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Interactive Software for Tutorials in Statics*

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The paper reviews the software packages that have recently appeared in the area of Statics. It refers to the advantages and drawbacks of the basic format of these packages and concentrates on a specific interactive software that has been used during the last two years at Concordia University. The student feedback about this particular computer-aided learning tool indicates generally favourable response but also some significant inertia in its utilization

INTRODUCTION

IT IS well known that the rapid evolution in the development of computers, their cost reduction and, consequently, their broad accessibility and utilization has influenced the curriculum and the teaching/learning approach in many engineering courses. Computer-aided learning first appeared in design courses followed by applications in more fundamental courses such as Statics. Software used for computer-aided learning in Statics has taken the form of interactive tutorials/problems, sometimes in computer disks provided with textbooks [1], or the form of more advanced knowledge-based expert systems [2].

Since computer-aided learning in Statics is relatively new, its effectiveness has not been evaluated. Statics is a fundamental course for first year engineering students in Building, Civil or Mechanical Engineering and its teaching has always been based on the traditional approach with lectures and tutorials. Innovations in teaching of Statics have concentrated on responsive education [3], the personalised system of instruction including different organizational systems for tutorial handling [4] and the development of educational models to help students grasp basic concepts [5]. Some preliminary evaluation of computer-aided learning in Statics has been attempted in the present study and the results in terms of student feedback received over two consecutive years are reported herein. The paper also reviews the various Statics software considered by the author and it concentrates on the application of the system used by his students.

COMPUTER SOFTWARE FOR STATICS

There have been three different systems of computer software for the Statics course considered by the author. All three software packages run on **IBM-PC** or compatible systems with color graphics card equivalent to the IBM color graphics adapter (256 K RAM, DOS 2.0 and higher). The first software is on a computer diskette provided with ref. [1] at no extra cost. This software includes 12 tutorials, each consisting of a problem for which students are likely to require additional help. It works in an interactive mode and appears easy to use and understand. The following items are covered in this software:

1. Components of a force.
2. Tension in cables.
3. Resultant of coplanar forces.
4. Reactions at supports.
5. Centroids.
6. Trusses by method of joints.
7. Trusses by method of sections.
8. Analysis of a frame.
9. *V* and *M* diagrams.
10. Friction.
11. Moments of inertia.
12. MOHR's circle.

Several features are also available to the user who generally selects the geometry (dimensions) of each tutorial problem, usually within some limits. The HELP, COMMENT (after providing a wrong answer), ANSWER (to provide the right answer), PROCEED (to show all values entered), ESCAPE, RESTART and ENTER commands are the most useful to the student. The use of a hand calculator is sometimes required and the student may select to perform these calculations or ask the 'tutor', i.e. the computer, to carry out this work. Note that the score of the correct answers is kept and presented to the student for purposes of performance evaluation.

The second software considered by the author is also on a computer diskette, which is sold separately from the textbook [6], for which it has been prepared as a supplement. It consists of over 300 basic questions and problems related to the explanations and theory outlined in the textbook. The software has been designed as a means to strengthen skills in the fundamentals and to serve as a self-test of the material.

The contents of the disk are divided into a series of lessons which cover most of the topics in the

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textbook. There are 23 lessons and each consists of a series of four different types of questions or problems. As the answers are entered a score is recorded which depends upon the type of problem or question asked. There are questions on basic definitions and problems that request drawing a diagram. Answers to these questions are provided after the student responds. It is then expected that the user honestly records the correctness of the response. Multiple-choice questions require the user to select the answers from a list: if incorrect on the first try the user is given a second chance; if this is incorrect as well, the correct answer is displayed. The last type of problem requires a calculation to be made and the answer entered in an answer box. Once a lesson is completed a grade and suggested rating is given. Note that the problems and questions in each lesson are only very basic. The utilization of this software becomes attractive through the use of 15 different colours (separate selection for foreground and background) and different levels of sound intensity (separate tones for correct and incorrect answers).

The third type of software has been issued by Prentice Hall [7] and is not associated with a particular textbook like the previous ones. It consists of 10 diskettes, each including a set of problems in one particular area of Statics. These problems are assigned as part of the course syllabus to help students prepare for exams. All answers are given and students are expected to try solving the problems before seeking help. The problems also serve as excellent examples in a lecture set-up assuming that electronic means are available in the classroom. The system is designed to give user control over the material presented and the speed of presentation. The interactive mode is not as distinct as in the previous software, although the presentation will pause at several points in a typical problem, waiting for user input. Alternative solution methodologies are also available for several problems. The cost of this software is higher for this system in comparison to the other two.

The author of this paper is not aware of any other computer software available for Statics at present. However, if such software packages prove to be attractive and successful, there is no doubt that more packages will follow.

Since reference [1] is used as a textbook for the six sections (35–40 students per section) of the Statics course taught at Concordia University, the first type of software was available to the students at no extra cost to enhance their study and understanding of the course material. Students were encouraged to utilize this software tool but several of them chose not to use it for a number of reasons.

STUDENT FEEDBACK

A simple questionnaire on the use of interactive software was prepared by the author in the fall of 1988. The questionnaire, which appears in the Appendix, was distributed to the students towards the end of the course. It asks the students about the utilization of the software or the reasons for not using it; general and specific comments; and suggestions for its improvement. Provision of student's name was optional and the majority of students completing the questionnaire preferred to remain anonymous. The questionnaire was first distributed to the students of Section V of Statics taught by the author in 1988. It was found that the majority of respondents (58%) had not used the software.

