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ABSTRACT

The effects of different types of feedback in computer assisted instruction (CAI) on relational concept learning by young children were compared in this study. Subjects were 89 kindergarten students whose primary language was English, and whose performance on the Boehm Test of Basic Concepts was within the average range chosen from classes in a predominantly low income New York City school district. Nine relational concepts were selected for CAI over a six-week period, and three conditions of computer-generated feeeback--textual, symbolic, and pictorial--were presented to the experimental groups. A control group participated in a color matching game on the computer. Motivational effects were measured by time and trials-to-criterion on the computer, and the Boehm Test of Basic Concepts was used to measure the immediate and delayed effects of CAI on the children's level of knowledge of basic relational concepts. Results indicated that, although children's performance across experimental groups was significantly better than the performance of the control group, there were no significant differences in performance among the feedback groups. These results suggest that learning within a microcomputer environment may be intrinsically stimulating for very young children. Three tables and 28 references are included. (Author/MES)

The Motivational Effects of Types of Computer Feedback on Children's Learning and Retention of Relational Concepts

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Running Head: Motivational Effects of Computer Feedback
on Relational Concept Learning & Retention

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ABSTRACT

This study compared the effects of three types of feedback in Computer-Assisted Instruction of basic relational concepts at the kindergarten level. Three conditions of feedback were presented and were characterized asTextual KR;Symbolic KR; and Pictorial KR. A control group participated in a color-matching game on the computer. Nine relational concepts were selected for CAI over a six-week period. Motivational effects were measured by time and trials-to-criterion on the computer and The Boehm Test of Basic Concepts was used to measure the immediate and delayed effects of CAI of basic relational concepts. The results indicated that although children's performance across experimental groups was significantly better than the control group, no significant differences were found among feedback groups. The absence of significant differences in computer-generated feedback suggested that learning within a mocrocomputer environment may be intrinsically motivating for very young children. Consequently, the the possible effects of external feedback stimuli regardless of type may be masked by the overpowering allure of this child-machine interactivity.

Over the last two decades, numerous studies have documented the effectiveness of computer-assisted instruction (CAI) for under-achieving children especially at the elementary school level. For example, in a review of the literature,

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Vinsonhaler and Bass (1972) reported that elementary school children who received computer-assisted drill and practice when supplemented to regular instruction showed improved performance gains of 1 to 8 months over children who received only conventional instruction. Similar conclusions were reached by (Jamison, Suppes & Wells, 1974; and Ragosta, 1982). Hartley's (1976) meta-analysis of findings from computer-based instruction reported that computer-based teaching raised examination scores in mathematics by approximately .4 standard deviations at the elementary level. The computer as a medium of instruction seems particularly advantageous in remedial math and reading classes which require a logical and systematic sequencing of instructional materials in small amounts and the provision of immediate and frequent feedback to student responses.

Despite the consensus that CAI is an effective method of instruction, there has been relatively little attention given to those generic attributes of the computer itself such as dynamic imagery, colorful graphics, sound and the quality of computer-child interactions that may have influenced the overall effects of CAI. Some researchers have argued that the explication of media's most essential attributes and the psychological functions that they accomplish are important in any study of media instruction (Heidt, 1975; Salomon, 1974; Salomon and Cohen, 1976; Salomon and Snow, 1968). Predictions of media-specific effects on learning are based on the theoretical notions that structural or symbolic differences of media attributes such as codes, formats that are used as message vehicles, may differentially interact with learner attributes leading to different educational ends (Mielke, 1972; Olson, 1976; Salomon, 1979; Salomon and Clark, 1977). Indeed, more recently, (Salomon and Gardner, 1986) cautioned that only specific and unique features of a medium make a difference and that researchers should investigate the computer's most salient characteristics and qualities to corresponding cognitions. One essential characteristic of CAI that may have a differential impact on student learning outcome is computer-generated feedback.

The term "feedback" is often used generically to describe any message that signals to the learner the adequacy of his/her responses and findings of its facilitative effects on performance are usually accounted for in terms of its informational and/or motivational attributes. Despite its importance in student learning, it is unclear as to what type of computer- generated feedback facilitates learning the most and the few studies which have investigated the effectiveness of different types of computer-generated feedback have yielded inconsistent results. For example, Lutz (1973) found that young children when given an animated representation of feedback plus an audio message for correct answers, spent a significantly larger portion of time attending to the CAI lesson than those children who were given only an audio message for correct and incorrect responses. On the other hand Fejar (1970) reported that differences in computer-generated social reinforcers in textual form did not affect 4th graders achievement in a CAI math program. One explanation for the discrepant findings may be related to the confounding motivational and informational properties inherent in certain types of feedback stimuli and consequently, may account for differences in learner's responsiveness to them.

