A Controlled Comparison of Traditional Classroom Instruction with Computer Based Instruction in an Engineering Class

Joseph E. Hummer, John W. Baugh, Jr., Bhavani P. Konuru, and Steven M. Click
North Carolina State University

ABSTRACT

Educators have long considered using computer-based instruction (CBI) because it promises both self-paced, interactive education for students and greater efficiency for instructors. In the past, the resources necessary for CBI were in short supply, but now that many universities maintain powerful computing environments, questions about the effectiveness and efficiency of CBI arise.

To investigate the effectiveness of CBI, the project team developed three CBI units--one each for design, analysis, and background information--for use in a junior-level transportation engineering class. The team then conducted controlled experiments with the units. The team divided the participating class randomly in half. An exam covering material other than that in the CBI units was used to ensure that neither group had superior students. One group received traditional classroom instruction while the other used the CBI unit. The team administered surveys to both groups before and after the use of the CBI units to determine student opinions. The same homework problem was given to both groups immediately after instruction. Finally, all students were tested over the material during an in-class exam. The team determined effectiveness of the CBI units via statistical analysis of homework scores, test scores, and survey responses from the two groups.

Based on the analysis of group scores, CBI was as effective as traditional classroom instruction. In addition, student attitudes toward the class and toward the engineering profession in general were not affected by the use of CBI. The results indicate that CBI has potential; however, questions on the efficiency of CBI remain.

INTRODUCTION

Educators have long considered using computer-based instruction (CBI) because it promises interactive, self-paced, highly visual, easily measured learning. In the past, a lack of available computing power made CBI infeasible at many universities. However, now that powerful computing platforms are routinely available, new questions arise: Do students using CBI learn as well as students receiving traditional classroom instruction? Which courses and types of problems are best suited to CBI? Are the hopes of educators justified?

A number of authors have published results on the effectiveness of CBI[1,2,3]. However, most of these experiments were performed in the humanities, and little research has been done on the effectiveness of CBI in engineering. In an attempt to determine CBI's effectiveness in engineering, three CBI units--one each for design (open-ended problems with no single "right answer"), analysis (closed-type problems with a single "right answer"), and review of background information--were developed for use in a junior-level transportation engineering class[4]. Experiments then compared the effectiveness of two of these units with traditional classroom instruction. This paper summarizes some of the results of those experiments.

CBI UNIT DEVELOPMENT

The CBI units were designed to meet several goals: they were meant to be more active than passive, more graphical than textual, challenging yet enjoyable. They covered a broad range of types of inst ruction so the study team could estimate the relative effectiveness of CBI in each area.

The units were designed for use in "Civil Engineering (CE) 305: Traffic Engineering." CE 305 is a junior-level course required of all CE majors at North Carolina State University. The unit topics, chosen by the project team as areas where CBI would likely provide the most help, included "Vertical Roadway Alignment" (design), "Trip Generation" (analysis), and "Basic Surveying" (background). The units ran on the College of Engineering's Unix-based workstation system and were programmed in the language CT[5]. The project team designed each unit to require approximately one hour of student time. The units included animation, hypertext, and feedback on quiz performance. Preparing a unit required a substantial investment (about 400 hours) of time. Hummer, et al.[6] provides more detail on the units and their development.

EXPERIMENTAL METHOD AND RESULTS

The project team conducted two experiments during Fall Semester 1993 and one during Spring Semester 1994. All three experiments followed the same general approach. Students in the course were randomly divided into an experimental and a control group. The first test in the course provided an initial statistical comparison to ensure that the groups were balanced academically. During the semester, students either participated in the CBI unit (experimental) group or the equivalent classroom lecture (control) group. Homework and test question grades on the subject were compared statistically to determine the effectiveness of the CBI units. The team tested only design and analysis units because of the instructor's (Hummer's) reluctance to test students on the background material not directly related to the course objectives. A teaching assistant independent of the project team performed the grading. The project team urged students not to share notes or unit access with students in other groups, and a later survey indicated that most complied[4].

