Computer-Based Games and Software in Civil Engineering as Educational Tools

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Abstract. Innovative approaches in teaching can be introduced in the classroom using the computer. In the author’s laboratory class on Computer Methods in Civil Engineering, students developed simple computer software applications and computer-based games on topics related to civil engineering using Visual Basic. By creating their own software applications, the students demonstrate their creativity and integrate concepts, methods and skills in mathematics, basic engineering and specialized civil engineering subjects. These software applications and games can be introduced in various courses in civil engineering like Engineering Mechanics, Strength of Materials, Fluid Mechanics, Structural Analysis and Structural design subjects to motivate learning and to facilitate retention and understanding of engineering concepts.

I. INTRODUCTION

The rapid development of fast, powerful and affordable microcomputers has provided educators options to introduce innovations in the teaching-learning process. How can computer technology be used effectively in the classroom to enhance the understanding of engineering concepts? How can the students’ interest be increased and how can learning be made as a fun activity through the use of computers? This paper presents computer-based games and software developed by undergraduate students at DLSU-Manila in one of their computer courses. These software applications can be used in the classroom in teaching and in conducting alternative class activities such as student competitions to facilitate retention and understanding of engineering concepts.

II. COMPUTER METHODS IN CIVIL ENGINEERING

The introduction of the Windows operating system and the growing interest in Graphics User Interface (GUI) has introduced new paradigms in computer programming and software development. Object Oriented Programming (OOP) is one of the most recent preferred techniques being used in the software development process (Anwar 1996, 2001). The traditional programming languages used in most of engineering applications, which are BASIC, FORTRAN and PASCAL, are not well suited for OOP implementation. Visual BASIC is a suitable language in introducing the students to OOP and Windows based applications. Visual BASIC is ideal for small to medium scale programs. This language is suitable for developing graphical and interactive software applications.

In the computer course for civil engineering students at DLSU-Manila, coded CIVCOMP, “Computer Methods in Civil Engineering,”, students learn to develop their own programs using Visual BASIC. CIVCOMP is a one unit laboratory course with three hours used for both lectures and hands-on training. This course is usually taken by students at the start of their senior year after they have completed most of their general engineering subjects in mathematics, physics, chemistry, engineering economy and mechanics, and general engineering subjects on structural analysis, fluid mechanics, hydraulics, surveying and engineering management.

A. Learning Objectives and Strategy

The objectives of the course CIVCOMP are: (a) To develop simple, easy-to-use computer software applications for solving basic civil engineering problems using Visual Basic, and (b) To familiarize students on advanced computing technologies for civil engineers. To achieve these learning objectives, an “active learning” approach where students “learn by doing” was adopted. Since the students have already a background in programming from their ENGCOMP subject, learning a new programming language through hands-on training was straightforward and undemanding. The activities conducted by the students during the term are:

- **Computer Examples** – Students follow step by step the examples in the textbook or reference to learn Visual Basic programming tools and syntax.
- **Computer Exercises** – Students apply Visual Basic programming tools to solve simple problems.
- **Computer Projects** – Students develop simple Visual Basic software applications including computer-based games to solve basic civil engineering problems.
**B. Computer Projects**

Through the computer projects, the students demonstrate their creativity and integrate concepts, methods and skills in mathematics, basic engineering and specialized civil engineering subjects. The students are expected to do the following: (a) understand the theory behind the problem, (b) derive and apply equations and numerical methods to solve the problem, (c) formulate an algorithm, (d) design a VB user’s interface which will accept input data and display the output, (e) write VB programs using correct syntax, (f) execute and debug the program, and (g) check the correctness of the results of the program.

After evaluating the software applications developed by the students, the following learning outcomes were observed (Oreta 2002):

(a) The students were able to integrate the knowledge, methods and skills learned in the other courses such as mathematics, numerical methods and the specialized civil engineering subjects in formulating a solution to their specific civil engineering problem,

(b) The students discovered by themselves the most appropriate way of presenting and solving the problem using the techniques learned from the computer exercises – an outcome expected by the “learning by doing” approach,

(c) The different designs of the user’s interface using colors, various objects such as buttons, text box, check box, labels and images illustrate the aesthetic talents and creativity of the students, and

(d) The student’s active involvement in the process: starting with the identification of the problem, formulation of the solution, algorithm development, interface design, writing and execution of the VB program up to the checking of the output, resulted in meaningful experiences which create interest and serve as a strong motivation for them to pursue similar activities like software development.

**III. SOFTWARE APPLICATIONS**

The students’ projects in CIVCOMP are simple visual basic software applications in civil engineering which may be used in “What if” type of learning. “What if these parameters are used, what will be the outcome” may be answered by the software. The software applications with their brief descriptions are shown in Appendix A. The software on deflection and elastic stress on beams may be used in the undergraduate course in Strength of Materials and Structural Analysis. The software may be used to illustrate the effect of various parameters of a beam on the deflection and bending stress. The software on Open Channel Flow may be introduced in the CE undergraduate course in Fluid Mechanics and Hydraulics. The students can explore the open channel flow for different types of cross-sections. The input parameters may be varied and the effect on the uniform depth of flow may be understood.

**IV. COMPUTER-BASED GAMES**

The computer-based games with their brief descriptions are shown in Appendix B. This software may be used to review the students on their understanding of the concepts. Student competitions may be conducted using the software to make the class more interesting and enjoyable. Through these activities, the students’ understanding and retention of the concepts hopefully may be improved.

