Developments in Business Simulation & Experiential Exercises, Volume 13, 1986

ASSESSING THE EFFECTS OF A COMPUTERIZED STUDY GUIDE IN MACROECONOMIC PRINCIPLES: A STATISTICAL ANALYSIS

Paul L. Altieri and A. Papathanasis
Central Connecticut State University[1]

ABSTRACT

The purpose of this study was to test the effectiveness of a computerized study guide in reinforcing the macroeconomic concepts taught in the classroom. The paper discusses the design of the software, its testing in the field, and a statistical analysis of its effects on learning and retention. The results suggest that when gender and GPA are taken into account, this form of CAI significantly improves the comprehension of complex economic concepts.

INTRODUCTION

Computer Aided Instruction (CAI) has been employed in economics with most of the field work of the computer simulation and game varieties. However, the effects on learning and retention of an interactive-type study guide that allows students, especially those in large undergraduate classes, to progress at their own pace had not been adequately tested. As a result, this paper describes the design of a computerized study guide for Principles of Macroeconomics, its testing in the field, and a statistical analysis of its effects on learning and retention.

LITERATURE OVERVIEW

Studies of the effectiveness of CAI and simulation games, including the non-computerized type, on cognitive behavior have produced mixed results in the past.

Wentworth and Lewis [16, p. 117] concluded that students exposed to a non-computerized version of an economics simulation game performed better when tested with an instrument designed to measure comprehension of economic concepts. The instrument is called TUCE (Test of Understanding in College Economics) and is published by the Joint Council on Economic Education [10]. It consists of a 30 question multiple-choice test, available in a variety of versions. Chizmar, Hiebert, and McCanney [4, p. 43], on the other hand, used CAI as an optional supplement. The test instrument did not uncover differences in scores between students who used the simulation and those who did not when the scores were adjusted for differences in GPA.

A study made by Cox [5, p. 30] using eight simulations differed from other studies because the values of the variables were chosen in advance by the instructor and not by the students. Again, no significant differences in scores were detected. On the other hand, Soper cites improvements in scores were detected in the study by Booms and Kaltreider as well as in the study by Bonello, Davisson, and

Jameson [11, p. 9].

Additional affirmative empirical evidence of the effectiveness of CAI was offered by the studies of (1) Paden, Dalgaard and Barr [9], (2) Swartz, Bonello, and Davisson [13], and (3) Marlin and Niss(7).

The conflicting results emerging from these studies could be attributed to methodological shortcomings. First and foremost, the methods were irreproducible. Second, a number of the studies used inappropriate statistical techniques. Lastly, the studies did not include a number of variables [2]. Our study avoided some of the aforementioned shortcomings by the use of the methodology given below.

HYPOTHESIS

We hypothesized that students in the experimental group would show a greater improvement in scores on the posttest, given at the end of the semester, over the pretest, administered at the beginning of trte semester, then those students in the control group. However, the abilities of the individual students, and whether or not they had studied economics in high school would probably also influence the improvement in scores. In addition, we agreed with Wehrs that gender might be another important factor [15, p. 1081 The students' SAT scores and Grade Point Averages (GPA) were selected as proxies for ability. We believed that the higher the SAT and GPA, the greater improvement the student would demonstrate.

METHODOLOGY

According to William E. Becker [1, p. 13] Miller [8, p. 51], and Spector and Mazzeo [12, p. 37] among others, a study should provide for 1) control, b) replication, c) generalization, and d) a favorable cost-benefit ratio. Our study satisfied the control requirement by dividing the sample into two groups, an experimental group and a control group. The replication requirement was also satisfied because the results of the study could be repeated under similar circumstances and conditions by other researchers. The results could be used to make generalized inferences about the population and, thus, satisfied the generalization requirement. Finally, the relatively low cost of the project satisfied the Cost-Benefit requirement.

We assumed in our model that students produced an output, understanding of economic concepts, using a vector of inputs specified by the following equation:

$$DIF = a + bPRE + cSAT + dHSECON + eCAI + fSEX + gGPA + U \quad (1)$$

where,

```
    TUCE = Test of Understanding in College Economics
     PRE = student's score on TUCE at the beginning
           of the semester
     DIF = student's score on TUCE at the beginning
           of the semester minus students' score on
           the TUCE administered at the end of the
           semester as part of the final examination
     SAT = Composite score on the Scholastic Aptitude
           Test
  HSECON = 1 if the student had taken a high school
           class in Economics, 0 otherwise
     CAI = 1 if the student was in the experimental
           group, 0 otherwise
     SEX = 1 if the student was female, 0 if male
     GPA = student's cumulative grade point average
       U = the disturbance term.
```

The variable DIF is used here as a proxy for learning. We expected that the coefficients of the variables CAI, SAT and CPA would be positive. The coefficient of PRE, on the other hand, should be negative. No a priori judgements were made concerning the sign of the SEX coefficient.

