The Interaction Of Elaboration-Based Expert Systems And Cognitive Style On Knowledge Development

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Abstract

Expert system research in accounting has focused on knowledge transfer from the expert system to the user. This early research spurred studies on how to appropriately design an intelligent computer-based decision aid so as to positively affect the user's development of knowledge. Researchers focused on the design of the user interface and pulled from research in cognitive psychology on knowledge acquisition. This research builds upon the existing literature by considering a factor that has yet to be examined, the user's individual cognitive styles, which may be interacting with the expert system designs thereby affecting knowledge development.

Prior research has shown that individuals have measurable differences in cognitive style. These differences have been shown to affect the development of knowledge. Cognitive fit between an expert system and the user may influence the user's reliance on the expert system. This, in turn, may affect knowledge development.

This study examines the interaction of the individual's cognitive style with a particular expert system design to determine whether or not the individual will attend to the expert system at a level great enough to facilitate knowledge acquisition and/or development. Knowledge development is a basic requirement in determining the success of an intelligent decision aid as discussed by Rose and Wolfe (1998). This study examines this interaction to ascertain whether a particular cognitive style is more compatible with expert systems.

Introduction

One stream of expert system research in accounting over the last ten years has focused on knowledge transfer from the expert system to the user. This research stems from previous auditing research that had as its objective to find methods that would result in auditors providing better and more consistent decisions. Early expert system research found that these systems were able to provide better and

more consistent decisions, however, in doing so the expert systems challenged the mainstream for developing expert auditors. Traditionally, accountants acquired expertise in a particular area through years of practice and experience. With the development of expert systems and the willingness of accounting firms to use these systems, the newer accountant's ability to acquire expertise was questioned. Thus, research into the effect of expert system use on the knowledge development resulted (Eining, 1988; Oz, 1989; Murphy 1990). These early studies found an affect, however

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some of the findings were in conflict.

This early research spurred new studies investigating how to appropriately design an intelligent computer-based decision aid so that the affect on the user's development of knowledge will be positive. The component of the expert system that was determined to most likely affect the user was the user interface. Researchers began to study how the design of the user interface affected knowledge development (Pei and Reneau, 1990; Odom and Dorr, 1995; Rose and Wolfe, 1998). These studies pulled from research in cognitive psychology on knowledge acquisition. This research builds upon the existing literature by considering a factor that has yet to be examined. This factor may be interacting with the particular expert system designs thereby affecting knowledge development. The factor, which has not been fully addressed in previous studies, is the user's individual cognitive styles.

In the next section, a review of the relevant literature will be presented and the hypotheses will be developed. This will be followed by a description of the research design and the results of the experiment. The final section will include a discussion of the results and suggestions for future research.

Hypotheses Development

The use of expert systems to improve decision-making has increased tremendously during the last decade resulting in research to determine the effect of expert system use on knowledge development. Fedorowicz, et al. (1992), Eining & Dorr (1991) and Murphy (1990) studied the effect of using an expert system on knowledge development. These studies found that expert system use does contribute to knowledge development. This side benefit of knowledge development is an important issue in the decision of whether to use expert systems. Rose and Wolfe (1998) found, during interviews with tax managers in Big 5 accounting firms, that one of the goals of using expert systems was training. However, a concern with using expert systems is the possibility that through extended use a "de-skilling" of the users may result. This phenome-

non occurs when the cognitive processing of the user is minimized in the decision-making process, resulting in a lack of knowledge development. This concern stimulated research into designing the expert systems so as to avoid "de-skilling" (Odom & Dorr, 1995; Steinbart & Accola, 1994; Pei, Steinbart & Reneau, 1994; Gal & Steinbart, 1992; Pei & Reneau, 1990). These studies found that certain designs of expert systems have a significant affect on knowledge development. Thus, an expert system design that stimulates cognitive processing may allow an organization to reap an incidental affect of increasing the knowledge of their employees.