**V. CONCLUSION**

How can computer technology be used in the classroom in engineering instruction is a challenge to engineering educators. This paper presents simple software applications and games developed by undergraduate civil engineering students which may be used to enhance the teaching and learning of the basic civil engineering courses. These software applications can be used as tools to improve the learning of engineering concepts. Innovative class activities such as student competitions using the computer-based games can be conducted to facilitate retention and emphasize important civil engineering concepts.

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The software applications were developed by undergraduate students in the CIVCOMP class of SY 2006-2007. The software applications presented in this paper were developed by the Ric Cruz, J.P. Sy, Danny Baluyot, Jr., Sherwin Lucas, Ricardo Vicencio III, Carlos Fabie, Ricahrd Masa, Pirre Lastimoso and Ledi Ruiz. Some of the software may be downloaded from http://mysite.dlsu.edu.ph/faculty/oretaa.

**REFERENCES**


APPENDIX A – SOFTWARE APPLICATIONS

1. Beam Deflection Application

This is a software application for solving the elastic deflection and slope of a beam. The inputs to the program are the cross-section dimension and properties of the I-section and the beam loadings and lengths. The outputs include the moment of inertia of the I-section, the beam deflection and slope at specified point X from the left end.

This application may be used in the course on Strength of Materials or Structural Analysis to demonstrate the effect of section properties, beam loading and lengths on the elastic deflection and slope of a beam. By computing the deflection of the beam at different values of X, the shape of the elastic curve can be drawn.

Software application by Ric Cruz.
2. Elastic Beam Stress Application

This a software application for solving the elastic bending stress of a T-section. The inputs to the program are the cross-section dimension and properties of the T-section and the beam loadings and lengths. The outputs include the location of the centroid and moment of inertia of the I-section. At a specified section X from the left end, the bending moment and the corresponding elastic bending stresses at the top and bottom of the section are computed.

The software may be used in the course on Strength of Materials in illustrating the effect of various parameters on the elastic bending stresses. The parameters that can be varied are the section dimensions, the magnitudes of the uniform and concentrated loads, and the beam lengths.

*Software application by J.P. Sy*
3. Open Channel Flow

This software application determines the normal depth of an open channel using Manning’s Equation:

\[ Q = \frac{k}{n} \cdot A \cdot R^{2/3} \cdot S^{1/2} \]

Where:  
- \( A \) = area of the flowing fluid  
- \( R \) = hydraulic radius \((A / P)\)  
- \( P \) = wetted perimeter  
- \( S \) = slope of channel bed  
- \( n \) = coefficient of roughness  
- \( k = 1.49 \) for English, \( 1.00 \) for metric  
- \( Q \) = flow rate of the weir

In this program, the user first selects the shape of the cross-section: (a) rectangle, (b) trapezoid, or (c) triangle. The system of units has to be chosen also. The inputs to the program are the dimensions of the cross-section and Manning’s equation parameters, \( S \), \( n \) and \( Q \). The output of the program is the normal depth of flow.

This software application can be used in the courses, Fluid Mechanics or Hydraulics. The values of the various parameters, such as dimensions of the cross-section, slope of channel bed, coefficient of roughness or flow rate, maybe varied to study the effect on the normal depth of flow.

*Software application by J.P. Sy*
APPENDIX B – COMPUTER-BASED GAMES

1. The Reaction Game

The main objective of this computer-based game is to test the student’s ability and quickness in solving for the reactions of statically determinate beams. This game has 10 different beam loading conditions and support conditions. As the level progresses, so is the difficulty of solving for the reactions. Each time the program is used, the forces and the length are generated randomly. There is also an allotted time for students to solve for the reactions, and if they fail to answer it on time, the game is over for them.

This game can be played in the Engineering Mechanics (Statics) or Strength of Materials class.

*Software application by Ricardo Vicencio III and Sherwin Lucas.*
2. Hangeneering

This is also a game to test the student’s mastery on solving reactions in statically determinate beams. There is a time limit which varies from 30 seconds to 90 seconds depending on the level of difficulty. The program chooses randomly the figure and the beam parameters. There is a formula for getting the score of the player. The game will be over when the user answered incorrectly three times or when the time has run out.

This game can be played in the Engineering Mechanics (Statics) or Strength of Materials class.

*Software application by J.P. Sy and Danny Baluyot, Jr.*
3. Jeopardeng

This is an adaptation of the famous American game Jeopardy. The game has four different categories that cover various topics about civil engineering. Each category has four objective questions. There is a database of questions which are selected randomly. The user answers all questions under the four categories in any order, aiming to bag a high score. After all questions have been answered within the time limit, the user is prompted to the “Final JeopardENG Round”; wherein a computational question will be asked to the user worth 5000 points.

This game can be played in class to review the students about civil engineering terms, concepts and definitions. A competition among students can be done with the student having the highest score declared as the winner.

*Software application by Carlos Fabie and Richard Masa.*
4. Tech-Tack-Two (Tic-Tac-Toe)

A game between two players on topics related to civil engineering. Each player takes turn – chooses a number and answers the question. The mark X or O will be displayed on the number chosen if the question is answered correctly. This game can be played in class to review the students about civil engineering terms, concepts and definitions.

*Software application by Pirre Lastimoso and Ledi Ruiz. Modified by A. Oreta*