DATA COLLECTION

The data were collected in five sections of Principles of Macroeconomics during the spring semester of 1985. The two instructors who taught the five classes used the same textbook, study guide, course outline, testing method and spent the same amount of time on each topic. The only variation was due to the personalities of the instructors. Two of the sections served as the experimental group; the control group contained three sections. The total sample contained 147 students. After adjustment for missing data, 127 observations were left.

All students in the sample were given TUCE, Macro Form A, both as a pretest and as a posttest. During the semester all students were expected to utilize the printed study guide which accompanied the textbook. Students in the experimental group, however, were allowed to substitute the use of the computerized study guide for the printed study guide. To provide the necessary incentives to perform well on the TUCE, students were allowed to substitute their performance on the TUCE (either the pretest or the posttest) for one of the regular course examinations. Finally, given that the students faced a fixed time constraint, we assumed that if they spent more time with the computer they would necessarily spend less time using the printed study guide.

SOFTWARE DESCRIPTION

The computer program for this study was written in BASIC for the DEC Rainbow personal computer by the authors and contained the following features. Upon signing on, the student entered his or her name and a password. Next, the main menu of topics corresponding to chapters in the textbook appeared on the screen. After selecting a particular topic, the student could choose either to read a tutorial or to proceed with a multiple choice drill session on that subject.

The tutorial was designed to complement the textbook and presented the material from a different perspective. Animated graphs and overlays distinguished the tutorial from the static presentation of the standard text. For instance, in the dynamic supply and demand analysis, an animated shift of the supply curve visually demonstrates the process of reaching the new equilibrium price and quantity. In the analysis of national income, the students can watch the aggregate demand curve shift upward as government spending increases. This is not possible in the static presentation of a textbook.

The program allowed the student to move back or forth through the pages of the tutorial at his or her own pace. The student could take a break, return later, and resume at the point where he or she left off. Multiple readings of the tutorial were also possible.

The quiz section presented multiple-choice questions and supporting animated graphs and tables. If the student answered correctly on the first try, the message "CORRECT" flashed on the screen. Two incorrect responses in a row caused the correct answer to appear on the screen. Upon completion of the quiz, the student was presented with his score. The length of the session in minutes was automatically recorded, along with the student's name, in a separate file accessible only to the instructor. An unanticipated problem arose when some students turned off the computer instead of exiting the program through software control. As a result, the time spent on the computer was not recorded, and thus, could not be used as an explanatory variable.

RESULTS

A backward-elimination procedure using the stepwise regression program of the SAS statistical package indicated that the variable HSECON did not contribute to the explanatory power of the model and could be eliminated.

The data in Table 1 indicate that the coefficients of the remaining variables are statistically significant. The coefficient of the variable PRE is negative. This result was anticipated since those who did well on the pretest had less room for improvement on the post-test. The coefficients of SAT and CPA are positive, as expected. The coefficient of CAI suggests that students who used the computerized study guide show a six percentage point improvement in mean scores compared to other students. Similarly the coefficients of CPA and SEX suggest a five and seven percentage point differential respectively. The coefficient of SEX being negative suggests that males may be more comfortable with the format of TUCE than females.

Although the R^2 and the adjusted R^2 of the model are not high, the computed F-statistic allows one to reject the null hypothesis that all coefficients are simultaneously zero. Finally, the correlation matrix of Table 2, together with the Durbin-Watson statistic and analysis of the residuals, suggest that the model does not suffer from multicollinearity and that it is correctly specified.

CONCLUSIONS

The purpose of this study was to test the effectiveness of a computerized study guide in reinforcing the macroeconomic concepts taught in the classroom. We felt that the interactive approach of the computer assisted instruction would be more effective than the

traditional study guide and simulation game variety of CAI. The results suggest that when gender and CPA are taken into account, the computerized study guide form of CAI significantly improves the comprehension of economic concepts.