The initial studies in the design area focused on comparing the structure of the decision aid with the knowledge structure of the users. Pei and Reneau (1990) studied the affect of training the users on the structure of the decision aid, thereby allowing for a match between the knowledge structure of the aid and the users. This approach would require organizations to retrain their employees based upon the structure of the expert system. Questions into the feasibility of this approach led researchers to pursue other alternatives. Later studies focused on changing the design of the expert system and not on retraining the user. Specifically, these studies examined the design of the user interface of the expert system and the affect of different designs on knowledge development. Initially these studies looked at the availability or no availability of explanations. Fedorowicz, et al. (1992), Eining and Dorr (1991) and Murphy (1990) found that explanations were not a significant factor in facilitating knowledge development through expert system use. Experimental design issues in these studies prompted more studies into the use of explanations. Odom and Dorr (1995) and Steinbart and Accola (1994) explored the use of more elaborate explanation facilities. They arrived at mixed results as to knowledge development based on the amount and placement of the explanations within the expert system. Specifically, Odom and Dorr (1995) designed six different user interfaces for an expert system that evaluated internal control in a payroll setting. They found a significant interaction between placement and type of elaboration provided in the user interface when measuring development

of declarative knowledge and no significant differences in the development of procedural knowledge. Steinbart and Accola (1994) found no effect for the more elaborate explanations. The results of these later studies may be limited by the lack of consideration of a variable that measured for cognitive fit between the users and the expert systems.

Prior research has shown that individuals have measurable differences in cognitive styles and that such differences will affect the development of knowledge when using computer-assisted instruction (Ott, Mann, and Moores, 1990). Furthermore, Arnold and Sutton (1998) have introduced a theory of technology dominance. They note that their theory of technology dominance focuses on "the factors impacting the use of a well-designed intelligent decision aid and not on the design of such aids (Arnold and Sutton, 1998)," however this author considers the design of the decision aid to be a crucial element in ensuring cognitive fit. The theory postulates that cognitive fit between the expert system and the user will influence the user's reliance on the expert system. They define reliance as "the decision aid becomes a part of the decision-making process and exerts some influence on decision outcomes" and cognitive fit as "congruence in the cognitive decision processes and prompted cognitive reasoning between the aid and the user" (Arnold and Sutton, 1998). Cognitive fit is a basic requirement for the success of an intelligent decision aid because without cognitive fit there cannot be reliance on the expert system by the user. Reliance is necessary for knowledge development to occur and knowledge development is a basic requirement in determining the success of an intelligent decision aid as discussed by Rose and Wolfe (1998). Therefore, cognitive fit facilitates reliance and reliance facilitates knowledge development.

Individuals have measurable differences in cognitive styles and it is possible that such differences will affect the development of knowledge. Cognitive style has been examined in the psychology literature and can be theoretically linked to the individual's knowledge development. Psychologists have developed methods for

grouping individuals based on varying magnitudes of differences. Waner and Echternacht (1993) found a significant difference in the personality types and preferences of individuals who teach office occupations and individuals who are office professionals. The differences centered on the factual versus how-to-do knowledge of the individuals. The teachers of the office skills were more comfortable with the factual knowledge while the actual office professionals were more comfortable with the how-to-do knowledge. The differences may be the result of the differences in cognitive style between the teachers and the professionals. The previously mentioned research by Ott, Mann, and Moores (1990) on student performance while using computer-assisted instruction more specifically addressed the affect of the students personality traits (cognitive style) on exam performance. Their findings suggest that personality trait is a factor in determining the affect of computer-assisted instruction of performance.

The Myers-Briggs Type Indicator (MBTI) is a widely used instrument for typing people to determine their individual cognitive styles. The MBTI measures an individual's preferences on four basic scales, each scale representing two opposite preferences. The four aspects of an individual's personality which are measured by the MBTI are (1) how one is oriented toward the outside world, (2) how one prefers to take in information, (3) how one likes to make decisions, and (4) how quickly one comes to a decision (Myers & McCaulley, 1989). Form G (Briggs & Myers, 1990) was used in this study to index the subjects' personality traits.

Previous research into the cognitive process has found that of the four aspects, the second aspect, how one prefers to take in information, and the third aspect, how one likes to make decisions, are involved in the cognitive process of decision making (Davis, 1982). The second aspect groups individuals as "sensing" or "intuitive" (SN) in the way they take in information. This aspect deals with the perception of individuals and "involves the input, filtration and condensation of cues in the environment" (Davis, 1982). Sensing (S) types tend to accept and work

with what is "given" in the here-and-now, and thus are realistic and practical. They are good at remembering and working with a great number of facts. Intuitive (N) types find information that is beyond their senses and look at the big picture to grasp the essential patterns. They grow expert at seeing new possibilities and new ways of doing things and value imagination and inspiration.

