EXPERT SYSTEMS VERSUS TRADITIONAL METHODS FOR TEACHING ACCOUNTING ISSUES

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ABSTRACT

The use of expert systems as pedagogical devices has received little attention in the accounting literature. This study reports on an experiment that was designed to assess the effects of expert system use on student learning. The cognitive theories of learning were drawn on to develop a framework for measuring learning when expert systems are used as pedagogical aids. Two components of leaning, declarative knowledge and procedural knowledge were measured. Treatment groups used either an expert system, received instruction, or used an expert system and received instruction.

The results indicate that instruction facilitated the development of declarative knowledge to a greater extent than the use of an expert system. Further, the results indicate that expert system use facilitated the development of procedural knowledge to a greater extent than the use of instruction. Thus, although students who learned transfer pricing using an expert system outperformed students who had learned the same subject matter through instruction in a procedural test, the expert system users did not appear to understand why the procedures they followed were effective.

INTRODUCTION

The use of expert systems as pedagogical devices has received little attention in the accounting literature. Expert systems are sophisticated computer programs, which are designed to replicate an expert's judgment in a modeled domain. Consequently, nonexperts who use expert systems have the opportunity to watch an "expert" at work. Böer and Livnat (1990) in a study of the effect of expert system use on homework assignments concluded that expert systems seemed to have the potential to enhance the learning process for accounting students. However, their experiment may not have measured student learning but may have instead observed the phenomenon that nonexperts who use expert systems make better decisions than nonexperts who do not.

The study herein reported draws on cognitive theories of learning to develop a framework for measuring learning when expert systems are used as pedagogical aids. A cognitive model of learning is presented in the next section and is then used to derive the research hypotheses. The research design and empirical results are then presented. The results are discussed in the conclusion, as are implications for accounting and business education and suggestions for future research.

COGNITIVE MODEL OF LEARNING

The cognitive model of learning is based on the processes, which affect data as the data flows through the human information processing system. When data enters the processing system, it is transformed into knowledge, which is stored in long-term memory. The type and amount of knowledge stored in long-term memory increases during learning.

Two types of knowledge are stored in long-term memory: declarative knowledge and procedural knowledge. Declarative knowledge is factual knowledge about a topic (Gagné, 1985). Declarative knowledge is instrumental in developing procedural knowledge, the knowledge of *how* to do something. Anderson (1985, p. 198) describes procedural knowledge as " . . . knowledge about how to perform various cognitive activities." Both declarative knowledge and procedural knowledge are developed as an individual learns a new skill.

Fitts and Posner (1967) identify three stages in skill development: the cognitive, associative and autonomous stages. Declarative knowledge, knowledge about facts and things, is developed in the cognitive stage, as are domain-general problem-solving strategies. Domain-specific problem solving procedures are developed during the associative phase as the individual corrects and refines the domain-general strategies. This refinement process occurs as new information interacts with developed knowledge. No clear distinction between the associative and autonomous stages exist. The speed and accuracy with which procedures are used increases as individuals move into the autonomous stage. Individuals generally move sequentially through all three phase as they develop a new skill.

Learning is measured in this study by measuring the development of declarative and procedural knowledge of the subjects. The amount of knowledge that the students have at the beginning of the experiment is important in measuring the earning that can be attributed to the treatments. According to the cognitive model, declarative knowledge and procedural knowledge are developed when prior knowledge interacts with new information.

This study compares the affects of instruction and expert system use on student learning. Learning results in the development of both declarative and procedural knowledge. However, different instructional technologies may have different effects on the type and extent of knowledge developed. The presentation of factual information should result in the development of declarative knowledge because declarative knowledge is knowledge about facts and things. The presentation of factual information should, on the other hand, have a limited effect on the development of procedural knowledge. Factual information by definition is information about things, not information about how to do things. Expert systems guide users through a decision-making process. This process demonstrates a procedure for solving a problem but may not simultaneously provide factual information about entities. Students, as they develop expertise in a target domain should be able to use their procedural knowledge to solve relevant problems, and also be able to explain or describe underlying concepts and facts. Thus, a viable instructional technology should facilitate the development of both declarative and procedural knowledge and will most likely guide students through the three stages of skill development (Fitts and Posner, 1967).

This experiment compares the relative effectiveness of instruction and expert system use on the development of declarative and procedural knowledge. The hypotheses to be tested are:

H1: There will be no difference in development of declarative knowledge
between treatment groups.

H2: There will be no difference in development of procedural knowledge
between treatment groups.