TABLE 1
ANALYSIS OF VARIANCE
DEP VARIABLE: DIF

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	5	8008.52	1601.704	16.261
ERROR	121	11918.71	98.50172	
C TOTAL	126	19927.23		

ROOT MSE	9.924803	R-SQUARE	0.4019
DEP MEAN	8.88189	ADJ R-SQ	0.3772
C.V.	111.742		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR
INTERCEP	1	4.942471	7.267543
PRE	1	-0.678361	0.09319297
CAI	1	6.390268	1.902453
SAT	1	0.01490436	0.007210013
GPA	1	5.240794	1.439852
		-7.14154	1.831468

VARIABLE	DF	T FOR H0: PARAMETER=0	PROB > ITI
INTERCEP	1	0.680	0.4978
PRE	1	-7.279	0.0001
CAI	1	3.359	0.0010
SAT	1	2.067	0.0409
GPA	1	3.640	0.0004
SEX	1	-3.899	0.0002

TABLE 2
CORRELATIONS AMONG THE VARIABLES

	PRE	CAI	SAT	GPA	SEX
PRE	1.0000	-0.0262	0.1873	0.2124	-0.1358
CAI	-0.0262	1.0000	-0.0960	0.1635	0.0578
SAT	0.1873	-0.0960	1.0000	0.1260	-0.1103
GPA	0.2124	0.1635	0.1260	1.0000	0.1102
SEX	-0.1358	0.0578	-0.1103	0.1102	1.0000

CORRELATION OF ESTIMATES

CORRB	INT	PRE	CAI	SAT	GPA	SEX
INT	1.00	-0.17	-0.12	-0.83	-0.28	-0.21
PRE	-0.17	1.00	0.04	-0.16	-0.22	0.14
CAI	-0.12	0.04	1.00	0.11	-0.17	-0.02
SAT	-0.83	-0.16	0.11	1.00	-0.07	0.12
GPA	-0.28	-0.22	-0.17	-0.07	1.00	-0.14
SEX	-0.21	0.14	-0.02	0.12	-0.14	1.00

DURBIN-WATSON D   1.933

REFERENCES

[1] Becker, William E., "Economic Education Research: Part I, Issues and Questions," Journal of Economic Education, Vol. 14, No. 1, (Winter 1983), pp. 10-18.

[2] _____, "Economic Education Research: Part II, New Directions in Theoretical Model Building," Journal of Economic Education, Vol. 14, No. 2, (Spring 1983), pp. 4-10.

[3] _____, "Economic Education Research: Part III, Statistical Estimation Methods, Journal of Economic Education, Vol. 14, No. 3, (Summer 1983), pp. 4-15.

[4] Chizinar, J.F., Hiebert, L.D., and Barnard J. McCanney, "Assessing the impact of an instructional innovation on achievement differentials: The case of CAI," Journal of Economic Education, (Fall 1977), Vol. 9, No. 1, pp. 42-46.

[5] Cox, Steven R., "Computer Assisted Instruction and student performance in macroeconomic principles," Journal of Economic Education, Vol. 6, No. 1, (Fall 1974), pp. 29-37.

[6] Hu, Teh Wei, Econometrics, University Park Press, Baltimore, 1973.

[7] Marlin and Niss, "The advanced learning system," Journal of Economic Education, Vol. 13, No. 2, (Summer 1982), pp. 26-39.

[8] Miller, Jimmie C., "Technical Efficiency in the Production of Economic Knowledge," Journal of Economic Education, Vol. 13, No. 2, (Summer 1982), pp. 3-13.

[9] Paden, Dalgaard and Barr, "A decade of CAI," Journal of Economic Education, Vol. 9, No. 1, (Fall 1977), pp. 14-20.

[10] Saunders, Phillip, Revised Test of Understanding in College Economics, Interpretive Manual, Joint Council on Economic Education, 1981.

[11] Soper, Johm, "CAI in Economics: A survey," Journal of Economic Education, Vol. 6, No. 1, (Fall 1974), pp. 1-28.

[12] Spector Lee C. and Michael Mazzeo, "Probit Analysis and Economic Education," Journal of Economic Education, Vol. 11, No. 1, (Spring 1980), pp. 37-44.

[13] Swartz, T.R., Frank J. Bonello and William I. Davisson, "The misuse of TUCE," Journal of Economic Education, Vol. 12, No. 1, (Winter 1980), pp. 23-33.

[14] Theil, Henri, Principles of Econometrics, John Wiley, 1971.

[15] Wehrs, William, "Incentive Structure and the TUCE," Journal of Economic Education, Vol. 9, No. 2, (Spring 1978), pp. 107-110.

[16] Wentworth, R.D., and Darrel Lewis, "An Evaluation of the use of the Marketplace game in Junior College Economics," Journal of Economic Education, Vol. 6, No. 2, (Spring 1975), pp. 113-119.