Fifty-one students participated in the Fall 1993 experiments. Table 1 shows the results of the first test, used to ensure that neither group was inherently superior. Though the mean score of the experimental group was slightly less than of the control group, the difference was not significant at the 95°/0 level. Thus, the groups displayed generally similar capabilities.

In CE 305, students work on homework assignments in three-person teams. The experimental group consisted of nine teams, leaving eight in the control group. On the day scheduled for the lecture on trip generation (the analysis unit), the experimental group went to the computer lab to use the CBI unit while the control group remained in the classroom. Immediately after class, both groups were given the same homework assignment. Table 1 compares the scores on this homework assignment. Again, the experimental group scored slightly lower than the control group, and again the difference was not significant at the 95°/0 confidence level. Thus, the method of instruction did not significantly affect homework scores.

Ten days after the homework assignment was given, the students took an open-note test which had two questions on trip generation. Table 1 shows the results from these two questions. There was a significant difference between the groups in scores on the first question, with the control group scoring higher, but not on , the second. Informal discussions with students indicated that the first question may have been biased. Many

Table 1: Project Results

Term	Evaluation Type	Question	Maximum Points	Group	Mean	Variance	N	t calculated	t* 950/0 level
Fall 1993	Test 1	Overall	100	Experimental	69.3	251	29	-0.59	2.01
				Control	72.1	320	24		
Fall 1993	Homework	Trip Gen.	15	Experimental	11.11	1.11	9	-1.71	2.16
				Control	12.12	1.84	8		
Fall 1993	Test Question #1	Trip Gen.	21	Experimental	9.52	42.1	25	-3.34	2.01
				Control	15.18	25.9	22		
Fall 1993	Test Question #2	Trip Gen.	12	Experimental	7.20	13.6	25	0.06	2.01
				Control	7.13	13.8	22		
Fall 1993	Test Question	Vert Align.	25	Experimental	17.4	31.2	25	-0.58	2.01
				Control	18.4	38.4	22		
Spring 1994	Test Question #1	Trip Gen.	2 0	Experimental	9.6	42.6	20	-0.36	2.03
				Control	10.33	36.1	18		
Spring 1994	Test Question #2	Trip Gen.	5	Experimental	3.85	3.50	20	-0.15	2.03
				Control	3.94	3.58	18		

students in the experimental group claimed that they were confused by the wording of the question, causing them to skip the question entirely. Thus, the statistical difference between the groups may not have resulted from a difference in the method of instruction.

Later in the semester, the students participated in a second experiment. While the control group attended a lecture which included an in-class exercise on vertical alignment design, the experimental group had the opportunity to use the CBI unit on vertical alignment design. While no homework was assigned on this topic, an open-note test ten days after the instruction required students to design a vertical alignment. Table 1 shows the scores from this question. While the experimental group scores were slightly lower than the control group scores, the difference was not significant at the 95°/0 level. Thus, there was no strong evidence of a difference in effectiveness between methods of instruction.

Before and after the Fall 1993 experiments, student completed surveys on their attitudes toward instructional methods (including CBI), the course, and the transportation engineering profession. The survey results, reported in detail elsewhere showed that students in the experimental group felt that CBI should be a supplement to, not a replacement for, classroom instruction. Those students rated CBI fourth of six methods in terms of enjoyable instruction and rated CBI as the least effective of the six listed methods. The limited use of CBI during these experiments did not change student attitudes towards the course or the profession.

Because of the potentially-biased test question during Fall Semester 1993, the project team retested the analysis unit using a new group of students. As in the Fall 1993 case, scores from the first exam suggested that both groups demonstrated similar abilities. The two groups had slightly different mean scores, but the difference was not statistically significant. The experiment proceeded as before, with an open-note test given two weeks after the instruction. Table 1 compares the scores on the two trip generation questions. Again, the experimental group scored slightly, but not significantly, lower than the control group. This suggests that the difference in mean test scores in the previous experiment may have been due to question bias rather than instruction method.

