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ABSTRACT

The purpose of this study was to determine the effects of two modes of computer-assisted instruction, simulation and tutorial, upon the ability of preservice elementary teachers to understand relationships between a number of concepts dealing with home energy. A number of instruments measuring various dimensions of learning style differences were administered to ascertain which learning style constructs interacted with mode of instruction to predict conceptual understanding and scores on an achievement test. Results of this study indicated that achievement scores were higher for users of the tutorial; however, the number of valid concept relationships did not differ by treatment. In addition, the difference in achievement scores favoring the tutorial specifically was found in subjects exhibiting an external locus of control, field independence, and/or high discrimination skill. Other individuals showed no difference in achievement by treatment. Additionally, subjects whose holist/serialist orientation was matched to the appropriate mode of instruction scored significantly higher on the achievement test than those who were mismatched. (Author)

# EFFECTS OF MODES OF COMPUTER-ASSISTED INSTRUCTION ON CONCEPTUAL UNDERSTANDING AND ACHIEVEMENT OF COLLEGE STUDENTS EXHIBITING INDIVIDUAL DIFFERENCES IN LEARNING: A PILOT STUDY

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## Abstract

The purpose of this study was to determine the effects of two modes of computer-assisted instruction, simulation and tutorial, upon the ability of preservice elementary teachers to understand relationships between a number of concepts dealing with home energy. A number of instruments measuring various dimensions of learning style differences were administered to ascertain which learning style constructs interacted with mode of instruction to predict conceptual understanding and scores on an achievement test.

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## Purpose of Study

The purpose of this study was to determine the effects of two modes of computer-assisted instruction, simulation d tutorial, on preservice elementary teachers' standing of relationships among a number of concepts dealing with home energy. A number of cognitive style instruments were administered to ascertain which learning style constructs interacted with mode of instruction to influence scores on a concept web and on an achievement test. The effect of matching subjects with particular learning styles to a specific mode of instruction was examined.

## Theoretical Basis for Study

The value of simulation as an instructional mode has been verified in a number of instances. Results of a meta-analysis by Kulik et al. (1983) indicated that simulations have the greatest effect on achievement of any mode of computer-assisted instruction. Zietsman and Hewson (1986) showed that simulations produced significant conceptual change in students holding misconceptions in science.

More pertinent to the present research, Heinze-Fry, Crovello and Novak (1984) suggested that exploring the simulation mode might lead to additional and altered linkages on students' cognitive frameworks. Novak et al. (1983) noted that the differences between experts' and novices' conceptual understanding were greatest in linkages between concepts as indicated by their performance on drawn concept maps.

Hammond (cited in Baird, 1986) suggested that studies involving computer instruction and cognitive style differences of learners may lead to information regarding optimum learning with computer-mediated instruction. Pask and Scott (1972) showed that students used different learning strategies when working on the computer. Baird and Koballa (1986) found an interaction between formal reasoning and mode of computer-assisted instruction.

Several dissertations have examined the influence on learning style on computer-assisted learning. Dahl (1985) studied the influence of field dependence/field independence on learning outcomes of drill-and-practice and simulation computer-assisted instruction. He found no main effects nor did he find a field dependency by mode interaction. Mullen's (1984) study of field orientation and learning on a drill-tutorial program also showed no relationship to performance. On the other hand, Post (1985) found that field independent students learned more than field dependent from the computer simulation/game, Rocky's Boots. Likewise, Willard (1985) found that field independence served as a reliable predictor of success in learning word processing.

The construct, locus of control, was examined by Hamilton (1985), who compared traditional lecture to computer-based instruction. He found neither main effect nor interactions. However, Wesley (1984) did find an interaction between locus of control and mode of instruction (textual programmed instruction vs. tutorial computer-assisted instruction). She found that individuals with an external locus of control did better when using computer-assisted instruction than when using the programmed text. No difference was found within the internals. Studies of the effect of learning style on computer programming performance by Cramer (1985) and Thronson (1985) did not show a significant relationship.

# Procedures of Study

## Determination of Learning Style Differences

Fifty-one elementary education majors were administerd a battery of learning style inventories (see Table I). A description of the various learning style constructs follows.

Field dependence/field independence was originally defined by Witkin as the degree of dependence on the structure of the prevailing visual field. In his later work, Witkin broadened the definition to describe a global-articulated dimension on which individuals differ in their tendency to structure their perceptual field (Goldstein and Blackman, 1978).