The third aspect, how one likes to make decisions, groups people as "thinking" or "feeling", (TF). This aspect deals with the evaluation of what was perceived to arrive at a decision. Thinking (T) types predict the logical consequences of any particular choice or action. People with a preference for thinking seek an objective standard of truth and are frequently good at analyzing what is wrong with something. Feeling (F) types consider what is important to them or to others and decide on the basis of person-centered values, regardless of logic. Those with a preference for "feeling" enjoy dealing with people. They tend to become sympathetic, appreciative, and tactful.

Based on these two mutually exclusive aspects for typing individuals using the Myers-Briggs Type Indicator the cognitive type of the subjects can be determined to be one of four possible types:

- ST Sensing-Thinking,
- SF Sensing-Feeling,
- NT Intuitive-Thinking, and
- NF Intuitive-Feeling.

The first hypothesis to be tested in this study looks at the affect of cognitive style on knowledge development.

H1: The cognitive style of the user's of the expert systems will have a significant effect on knowledge development.

In addition to the affect of the individual's cognitive style alone, the interaction of the individual's cognitive style with the expert system may further facilitate whether or not the individual will attend to the expert system at a greater

level thereby resulting in knowledge acquisition and/or development. This affect will be tested with hypothesis 2:

H2: The cognitive styles of user's of the expert systems interaction with the expert systems will have a significant effect on knowledge development.

Based on the previous discussion of the four cognitive types, not only should the interaction occur, but also certain cognitive styles should prefer the expert system. This is the basis of hypothesis 3:

H3: The sensing-thinking (ST) cognitive style will vary significantly from the other cognitive styles in the effect on knowledge development.

Of the four cognitive styles, the sensing-thinking (ST) style is predicted to vary significantly due to the nature of expert systems and the preferences of the ST style. The ST individual perceives things from the factual perspective. They tend to accept and work with what is given. The ST individual then evaluates the facts through an impersonal logic process. This combination of perception and evaluation is most in line with the use of any expert system. Individuals that perceive things intuitively (N) prefer seeing the big picture very much unlike the structure process followed by an expert system. Accordingly, individuals that evaluate with their feelings (F) prefer a more subjective process than that provided by expert systems.

Research Design

The hypotheses were tested in a laboratory study with 126 accounting students enrolled in five sections of an accounting information systems course at a major midwestern university. Subjects were required to evaluate internal control for payroll procedures and had received four days of class lectures on internal control prior to the experiment but no specific coverage of internal control in payroll systems.

The internal control evaluation is representative of assignments performed by entry-level

auditors and is a task that allows for measurement of declarative knowledge. Upper level accounting students were used because they represent the primary source of novice auditors hired by public accounting firms. Subjects were randomly assigned to one of six different expert systems. The homogeneity of the experimental groups was evaluated using data collected on each subject's age, gender, educational classification, and performance on pretest instruments. Differences in mean values in age and pretest measures for declarative knowledge were tested using an ANOVA F-test. Differences in frequencies of the gender and class data were evaluated using a contingency table based on chi-square analysis for the groups.

The experiment was administered in five sessions over a five-week period. During the first session, subjects completed a demographic questionnaire and Myers-Briggs Form G. Sessions two through four were held over a three-week period. Each subject attended one one-hour session per week in the computer lab during which five cases were evaluated with the aid of the ES assigned to that subject. The internal control cases consisted of a narrative description of a specific situation similar to the type of scenarios used by Eining (1988). The ES's evaluation of the strength of the control structure, on a Very Weak to Very Strong scale, was provided to the subjects at the end of each case. The students were monitored during all sessions and no instances of hurried behavior were observed.

Session five was completed one week after the last computer lab in a regular classroom without the aid of the ESs. The subjects, over a one-hour period, completed a 10-question multiple-choice posttest to measure declarative knowledge. To minimize the risk of outside study between sessions, subjects were not told that they would be given the posttest measure. Motivation to attend to the material was provided by guaranteeing the students 50 bonus points toward their final class grade if they diligently evaluated the internal control cases over the three-week training period. In addition, subjects were told that several

monitors would walk the room to evaluate their efforts and that anyone not working seriously would be disqualified from receiving the bonus points.