EXPERIMENTAL METHOD

Task

Subjects completed a set of transfer pricing cases in this experiment. Transfer pricing has been suggested as a viable topic for expert system-based instruction (Böer and Livnat, 1990). Transfer pricing decisions required the analysis of a complex set of rules. However, these rules can be readily divided into small segments and then analyzed in sequence during the decision process.

The rules for the transfer pricing expert system were derived from Thomas (1989) matrix approach to transfer pricing. The rules were implemented using a rule-based expert system shell using a series of IF-THEN statements. The subjects had the option of viewing the rules and the reasons for the queries made by the expert system during a consultation session. The subjects could also look at a complete explanation of the solution path upon completion of the session.

Subjects

Ninety-seven students from three sections of undergraduate managerial accounting taught by the same instructor participated in this study. This course is a required course for several majors at the sophomore level. Treatments were randomly assigned to course sections, and not individual students. Consequently, group sizes were uneven.

Demographic Questionnaire

To test for homogeneity of the sections, the students completed a demographic questionnaire. The variables on the questionnaire were tested for use as covariates in the analysis.

Pretest

All three sections were given a pretest to measure their knowledge of transfer pricing prior to the treatment. The pretest consisted of ten questions designed to measure the student's declarative knowledge. Base-level procedural knowledge was measured by having the students solve six transfer-pricing problems. The subjects were required to act upon the information presented that is to use procedural knowledge, in solving these cases. Both pretest elements were conducted without the use of any learning aids.

Cases

The subjects were then given a set of transfer pricing cases to solve after they had received instruction and/or an expert system. The assigned cases became progressively more difficult to maximize the benefits of the learning experience. The subjects completed a posttest after finishing all of the experimental cases. The posttest was given one week after the pretest and two days after completion of the experimental cases.

Posttest

The posttest, given to all three sections, consisted of the same ten questions that were used in the pretest to measure declarative knowledge. However, the order of the questions on the posttest differed from the order on the pretest. Seven transfer pricing problems were given to the students to measure their new levels of procedural knowledge. The posttest was completed by all three sections without the use of any type of decision aid to ensure that learning, and not tool use, was being measured.

Independent Variables

Two independent variables were manipulated in this study: instruction and expert system use. Instruction was manipulated by presenting two sections with the matrix approach to transfer pricing. This presentation consisted of lectures and problem solving demonstrations using the matrix approach. Expert system use was manipulated by providing two sections with a transfer-pricing expert system. The use and operation of the expert system was demonstrated in class and the subjects observed the instructor solving sample problems using the expert system during class. One section received instruction only (21 subjects), another section received an expert system only (41 subjects). The third section (35 subjects) was provided with both the transfer pricing expert system and a discussion of the matrix approach. Thus, the third section was presented with two approaches to solving transfer-pricing problems. Several copies of the expert system were available to the subjects in the computer lab for their use in solving the experimental cases.

Dependent Variables

Two variables were used to measure the development of the subjects knowledge over the course of the experiment. The development of declarative knowledge was measured as the percentage of correct answers on the multiple-choice posttest. The percentage of correct answers on the posttest transfer pricing problems was used as a measure of procedural knowledge. Pretest scores were used as covariates in the ANCOVA models. Cook and Campbell (1979) note that gain score analysis, the use of the difference between pretest and posttest scores as the dependent variable, is generally less precise than covariance analysis. Gain score analysis does not test for interaction effects between the pretest and treatments.

RESULTS

Subjects

Subject demographics are presented in Table 1. As discussed above, treatment group sizes were unequal. However, the demographic factors appear to be similar across treatment groups. A Tukey HSD test indicated that mean GPAs between groups were not significantly different (alpha = 0.05, critical range = 0.332). Nevertheless, gender and class (sophomore, junior, senior) were used as covariates in the following analyses.

Table 1
Subject Demographics by Treatment Group

	Instruction and Expert System	Instruction	Expert System
n	35	21	41
n by class			
Sophomore	18	11	36
Junior	13	7	5
Senior	4	3	0
n by gender			
Female	15	11	17
Male	20	10	24
Mean GPA (std dev)	2.806 (0.526)	2.903 (0.529)	3.096 (0.556)

Hypothesis 1

The first hypothesis postulated that the experimental treatment would not have a significant effect on the development of students' declarative knowledge. Table 2 shows the differences in pretest and posttest multiple choice scores by subject. The differences between mean pretest and posttest scores for the expert system with instruction and the instruction only treatment groups appear greater than that of the expert system treatment group. Moreover, subjects generally exhibited an increase in perceptual cohesiveness (reduced standard deviation) as a result of treatment application.