The holist/serialist construct was first described as a learning strategy by Pask and Scott (1972). Holists use a global approach to learning, first building broad descriptions and then fitting in details. Serialists use a local approach, concentrating on narrow procedures before an overall picture emerges (Ford, 1985). One of the difficulties in using this construct is that the tasks used by Pask to determine the individual's preferred strategy require long and complicated procedures. Ford (1985) has developed an instrument that predicts holist and serialist competence relatively quickly and easily. Subjects are classified holist or serialist based on the majority of their responses on the Study Preference Questionnaire.

Ambiguity tolerance is the tendency to perceive ambiguous material or situations as threatening (MacDonald, 1970).

Locus of control was described by Rotter (1966) as the extent to which people believe they exercise control over their lives (internally controlled) or the degree to which they believe their destinies are determined by fate, chance, or powerful others (externally controlled).

Category width was defined by Pettigrew (1958) as a subject's "typical equivalence range for classifying objects." Alternatively, he also viewed category width as tapping a measure of "risk taking" with broad categorizers risking Type I errors and narrow categorizers willing to make Type II errors.

Keefe and Monk (1986) described the cognitive skill subscales on their Learning Styles Profile as follows:

Analytic skill - to identify simple figures hidden in a complex field; to use the critical element of a problem in a different way.

Spatial skill - to identify geometric shapes and rotate objects in the imagination; to recognize and construct objects in mental space.

Discrimination skill - to visualize the important elements of a task; to focus attention on required detail and avoid distractions.

Categorizing skill - to use reasonable vs. vague criteria for classifying information; to form accurate, complete, and organized categories of information.

Sequential processing skill - to process information sequentially and verbally; to readily derive meaning from information presented sequentially or verbally.

Memory skill - to retain distinct vs. vague images in repeated tasks; to detect and remember subtle changes in information.

TABLE I

Cognitive Style Constructs, Instruments, and Variable Names

| Construct | Instrument | Variable Name |
|---|---|---|
| Field Dependence/ Independence | Group Embedded Figures Test (Witkin, et. al., 1972) | GEFT |
| Holist/Serialist | Study Preference Questionnaire (Ford, 1985) | SPQ |
| Ambiguity Tolerance | MacDonald's AT-20 (MacDonald, 1970) | MAT |
| Locus of Control | Rotter's Internal/External Scale (Rotter, 1966) | RLOC |
| Category Width | Pettigrew's C-W Scale (Pettigrew, 1958) | PCW |
| Analytic Skill | Learning Styles Profile (Keefe and Monk, 1986) | ANL |
| Spatial Skill | Learning Styles Profile (Keefe and Monk, 1986) | SPAT |
| Discrimination Skill | Learning Styles Profile (Keefe and Monk, 1986) | DISC |
| Categorizing Skill | Learning Styles Profile (Keefe and Monk, 1986) | CAT |
| Sequential Skill | Learning Styles Profile (Keefe and Monk, 1986) | SEQ |
| Memory Skill | Learning Styles Profile (Keefe and Monk, 1986) | MEM |

## Assignment to Mode of Instruction

Each subject was randomly assigned to one of two modes of computer assisted instruction. Subjects were instructed to spend as much time as they preferred in learning about home energy and were told that they would be given a test covering the information in the instructional package when they completed the computer-assisted instruction. One group used a computer simulation of home energy use and the other a tutorial on the same topic. The simulation was developed by the authors and allowed the user to manipulate nine variables. The tutorial was constructed by the authors using the guidelines developed by Gagne, et. al. (1981). Each student received a diskette which contained the assigned instructional sequence.

## Dependent Variables

Conceptual relationships were measured by subjects' responses on a concept web. Subjects were given a set of 13 concepts arranged in a circle. They were instructed to draw lines between concepts that they believed were related and then specify the nature of the relationship between the concepts. Since all subjects had experience in constructing concept maps and had read Novak and Gowin's (1984) explanation of how to construct concept maps, this variant was not unfamiliar to them. The advantage of using concept webs over concept maps is that the mapping process requires subjects to select a hierarcial pattern, whereas the concept web allows subjects to examine all possible combinations of concepts. Subjects' scores were the number of accurate relationships identified, as indicated by use of an appropriate connecting word.