The posttest multiple-choice examination, which measured declarative knowledge, examined the subjects on the factual and theoretical information relating to internal control. Accuracy (number of correct answers) was used to measure the development of declarative knowledge.

Results

The first hypothesis (H1) predicts that the cognitive style of the user's of the expert systems will have a significant effect on knowledge development. The knowledge development was measured through the posttest multiple-choice examination given to the subjects. The cognitive styles of the subjects were determined using the Myers-Briggs Type Indicator Form G. The ANOVA result shown in Table 1 analyzing the dependent variable—knowledge development—by cognitive type shows a significant effect ($F=11.457$, $p<0.000$). Thus, cognitive style does have a significant effect on knowledge development. Based on this result, hypothesis one is accepted.

TABLE 1
ANOVA for Declarative Knowledge

Source	SS	df	MS	F	p-value
Cognitive Style	809.868	3	269.956	11.457	0.000
Error	2898.132	123	23.562		
Total	3708	126		$R = .467$	$R^2 = .218$

The second hypothesis (H2) predicts that the cognitive styles of user's of the expert systems interaction with the expert systems will have a significant effect on knowledge development. This was tested using ANOVA with declarative knowledge as the dependent variable and the individual's cognitive styles, the expert systems and the interaction of those as independent variables. The ANOVA result shown in Table 2 shows a significant effect for all variables. The expert systems are significant at ($F = 2.642$, $p<.027$), the cognitive styles are significant at ($F=14.953$,

$p < .000$), and the interaction of the expert systems with the cognitive styles is significant at ($F = 2.047$, $p < .019$). Finding a significant interaction effect supports acceptance of hypothesis two.

(1995) by considering the possible effect of cognitive style and the interaction of cognitive style with the particular expert system designs. Their study found that the design of the expert system affected knowledge development of the individuals that used an expert system. Through examining the affect of the individual's cognitive style it may be possible to determine if particular cognitive styles prefer expert systems as decision aids.

TABLE 2 ANOVA for Declarative Knowledge					
Source	SS	df	MS	F	p-value
Expert System (ES)	280.454	5	56.091	2.642	0.027
Cognitive Style (CS)	952.299	3	317.433	14.953	0.000
ES x CS	651.824	15	43.455	2.047	0.019
Error	2186.497	103	21.228		
Total	4071.074	126		$R = .641$	$R^2 = .410$

The finding of a significant interaction effect also provided a need to examine the main effects in more detail. Further study of the expert system (ES) main effect resulted in finding of no significant differences between the individual expert systems. However, further analysis of the cognitive style (CS) main effect found that the sensing-thinking (ST) cognitive type was significantly different from each of the other three cognitive types.

The third hypothesis (H3) predicts that the sensing-thinking (ST) cognitive style will vary significantly from the other cognitive styles in the effect on knowledge development. Table 3 presents the Bonferroni pairwise comparison for the cognitive style variable.

TABLE 3 Bonferroni pairwise comparison for Cognitive Style				
	ST	SF	NT	NF
ST	1.000			
SF	0.064	1.000		
NT	0.000	0.085	1.000	
NF	0.003	1.000	0.971	1.000

Based on the pairwise comparison, the sensing-thinking (ST) cognitive style is significantly different from each of the intuitive (N) cognitive styles and marginally significantly different from the other sensing (SF) cognitive style.

Summary and Discussion

This study extends Odom and Dorr

The first hypothesis considered whether an individual's cognitive style significantly affected knowledge development during expert system use. The subjects were typed using the Myers-Briggs Type Indicator Form G into one of four cognitive styles. The testing of this hypothesis found that the cognitive style of the subjects significantly affected knowledge development. This is an important finding in that it may help explain some of the previously conflicting results concerning knowledge development during expert system use. Additionally, future research should consider the individual's cognitive style as a variable that affects the learning ability of an individual.

Expanding on the initial findings, an expanded model looked for an interaction effect on knowledge development between an individual's cognitive style and using an expert system. This effect was found along with an individual effect for both expert system and cognitive style. Finding the interaction means that further analysis is necessary for interpretation. Based on that further analysis, one of three interpretations is plausible: (1) there is a significant interaction effect, (2) there is a significant main effect, or (3) there are both effects.