Any type of feedback which manifestly serves an informational function may indirectly motivate the learner to exert more effort, persevere longer in a task or even reinforce a correct response if he/she values being correct or wants to enhance the level of task performance. Indeed, there is some support for this notion in the non-computer literature on the motivational effects of knowledge of Results (Locke, Cartledge and Koeppel, 1968) or the reinforcement and informational effects of different types of feedback on children's conceptual learning (Marshall, 1969; McCullers & Martin, 1971; Spear, 1970). From the point of view of a prescriptive computer-based instructional psychology, it is important that the possible motivational attributes of computer-generated feedback be empirically assessed to determine the conditions under which different types of feedback can be arranged to maximize learning from a computer source.

The present study investigated the comparative effectiveness of three types of computer feedback (Symbolic KR, Textual KR and Pictorial KR) on children's learning and retention of relational concepts. Throughout this paper the term "feedback" is used generically to describe any message that signals to the learner whether his/her response is right or wrong. In order to assess the motivational effects of types of feedback independent of their informational attributes, preliminary instructions explained response contingencies to subjects to ensure that the three experimental conditions were informationally equivalent.

Thus, in accepting the validity of media researchers' contention that specific aspects of media makes a difference, this study investigated whether different types of computer-generated feedback differentially facilitated basic relational concept performance in young children.

METHODS

Subjects

A sample of 92 subjects was selected from five kindergarten classes in three elementary schools in a predominantly low income New York City school district (according to the U.S. Bureau of Census (1980). A total of 89 subjects whose primary language was English and whose performance on the Boehm Test of Basic Concepts was within the average range, completed the study (three subjects were absent for the posttest). The sample comprised 44 boys and 45 girls (mean age = 5 years 8 months); 62% were from Hispanic background and 38% were Black. Subjects were randomly assigned to one control and three experimental groups.

Materials and Apparatus

The teaching materials consisted of a six unit sequence of computer-assisted instruction each made up of three parts. Part 1, the 'teaching mode' consisted of at least four items for demonstration and instruction; four additional items were used for practice in Part 2, the 'practice mode'; Part 3, the 'testing mode' consisted of 10 items for the assessment of concept knowledge. Colorful illustrations were used in each frame to demonstrate and teach the concepts, some of which were activated by S's input from the keyboard. Target concepts were categorized as individual concepts (pair, equal and third) and concept pairs (above-below, forward-backward and right-left). Children from economically disadvantaged backgrounds experienced the greatest difficulty with these concepts according to the normative data for the Boehm Test of Basic Concepts (1971). Three feedback conditions were used in the practice phase of the study. A standard 21" color monitor was used to display the instructional material. The monitor was connected to a Texas instrument (TI-99/4A) microcomputer with 48k memory and equipped with a disk drive and a disk controller. A software clock was designed to monitor responses for each subject on the computer-administered criterion test. A management system stored all programs on floppy diskettes and self-adhesive removable labels were color- coded to highlight specific keys on the keyboard.

Measures

Three instruments were used to evaluate the effects of feedback on relational concepts acquisition. (1) Time-to Criterion; (2) Trials- to-Criterion; and (3) The Boehm Test of Basic Concepts (Form A and B).

Time-to- Criterion (mean response latency in seconds) and Trials -to- Criterion (mean number of correct responses) both measured rate of concept acquisition on the microcomputer.

Mastery level was set at three consecutive correct responses for individual concepts and six consecutive correct responses for concept pairs over 10 trials. (Results from a pilot study in which Trials-to-Criterion was used as a measure of basic acquisition showed that children reached criterion over a series of 10 trails on the microcomputer. The purpose of these measures was to assess the possible motivational influences of the different types of feedback on concept mastery. While it was assumed that all experimental subjects would learn since each group was exposed to the same instructional units , the psychological question from a media perspective was: Would subjects take a longer time or more trials to mastery, given differences in the feedback conditions ?

(3) The Boehm Test of Basic Concepts (BTBC) Form A & B was each administered to half of the subjects in the study (Form A, N=51; Form B, N=52). This was done to obtain baseline diagnostic information on subjects' knowledge of basic concepts. Each version of the test was again administered to experimental and control groups following the six-week intervention to evaluate any generalizable effects of the experiment on children's level of basic concepts knowledge. Form A was administered to subjects who had taken Form B on the pretest and Form B to subjects who had taken Form A on the pretest. The Boehm Test of Basic Concepts (Form A & B) was used again approximately three weeks after the immediate posttest to evaluate any lasting generalizable effects of the intervention.