Achievement was measured by a set of 30 multiple choice questions developed by the authors. One half of the questions were designed to test lower-level understanding (i.e., Bloom's (1956) Taxonomy levels I-II: Knowledge, Comprehension) and one half tested upper-level understanding (i.e., Bloom's Taxonomy levels III-VI: Application, Analysis, Synthesis, Evaluation). Classification of the questions was done by two experts. The results of the tests were analyzed for item validity (Borg and Gall, 1979) and those items with an item validity of less than 0.4 were eliminated. The remaining items were then used as measures of achievement and became the Home Energy Achievement Test. The test consisted of 7 lower-level questions and 8 upper-level questions. Inter-rater reliability on classifying the 15 questions was 100%. The K-R 20 reliability estimate for the test was .74.

## Results

The means, standard deviations, and ranges of each of the instruments used in the study are shown in Table II.

Table III reports the correlation R values among the various cognitive style instruments. Of note are the correlations between instruments measuring the same construct: GEFT and ANL (r=.32) and PCW and CAT (r=.44). Also of interest are the correlations between SPQ and other instruments. The correlation between SPQ and MAT (r=.39) suggests a relationship between high ambiguity tolerance and holist strategy. Likewise, broad category width correlates significantly with holist strategy (r=.33). On the other hand, high discrimination skills are negatively correlated with holist strategy (r=-.45). That is, high discrimination skills are correlated with serialist strategy.

The relationship of the dependent variables to the various independent cognitive style variables was determined using simple regression techniques. The SAS General Linear Methods procedure allows one to regress the interaction of terms, in this case, the interaction of cognitive style with mode of computer-assisted instruction.

Table IV shows the results of the simple regressions on concept web score. Only discrimination skill serves as a predictor of concept web score, with high discriminators making more valid connections between concepts.

Table V shows that two learning styles directly influence achievement test performance, spatial skill and analytic skill, and that several interactions have a significant influence on the achievement score.

Before examining the interactions, it is important to first look at the main treatment effects on the two dependent measures. As seen in Table VI, the mode of computer-assisted instruction had no effect on the number of valid concept connections; but on the more traditional achievement test, users of the tutorial scored significantly higher than users of the simulation.

Of particular interest to us was the question, of whether it improves a learner's performance to match learning strategy with a particular mode of instruction. Specifically, is achievement increased by matching holists to simulations and serialists to tutorials, over mismatches of holists using tutorals and serialists using simulations? Table VII shows the results of the *t*-tests comparing the matched with the mismatched. The results indicate a possible favoring of matched over mismatched on the concept web ($p$=.097) and a clear favoring of the matched condition over the mismatched condition on the achievement test ($p$=.015).

In addition, we also asked the question, of whether learners with a particular learning style are likely to do better with tutorials or simulations. Using the concept web as the measure of "doing better," we found no significant difference between the two modes of computer-assisted instruction for any of the learning styles. However, as shown in Table VIII, we found that achievement was significantly ($p<.05$) greater for tutorial users than simulation users for the following style variables: field independent, external locus of control, high discrimination skill, high analytic skill, and low memory skills.

TABLE II

Means, Standard Deviations, and Ranges (N=45)

| Instrument | Mean | S.D. | Range |
|---|---|---|---|
| Group Embedded Figures Test (GEFT) | 12.2 | 4.08 | 2-18 |
| Study Preference Questionnaire (SPQ) | 12.6 | 3.74 | 5-19 |
| MacDonald's Ambiguity Tolerance (MAT) | 9.6 | 3.87 | 3-17 |
| Rotter's Locus of Control (RLOC) | 9.5 | 4.34 | 2-20 |
| Pettigrew's Category Width (PCW) | 58.6 | 22.99 | 15-111 |
| Learning Styles Profile | | | |
| Analytic Skill (ANL) | 4.0 | 1.21 | 1-5 |
| Spatial Skill (SPAT) | 4.0 | 1.07 | 1-5 |
| Discrimination Skill (DISC) | 2.6 | 1.50 | 0-5 |
| Categorizing Skill (CAT) | 9.6 | 4.64 | 0-21 |
| Sequential Processing Skill (SEQ) | 5.8 | 0.53 | 4-6 |
| Memory Skill (MEM) | 7.3 | 2.32 | 3-12 |
| Concept Web (CONWEB) | 14.8 | 7.37 | 5-40 |
| Home Energy Achievement Test (HEAT) | 9.3 | 2.93 | 3-15 |

