transportation planning.

Specialized engineering application software are appropriate for professional design classes such as reinforced concrete and steel design, structural analysis or construction management. These software may be introduced as a supplementary tool for the students to compare their results using hand calculations. For example, in the author's class in Matrix Analysis of Structures, students analyzed structural systems following the step-by-step matrix approach and results are compared to those obtained from a standard structural analysis program. The software are also useful since they allow the students to experience solving realistic problems which would not be normally be available until they are employed in industry. A clear advantage of using these software, especially those with graphics and simulation, is that students can visualize the behavior of complex systems. Figure 2, for example, presents the displaced configuration of a plane truss due to vertical loads. By varying the magnitude of the loads, students can immediately see the behavior of the structure due to variation of parameters. This increases the student’s “feel” to real life problems. However, it must be forewarned that students using such powerful software can suffer from the “black box” syndrome. As the program becomes more complex, it becomes increasingly likely that the student will not understand the internal workings of the program and the possibility of “garbage in, garbage out” becomes most likely where the student can not detect the errors. It is thus important that before exposing them to these specialized software, they should have already been instructed on the fundamentals for which the software are based. These software must be used as an aid to increase learning and understanding of complex systems. It must also be
emphasized that what must be developed in the students when using these software is their ability to make sound judgements based on results obtained from the software.

2.3 Programming Software

Programming software such as Turbo Pascal, C or Visual Basic are used when one wants to develop his own computer programs. Among the three groups of software, the use of programming software has the most comprehensive learning objectives. The use of a programming software would require from the student the following: (a) ability to analyze the problem and write an appropriate algorithm (b) knowledge of numerical techniques appropriate for programming, (c) ability to write, debug and execute a program, and (d) ability to evaluate the correctness of the output of the program.

At the De La Salle University, students study programming using a high level language such as Pascal or C in the general engineering course, ENGCOMP. During their third year, students are then instructed on the basics of using the computer for solving various problems in a civil engineering in the course, CENCOMP - Civil Engineering Computer Methods (Oreta 2000). The objectives of the course are: (a) to instruct students on numerical methods used in the solution of CE problems, (b) to develop simple, easy-to-use computer programs to solve various problems in CE, and (c) to familiarize the students on advanced computing technologies and software used in practice.
There are three projects required in the course. The first two projects involve the application of numerical methods to civil engineering problems. In these two projects, students are required to write a program in C or Pascal to solve problems such as finding the maximum deflection of a beam between two supports using Newton Raphson's method, regression analysis and curve fitting of concrete experimental data or area computation using numerical integration. The final project for the course is the development of a simple software using Visual Basic on a problem of their choice, which is related to their field of specialization. Figure 3 is a sample Visual Basic interface of a program on the use of Boussinesq’s method to compute the vertical effective stress in the soil, beneath a square, rectangular and continuous footing. This program also allows the user to compute for the net bearing pressure (q’).

Figure 3. Sample of a Student’s CENCOMP program

Other simple programs on various applications of civil engineering were also developed. The programs, such as working stress design of beams, strength design of beams, curved beams, stadia sights, net ultimate bearing capacity, sieve analysis, boundaries in a closed curve, cracking moment of beams, design aid for timber, settlement of square footing and pipes in series and parallel, show the varied interest of the students. It can be concluded that through courses like this, students appreciate the
usefulness of the computer in solving various problems in civil engineering and can develop and demonstrate their creativity through the simple programs they create.

3. CONCLUSION

The computer can play a useful and important role in the teaching and learning of civil engineering concepts and applications. Depending on the type of software used, the professor can design the course such that the computer can be used advantageously to increase the understanding of engineering concepts and to develop sound judgement in students. Since the development of faster and more affordable computers will be the trend, it is necessary that civil engineering schools should increase the awareness in students on the significant role computers play in education and in the industry.

REFERENCES


ABOUT THE AUTHOR

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