CONCLUSIONS AND RECOMMENDATIONS

Powerful computing systems at most universities allows instructors to consider CBI as a teaching tool. The results summarized in this paper are among the first evaluations of CBI in engineering and among the first with any experimental control. The experiments generally showed minimal differences in test question performance between students listening to traditional lectures and those using CBI. The one significant difference found, lower scores for the CBI group on a test question about the analysis unit, was likely due to bias inherent in the question.

Readers should use caution in applying these findings out of context. These findings were for one course at one university using three custom-made units. They may not apply directly to other areas of engineering, other universities, or other types of units.

CBI appears to have potential, but more work is needed before instructors can routinely apply it. The project team recommends the following as promising areas of future work on the effectiveness of CBI:

1. This research involved only three short CBI units. Future research should study classes or curricula with significantly increased CBI usage.
2. Studies are needed to determine the effectiveness of CBI for professional education and training in engineering and technology.

3. CBI cost-effectiveness is unknown. Instructors and administrators need good estimates of CBI development costs, lecture time savings, other "hidden" time requirements with CBI, and other costs to determine whether unit development is worthwhile.
4. - Instructors need to know how the effectiveness of CBI varies with different student learning styles.

ACKNOWLEDGMENTS

The Center for Technology and Communication of Project SUCCEED provided support for this effort. Project SUCCEED was funded by the National Science Foundation. North Carolina State University and The University of North Carolina at Charlotte also provided support. The views expressed in this paper are those of the authors and do not necessarily represent the views of the entities named above. The authors assume fill responsibility for the accuracy of the data and conclusions presented in this paper.

REFERENCES

1. Kulik, J.A. and C.C. Kulik (199 1). Review of Recent Literature on Computer Based Instruction. *Contemporary Educational Psychology,* Volume 12, Pages 222-230.
2. Kulik, J.A. and C.C. Kulik (1991). Effectiveness of Computer Based Instruction; An Updated Analysis. *Computers in Human Behavior.* Volume 7, Page 75.
3. Roblyer, M.D., W.H. Castine and F.A. King (1988). *Assessing the Impact of Computer Based Instruction: A Review of Recent Research.* The Hawork Press, New York, NY.
4. Konuru, B.P. (1994). *The Potential of Computer Based Instruction for a Variety of Engineering Problems. MS.* Thesis, North Carolina State University, Raleigh, NC.
5. Sherwood, J.N. (1989). *cT Version* **2.0** *Reference Manual.* Falcon Software, Inc., Wentworth, NH.
6. Hummer, J.E., J.W. Baugh, Jr., M. Abraham and B.P. Konuru (1993). Creating Interactive Animated Instructional Programs on a Unix-Based Workstation. *Proceedings, Frontiers in Education 23rd Annual Conference.* IEEE and ASEE, Washington DC, November 6-9, Pages 70-75.

AUTHOR BIOGRAPHIES

JOSEPH E. HUMMER PH.D., P.E., is an Assistant Professor in the Department of Civil Engineering at North Carolina State University. Dr. Hummer was the Principal Investigator of the project which resulted in this paper. He teaches and researches in traffic operations and highway safety and is a Member of ASEE.

JOHN W. BAUGH, JR., PH.D. is an Associate Professor in the Department of Civil Engineering at North Carolina State University. Dr. Baugh specializes in computer applications in civil engineering and he contributed his expertise to the development of the CBI units.

BHAVANI P. KONURU is a Transportation Engineer with Parsons, Brinckerhoff, Quade, and Douglas, Inc. in Morrisville, NC, where he specializes in highway design and traffic operations. Mr. Konuru was the lead Research Assistant on the project which resulted in this paper and wrote his M.S. thesis on the subject.

STEVEN M. CLICK is a Ph.D. student and Research Assistant in the Department of Civil Engineering at North Carolina State University. Mr. Click expects to finish his dissertation in the area of traffic operations by August 1997. He is active in the ASEE student chapter and has a keen interest in teaching.