TABLE III

Pearson Correlation Coefficients Among Cognitive Style Instruments

| Inst. | GEFT | SPQ | MAT | RLOC | PCW | ANL | SPAT | DISC | CAT | SEQ | MEM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GEFT | 1.0 | | | | | | | | | | |
| SPQ | -.13 | 1.0 | | | | | | | | | |
| MAT | .10 | .39** | 1.0 | | | | | | | | |
| RLOC | .05 | .09 | .07 | 1.0 | | | | | | | |
| PCW | .07 | .33* | .11 | .08 | 1.0 | | | | | | |
| ANL | .32* | .00 | .12 | .04 | -.03 | 1.0 | | | | | |
| SPAT | .20 | -.18 | -.08 | -.05 | -.04 | .26 | 1.0 | | | | |
| DISC | .12 | -.45** | -.06 | .00 | -.19 | -.02 | .02 | 1.0 | | | |
| CAT | -.09 | .24 | .00 | -.05 | .44** | .20 | .07 | -.19 | 1.0 | | |
| SEQ | .39** | -.10 | -.18 | .36* | .22 | .24 | .02 | -.01 | -.09 | 1.0 | |
| MEM | .18 | -.05 | .02 | .04 | .20 | .50*** | .04 | .00 | .12 | .30* | 1.0 |

* $p < .05$
** $p < .01$
*** $p < .001$

TABLE IV

Regression of Cognitive Style Variables and Interaction of Cognitive Style Variables with Mode of CAI on Concept Web

| Variable | R-square | p |
|---|---|---|
| DISC | .10 | .04 |
| DISC*MODE | .10 | .10 |
| SEQ*MODE | .03 | .57 |
| SEQ | .02 | .34 |
| MAT*MODE | .02 | .63 |
| CAT*MODE | .02 | .66 |
| ANL*MODE | .02 | .69 |
| MAT | .02 | .39 |
| ANL | .02 | .42 |
| SPQ*MODE | .01 | .74 |
| SPAT*MODE | .01 | .79 |
| SPAT | .01 | .57 |
| GEFT*MODE | .01 | .85 |
| GEFT | .01 | .58 |
| PCW*MODE | .01 | .86 |
| MEM*MODE | .01 | .87 |
| RLOC*MODE | .01 | .90 |
| CAT | .00 | .73 |
| RLOC | .00 | .75 |
| MEM | .00 | .78 |
| PCW | .00 | .80 |
| SPQ | .00 | .97 |

TABLE V

Regression of Cognitive Style Variables and Interaction of Cognitive Style Variables with Mode of CAI on Home Energy Achievement Test

| Variable | R-square | p |
|---|---|---|
| SPAT*MODE | .26 | .002 |
| ANL*MODE | .20 | .010 |
| SPAT | .19 | .003 |
| RLOC*MODE | .17 | .018 |
| DISC*MODE | .14 | .039 |
| GEFT*MODE | .14 | .040 |
| MEM*MODE | .14 | .038 |
| SEQ*MODE | .12 | .063 |
| ANL | .10 | .036 |
| MAT*MODE | .10 | .101 |
| CAT*MODE | .09 | .129 |
| RLOC | .08 | .059 |
| PCW*MODE | .08 | .178 |
| SPQ*MODE | .07 | .214 |
| MEM | .05 | .122 |
| GEFT | .03 | .285 |
| PCW | .01 | .490 |
| CAT | .01 | .592 |
| SEQ | .00 | .655 |
| DISC | .00 | .787 |
| SPQ | .00 | .843 |
| MAT | .00 | .972 |

TABLE VI

Effect of Mode of CAI
on Concept Web and Home Energy Achievement Test

| Mode of CAI | N | Mean | SD | t | p |
|---|---|---|---|---|---|
| Dependent Variable = CONWEB | | | | | |
| Tutorial | 22 | 14.1 | 5.45 | -.12 | .907 |
| Simulation | 22 | 14.4 | 7.29 | | |
| Dependent Variable = HEAT | | | | | |
| Tutorial | 22 | 10.4 | 2.68 | 2.55 | .014 |
| Simulation | 23 | 8.3 | 2.83 | | |

TABLE VII

Effect of Matching
Holists With Simulation and Serialists With Tutorial
on Concept Web and Home Energy Achievement Test

| Condition | N | Mean | SD | t | p |
|---|---|---|---|---|---|
| Dependent Variable = CONWEB | | | | | |
| Matched | 18 | 16.2 | 7.43 | -1.70 | .097 |
| Mismatched | 26 | 12.9 | 5.26 | | |
| Dependent Variable = HEAT | | | | | |
| Matched | 18 | 10.5 | 2.54 | -2.53 | .015 |
| Mismatched | 27 | 8.5 | 2.90 | | |