Special efforts were made in the fall of 1989 to increase the rate of utilization of this software. Students of Section V were particularly and continuously encouraged to attempt the tutorials of the software and arrangements were made for the availability of more computer systems for students' use. The questionnaire was then distributed to this group of students and their survey indicated that the majority (55%) of the respondents had utilized the diskette and practiced with the tutorials.

A variety of comments were made by the respondents and some of them were made by several students in either year. For instance, the vast majority of students using the software required a higher variety of problems in the tutorials and some wanted more difficult cases to be included. On the other hand, limited access to computers—or computers with necessary accessories—was the most common reason provided by the students who did not utilize the diskette. Table 1 shows the results of the survey for Section V of the course in terms of percentage of responses and common general comments made by the respondents in both 1988–89 and 1989–90 academic years. Clearly, several students made more than one common comments in their responses.

In the fall of 1989, with the assistance of the instructors of the other five sections of the Statics course, the questionnaire shown in the Appendix was also distributed to the students of the other sections in order to obtain a more global response from a higher number of students. There were 141 respondents in total from these sections. It is noteworthy that, although the software was available to all first year students taking the Statics course, no special effort had been made by their instructors to persist in its utilization. The results of this survey are presented in Table 2 and are organized in the same format with those of Table 1. They indicate that only 32% of the respondents had used the software, which shows a rather high degree of inertia on the students' part. On the other hand, comparison with the data of Table 1 suggests that the instructor's continuous encouragement and persistence clearly increased the number of students interested in the software.

The common comments of the group of 141 respondents were similar to those of students from Section V. Most of the students who had used the software suggested that they would prefer more variety and challenge in the tutorial problems. However, the majority of students, who preferred

not to use the software appeared concerned with the additional time required for this exercise. In other words, students considered the software as counterproductive and decided *a priori* that it would not enhance their abilities satisfactorily enough to justify their time investment. Limited access to computers fell in the second place but it is fair to report that some students explained that their response really meant that they did not have a computer at home rather than they could not access the computers at their disposition on university premises.

Problems on centroids and shear and bending moment diagrams were liked mostly by the students who used the software. This has been shown from the responses received on the section of the questionnaire regarding specific comments on the various tutorials.

Particular comments

These comments were made by a small number of students (up to four) and they reflect different experiences, suggestions and reactions. They include the following:

- Diskette should be sold separately from the textbook;
- Diskette should also be available in $3\frac{1}{2}''$ format and for Apple/Macintosh systems as well;
- Tutorials should include different categories of problems, i.e. easy, intermediate and difficult;
- Diskette appears defective—could the library magnetic detectors have affected them?
- Solutions of tutorial problems should be printed.

Note that the last suggestion can be implemented but an additional program (DOS Graphic) is required for this purpose.

Some students liked the explanations provided by the tutorials but one respondent complaining about the relative simplicity of the problems noted:

"I averaged over 90% on computer questions but I understand only 60% of the book questions"

Comments of this nature testify to the supplemental character of assistance that students may

Table 1. Percentage of responses for software utilization and common general comments—Section V

Response in utilization	Common comments	Fall 1988 (%)	Fall 1989 (%)
YES 42%—1988 55%—1989	More problems; more complicated problems are required	61	78
	Fewer calculations; more emphasis on methodology is required	28	
NO 58%—1988 45%—1989	Limited access to computers	64	40
	Perception of additional time required	44	20
	Utilization of previous edition textbook; no access to diskette	12	13
	Perception of lack of need for software utilization because of book excellence		7

Table 2. Percentage of responses for software utilization and common general comments—other 5 sections

Response in utilization	Common comments	Fall 1989 (%)
YES 32%	More problems; more complicated problems are required	62
	Fewer calculations; more emphasis on methodology is required	11
NO 68%	Limited access to computers	20
	Perception of additional time required	34
	Utilization of previous edition textbook; no access to diskette	8
	Perception of lack of need for software utilization because of book excellence	15

receive from the computer tutorials. Instructors should spell out clearly that utilization of this computer software is an additional and not a substitute tool to assist the students in handling problems of Statics.

CONCLUSIONS

The paper refers to the most common interactive software available for tutorials in Statics and describes its main features. Student feedback received over two consecutive years from groups using a textbook with a computer diskette available at no extra cost has shown the following:

1. First year students generally have a high inertia in using computer-aided learning tools and require strong and persistent encouragement to be persuaded about potential benefits from their utilization.
2. Students using the software were mostly positive about it with several of them asking for more complicated and challenging problems.
3. Excuses of students who decided not to use this software concentrated mainly on limited access to computer facilities and the perception of significant time allocation required, which would overload their very tight and demanding schedules.

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APPENDIX: Student feedback questionnaire

A) Did you use the software? Yes_____ No_____

If the answer is no, please specify reasons and comment on possible improvements.

If the answer is yes, please comment on the tutorials tried out. Specify advantages and drawbacks.

General comments: *Comments for specific tutorials*:

B) Please provide suggestions for improvement of this software.

C) Any other suggestions to improve this course?

NAME (optional):