The results of the ANCOVA test of hypothesis 1 are presented in Table 3. This test indicates that instruction had a significant (F=3.342, df=1, 87, p=.O71) effect on the development of declarative knowledge as measured by the multiple choice instrument and that pretest scores had a highly significant (F=1.716, df=1, 87, p=.000) effect. Neither expert system nor the other covariates (gender and class) had significant effects on posttest scores. Consequently Hi is rejected.

Table 2
Mean Declarative Knowledge Pretest and Posttest Scores (standard deviation)

Treatment	Pretest	Posttest	Difference
Expert System & Instruction	4.486 (1.869)	7.571 (0.815)	3.085
Instruction	4.571 (1.720)	7.476 (1.365)	2.905
Expert System	5.049 (1.341)	6.927 (1.836)	1.878

Table 3
ANCOVA Analysis of Posttest Multiple Choice Scores

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	p
Pretest	1,916.546	1	1,916.546	377.995	.000
Instruction	16.947	1	16.947	3.342	.071
Expert System	1.716	1	1.716	0.339	.562
Class	21.039	2	10.520	2.075	.132
Gender	0.994	1	0.994	0.196	.659
Error	441.115	87	5.070		
Squared Multiple R:	.914				

Hypothesis 2

The second hypothesis postulated that the treatments would not affect the development of procedural knowledge. The development of procedural knowledge was measured by the percentage of correct responses to a series of transfer-pricing cases. Mean percentages by treatment are presented in Table 4. Subjects who used the expert system showed slightly higher posttest scores and greater differences between pretest and posttest scores than the other treatment groups. Standard deviations for all groups decreased after the treatment indicating an increase in response consensus.

The differences between pretest and posttest scores within all of the groups appears to be significant. Treatment differences were tested in an ANCOVA model. Posttest score was the dependent variable and pretest score,

Table 4
Mean Procedural Knowledge Pretest and Posttest Scores (standard deviation)

Treatment	Pretest	Posttest	Difference
Expert System & Instruction	6.400 (4.001)	22.800 (2.374)	16.400
Instruction	6.810 (3.737)	22.143 (3.395)	15.333
Expert System	6.585 (4.260)	23.659 (1.334)	17.074

treatments, gender and class were treated as independent variables in the analysis. The results of the ANCOVA test are presented in Table 5.

As shown in Table 5, expert system use had a significant effect (F=7.722, df=i, 87, p=0.007) on the development of students' procedural knowledge, as did class and the pretest scores. Instruction did not have a significant effect on posttest scores (F=122.552, df=1, 87, p=0.270). Consequently, H2 is rejected. Subjects who had used the expert system showed both the highest mean posttest score and the greatest gain score. Students who received instruction only showed the lowest mean posttest score and the smallest gain score.

Table 5
ANCOVA Analysis of Posttest Case Scores

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	p
Pretest	11,251.317	1	11,251.317	112.951	.000
Instruction	122.552	1	122.552	1.230	.270
Expert System	769.253	1	769.253	7.722	.007
Class	1,280.476	2	640.238	6.427	.002
Gender	164.185	1	164.185	1.648	.203
Error	8,666.267	87	99.612		
Squared Multiple R:	.826				

CONCLUSION

This experiment was designed to assess the effects of expert system use on student learning. Two components of learning, declarative knowledge and procedural knowledge, were measured. Treatment groups used either an expert system, received instruction, or used an expert system and received instruction.

The results indicate that expert system use facilitated the development of procedural knowledge. Further, the results indicate that expert system use did not facilitate the development of declarative knowledge to the same extent, as did instruction. Thus, although students who learned transfer pricing using an expert system outperformed students who had learned the same subject matter through instruction in a procedural test, the expert system users did not appear to understand why the procedures they followed were effective. It appears that expert system use may have "jump started the skill development process because the expert system users did not appear to develop the same level of declarative knowledge. Instruction appears to facilitate the development of declarative knowledge and to provide answers to “why?’ questions while expert system use, or learning by example, provides answers to ‘how?” questions. These results are consistent, for the most part, with Murphy (i990) who demonstrated that expert system use had an adverse effect on the development of subjects’ semantic memory (declarative knowledge). Consequently, it appears that expert systems may function as viable instructional aids, but that they should not be used as replacements for factual instruction.

Research is needed to determine if these findings are generalizable to a larger class of learning problems. In addition, research is needed to assess the long-term effects of expert system use on the development of both declarative and procedural knowledge. Research should be conducted to assess the effect of expert system explanations on the development of declarative knowledge.

This research suffers from the same limitations as most laboratory experiments but should provide guidance for others considering the use of expert systems as pedagogical aids. The use of three courses taught by the same instructor controlled for instructor effects but limits the generalizability of the findings. An instructor can provide the detailed or declarative knowledge about the target domain while the expert system will provide the students with an “expert and the opportunity to learn by example.

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