The Instructional Program

The instructional program for the experimental groups was based on specific teaching prescriptions which Clark (1971) compiled from experimental studies on concept acquisition. They were as follows: (a) systematic presentation of examples and non-examples of each labeled concept; (b) directing subject's attention to the relationship between concept and a reference object; (c) elicitation of concept label from subjects; (d) provision of feedback after every response. The general procedure for a typical session was as follows:

1. Teaching phase: Four illustrations were presented and in each case the examiner read the instructions from a script for the subject who responded by pressing appropriate keys on the keyboard.

2. Practice phase: Four illustrations were presented consecutively and in each case E asked a question from the script and the subject responded by pressing one of three color-coded keys corresponding to the subject's color choice.

3. Testing phase: Each subject was tested individually for mastery of the concepts taught in that session. The level of mastery was set at 3 consecutive correct responses for individual concepts and six consecutive correct responses for concept pairs. E activated the timer on each trial immediately after reading the last word of the instructions; it stopped when the subject made a response by pressing one of the three keys. The testing period ended either when the subject reached criteria or after 10 trials were presented for each concept.

(A counterbalancing feature was also used in the instructional sequence of concept presentation across experimental conditions to avoid a confounding influence of an order effect).

Intervention Procedures

Each of the three experimental groups received a different type of computer-feedback during the practice phase of the study. Prior to the presentation of the first frame, E read the appropriate instructions, some of which were identical for all groups and others were particular to the treatment. The general instructions follow; those in parenthesis indicate specific instructions for the relevant experimental condition.

> "The computer will show you a picture on the screen and I will ask you a question about it. You must do two things - point to your answer on the screen and then press the key with the color that is your answer. If your answer is right, (Textual KR...... the computer will print words that will say, 'yes, that is right.' I will read whatever the computer prints on the screen); (Symbolic KR....the computer will play music and show you many colors; (Pictorial KR.....the computer will make your answer blink) If your answer is wrong, (Textual KR.... the computer will print words that say, 'No, that is wrong.' I will read whatever the computer prints on the screen); (Symbolic KR... the computer will make a buzzing sound and change one color; (Pictorial KR... the computer will show you the right answer by making that one blink)".

Within each experimental condition, the exposure time between feedback to the students' response and display of the next frame was a constant six seconds. A control group was included in the design of the study to estimate possible systematic treatment effects from changes due to normal developmental growth as well as to ensure that all groups had a microcomputer experience. The control group participated in a color-matching game for a comparable number of sessions as the experimental groups.

RESULTS

The Boehm Test of Basic Concepts

A 2 X 3 factorial analysis of covariance was carried out on each of the three dependent variables. Pretreatment scores on the Boehm Test of Basic Concepts was used as a covariate in the analysis. The original and adjusted pretest, posttest and delayed posttest means and standard deviations are presented in Table 1. The results indicated that the mean score for each of the three experimental groups and control group increased from the pretest to the posttest and was maintained on the delayed posttest as measured by the Boehm Test of Basic Concepts.

Insert Table 1 about here

A summary of the analysis of covariances on the immediate and delayed posttest on each of the groups is presented in Table 2. The analysis indicated that the three feedback conditions produced greater gains on concept acquisition that the control group on both the immediate and delayed BTBC scores. The Scheffe Contrasts method was used to compare the mean scores of both experimental and control groups. The comparisons showed that while the mean score of each experimental group on both the immediate and delayed posttest measures increased, ($p < .01$), there were no significant differences among the three experimental groups.

Insert Table 2 about here

Time-to-Criterion

The mean time-to-criterion in seconds was calculated for mastery tests administered on the microcomputer. For individual concepts, students needed a mean of 10.71 seconds in the Textual KR condition, 9.61 in the Symbolic KR condition and 11.46 in the Pictoria' KR condition. For concept pairs, pupils needed a mean of 22.44 seconds in the Textual KR condition, 22.04 in the Symbolic KR condition and 25.08 in the Pictorial KR condition. There were no significant differences among the feedback conditions for both individual and concept pairs. Thus, rate of acquisition was equally efficient across experimental conditions indicating that differences in feedback type did not differentially affect concept performance.

Trials-to-Criterion

The trials-to-criterion results paralled those of the time-to-criterion of concept acquisition as was indicated in the mean number trials pupil needed to achieve criterion on all concepts. On the average, subjects attained criterion in four trials for individual concepts and seven trials for concepts pairs across conditions. Again, there were no significant differences among feedback conditions.