TABLE VIII

Effect of Mode of CAI
Among Learners With Specific Cognitive Styles
on Home Energy Achievement Test

| COGNITIVE STYLE<br>Mode of CAI | N | Mean | SD | t | p |
|---|---|---|---|---|---|
| FIELD DEPENDENT (GEFT<13) | | | | | |
| Tutorial | 10 | 9.7 | 2.50 | 1.31 | .21 |
| Simulation | 11 | 8.1 | 3.11 | | |
| FIELD INDEPENDENT (GEFT>12) | | | | | |
| Tutorial | 12 | 11.0 | 2.80 | 2.24 | .04 |
| Simulation | 12 | 8.5 | 2.67 | | |
| INTERNAL LOCUS OF CONTROL (RLOC<9) | | | | | |
| Tutorial | 10 | 11.2 | 1.87 | 1.80 | .09 |
| Simulation | 11 | 9.5 | 2.30 | | |
| EXTERNAL LOCUS OF CONTROL (RLOC>8) | | | | | |
| Tutorial | 12 | 9.8 | 3.13 | 2.11 | .05 |
| Simulation | 12 | 7.1 | 2.85 | | |
| LOW DISCRIMINATION SKILL (DISC>2) | | | | | |
| Tutorial | 11 | 9.9 | 3.17 | 1.00 | .33 |
| Simulation | 10 | 8.6 | 2.84 | | |
| HIGH DISCRIMINATION SKILL (DISC<3) | | | | | |
| Tutorial | 11 | 10.9 | 2.12 | 2.74 | .01 |
| Simulation | 13 | 8.1 | 2.92 | | |
| LOW ANALYTIC SKILL (ANL<4) | | | | | |
| Tutorial | 7 | 9.7 | 3.09 | 1.47 | .17 |
| Simulation | 6 | 7.3 | 2.66 | | |
| HIGH ANALYTIC SKILL (ANL>3) | | | | | |
| Tutorial | 15 | 10.7 | 2.52 | 2.18 | .04 |
| Simulation | 17 | 8.6 | 2.89 | | |
| LOW MEMORY SKILL (MEM<8) | | | | | |
| Tutorial | 12 | 10.1 | 2.97 | 2.45 | .02 |
| Simulation | 13 | 7.4 | 2.53 | | |
| HIGH MEMORY SKILL (MEM>7) | | | | | |
| Tutorial | 10 | 10.8 | 2.39 | 1.10 | .29 |
| Simulation | 10 | 9.5 | 2.88 | | |

## Conclusions and Implications

The results of this study show that learning style does interact with mode of computer assisted instruction to influence student achievement in the area of energy use and conservation. Although the data suggests that learners with many learning styles do equally well in achievement on tutorials and simulations, it is clear that some learners are more effective when using tutorials than when using simulations. Of course, knowing this is only useful if it is relatively simple to identify who can and who cannot benefit most from a particular mode.

The Study Preference Questionnaire can be administered to a group of students and scored by them in less than fifteen minutes. Having diagnosed the students' preference for holist or serialist strategies, the teacher is in a position to match serialists to tutorial computer-assisted instruction and holists to simulation instruction. Our study indicates that this matching will not only improve achievement but will probably enhance the learners' development of concept relationships.

In an ideal setting, the learner who could use both holist and serialist strategies would be proficient at learning from both modes of instruction. Future research should examine what techniques would be effective in helping serialists become better users of simulations and holists better users of tutorials. Research reported by Das et. al.

(1979) indicates that intervention activities can produce change in the similar construct of simultaneous/successive processing.

Until those strategies are developed, we need to identify those learners who will not benefit from using simulations. Our study indicates that individuals who are serialist, field independent, external in locus of control, high in discrimination skill, and/or low in memory skill will have difficulty learning from simulations. A likely source of the difficulty may lie in these individuals' inabilities to absorb information from a simultaneously changing field of information, so characteristic of simulations. For these learners, use of a simulation should be preceded by more structured learning activities; or the actual use of the simulation should be more structured.

In addition, the use of the concept web to measure concept relationships needs to be explored with more research and application studies. It appears from this study that the instrument measures something quite different from the traditional achievement tests, finding which corroborate Novak and Gowin's (1984) conclusions that concept maps assess a different learning dimension. Our data suggests that the kinds of learning styles that influence achievement learning do not influence performance on concept web construction. This lack of discrimination may interpreted positively: concept webs provide a means for overcoming the bias multiple-choice achievement tests have for particular learners. Alternatively, we might view the concept web as a "noisy" and unreliable instrument for research and assessment procedures. More research and practice are needed to answer this question.

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