The analysis conducted for the third hypothesis helped to further understand the previous results. A comparison of the four cognitive styles resulted in finding that the sensing-thinking (ST) individuals were significantly different from the other three cognitive styles. This finding was predicted in hypothesis three due to the character-

istics of this cognitive style. Based on this result, the significant findings in hypothesis two primarily result from the significant effect of the sensing-thinking (ST) cognitive style.

The results of this study will provide a better understanding of the interaction of the individual cognitive styles with the use of expert systems as decision aids. The findings suggest that a particular cognitive style, sensing-thinking (ST), performs better while using an expert system than do the other cognitive styles. Performance was measured as knowledge development in this study. This should provide organizations with more information as they continue using expert systems as decision aids.

References

1. Arnold, V. and S. G. Sutton, (1998). The Theory of Technology Dominance: Understanding the Impact of Intelligent Decision Aids on Decision Makers' Judgments. *Advances in Accounting Behavioral Research*, pp. 175-194.
2. Briggs, K., and I. Myers, (1990). *Myers-Briggs Type Indicator Form G Booklet*. Palo Alto, CA: Consulting Psychologists Press.
3. Davis, D. (1982). Are Some Cognitive Types Better Decision Makers Than Others? An Empirical Investigation. *Human Systems Management*, pp. 165-172.
4. Eining, M., (1988), *Expert Systems and Auditor Decision Making: An Empirical Test*, Unpublished Ph. D. dissertation, Oklahoma State University.
5. Eining, M. and P. Dorr, (1991), The Impact of Expert System Usage on Experiential Learning in an Auditing Setting, *Journal of Information Systems*, pp. 1-16.
6. Fedorowicz, J., E. Oz and P. D. Berger, (1992), A Learning Curve Analysis of Expert System Use, *Decision Sciences*, pp. 797-818.
7. Gal, G. and P. J. Steinbart, (1992), Interface Style and Training Task Difficulty as Determinants of Effective Computer-Assisted Knowledge Transfer, *Decision Sciences*, pp. 128-143.
8. Murphy, D. S., (1990), Expert System Use and the Development of Expertise in Auditing: A Preliminary Investigation, *Journal of Information Systems*, pp. 18-35.
9. Myers, I. B., (1987), *Introduction to Type: A Description of the Theory and Applications of the Myers-Briggs Type Indicator*. Palo Alto, CA: Consulting Psychologists Press.
10. Myers, I. B., and M. H. McCaulley, (1989), *Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator*. Palo Alto, CA: Consulting Psychologists Press.
11. Odom, M. D. and P. Dorr, (1995), The Impact of Elaboration-Based Expert System Interfaces on De-Skilling: An Epistemological Issue, *Journal of Information Systems*, pp. 1-18.
12. Ott, R. L., M. H. Mann, and C. T. Moores, (1990), An Empirical Investigation into the Interactive Effects of Student Personality Traits and Method of Instruction (Lecture or CAI) on Student Performance in Elementary Accounting. *Journal of Accounting Education*, pp. 17-35.
13. Oz, E., (1989), *A Study of Improvement in Decision-Making Skills Through the Use of Expert Systems*, Unpublished Ph. D. dissertation, Boston University.
14. Pei, B. K. W. and J. H. Reneau, (1990), The Effects of Memory Structure in Using Rule-Based Expert Systems for Training: A Framework and An Empirical Test, *Decision Sciences*, pp. 263-286.
15. Pei, B. K. W., P. J. Steinbart and J. H. Reneau, (1994), The Effects of Judgment Strategy and Prompting on Using Rule-Based Expert Systems for Knowledge Transfer, *Journal of Information Systems*, pp. 21-42.
16. Rose, J. M. and C. Wolfe, (1998), Schema Acquisition and the Effects of Cognitive Load Imposed by Decision Aid Design Alternatives: A Tax Setting, Proceedings of the AIS Research Symposium.
17. Steinbart, P. J. and W. L. Accola, (1994), The Effects of Explanation Type and User Involvement on learning From and Satisfaction with Expert Systems, *Journal of In-*

- formation Systems, pp. 1-17.
18. Waner, K., and L. Echternacht, (1993). Using the Myers-Briggs Type Indicator to Compare Personality Types of Business Teachers Who Teach Office Occupations With Personality Types of Office Professionals. *The Delta Pi Epsilon Journal*, pp. 53-68.

Notes