Discussion

The purpose of this study was to assess the effects of of different types of computer- generated feedback on the quality of concept performance when post-response information was controlled. The results indicated that no significant differences we^e found among feedback conditions either on the efficiency (time-to-criterion) or the accuracy (trials-to-criterion) measures. However, experimental subjects were able to generalize their learning from a microcomputer environment as reflected in improvement from pre to post and delayed posttests scores on the Boehm Test of Basic Concepts. Two plausible explanations may be advanced to account for the findings in the study. First, the no difference in type of feedback suggests that other contingencies of feedback were probably operating across experimental groups, and the nature of the motivating stimulus was not as important as the relations which prevailed between the behavior and the consequences of that behavior. According to the principles of reinforcement theory, the frequency, and the temporal contiquity of the stimulus-response connection are presumed to be important ingredients in the mechanism that makes behavior possible and sustain it in strength. In the present study, feedback was administered after each of four consecutive trials and the exposure time between feedback to subject's response and display of next frame was a constant six seconds within each experimental condition. These contingencies may have been the critical variables in producing and maintaining over time the performance gains within each group. This explanation would be consistent with Skinner's caution that...........

> It is not the reinforcers which count so much as their relations to behavior. In improving teaching it is less important to find reinforcers than to design better contingencies than those already available (Skinner, 1968, p.6).

Perhaps, a more provocative interpretation of the findings of this study may have less to do with traditional notions of feedback than learning within a microcomputer environment which may be very different from a classroom. Task involvement in a microcomputer environment may be intrinsically motivating to young children and consequently, interacting with the microcomputer may have altered the conditions under which certain external reinforces are differentially effective. In this study, the power of making things happen (e.g., making an airplane glide above the moon or a dog nudge a hoop to its left) and observing the consequences of one's actions (the appearance of words on the screen, the sound of music or the animation of a picture), may have provided children with a sense of personal control over their learning, sustain their interest and thereby enriching the quality of their task involvement. The effects of external feedback regardless of type may have been masked by the overpowering allure of this child-machine interactivity. Furthermore, the fact that only two children were unable to complete the experiment over a two-month period suggests that all children irrespective of experimental condition to which they were assigned, were motivated and eager to "play with the computer" (actual words of some subjects).

Recent reserach on children's learning from a microcomputer source lends some support to the notion that courseware in such an enviornment may possess intrinsically motivating elements such as animations, sound, graphics (Banet, 1979; Carson Perez & White, 1985; Malone, 1980). It is very likely that the computer

may be a motivator in its own right; the novelty of working in such an environment may have sufficiently motivated students to establish and maintain optimal level of mental arousal across experimental groups. Under such conditions children showed improved performance regardless of the type of feedback administered.

In summary, this study investigated the motivational effects of computer-generated feedback on the learning and retention of children's learning and retention of relational concepts. No differences were found among feedback types although all subjects improved from pre to post and delayed posttests on the Boehm Test of Basic Concepts. Despite the findings in the study, there is an intuitive appeal to the notion that children may show differential responsiveness to different types of feedback as is also suggested in the non-computer based research literature (Blair, 1972; Cradler & Goodwin, 1971; Portugueses & Feshback, 1972). Certainly, more extensive experimental laboratory research should be conducted on the possible motivational value of different types of computer feedback which may yield diffrences that are difficult to assess in non- laboratory settings. Furthermore, the use of graphics and sound to present instruction may affect the quality of children's learning experiences in a manner not easily accounted for by traditional learning theories. More experimental work ought to be done on the motivational and attentional characteristics of courseware, the level of computer interactivity and the communicative potential of animated pictorial immagery in influencing the quality of concept acquisition.

TABLE 1

Original and Adjusted Means and Standard Deviations of Pretest, Posttest and Delayed Posttests* under Experimental and Control Conditions

Pretest	Textual	Symbolic	Pictorial	Control
	N = 23	N = 21	N = 22	N = 23
M	30.43	31.76	30.22	30.91
SD	6.51	6.56	7.19	7.43
Posttest (immediate)				
M (original)	34.73	36.85	34.50	32.00
M (adjusted)	35.13**	35.76	35.20**	31.70
SD	6.75	6.75	7.43	7.88
Posttest (delayed)				
M (original)	34.43	36.80	34.00	32.65
(adjusted)	34.83	35.68**	34.73**	32.56
SD	7.13	6.89	7.19	7.71

* The highest possible score on the Boehm Test of Basic Concepts is 50.

**$p < .01$

TABLE 2

Analysis of Covariance on Immediate Posttest by Experimental Conditions

Source	SS	DF	MS	F
Covariate Pretest	4303.830	1	4303.830	1855.435
Main Effects	210.265	4	52.566	22.666*
2-way interactions treatment by sex	4.519	3	1.506	.649
Explained	4518.613	8	564.827	243.504
Residual	185.566	80	2.320	
Total	4704.180	88	53.457	

TABLE 3

Analysis of Covariance on Delayed Posttest by Experimental Conditions

Source	SS	DF	MS	F
Covariate Pretest	4294.19	1	4294.19	1446.49
Main Effects	120.20	3	40.06	13.49*
Explained	4414.40	4	1103.607	371.747
Residual	249.376	84	2.96	
Total	4663.770	88	52.99	

**p< .01

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