IMPROVEMENT OF ANALOGIZING PERFORMANCE: A CAI-MASTERY APPROACH

R. YARACS, C. P. OLANDER, M. E. ULRICH, AND C. E. McDADE

JACKSONVILLE STATE UNIVERSITY

The mastery of analogy principles is one of many task necessary for prospective graduate students, but generally the analogy portion of post-graduate examinations is a stumbling block to many students, probably due in part to their unfamiliarity with types of relationships that exist. Undergraduates at a state funded university who wished to improve their analogizing performance volunteered as subjects. Twenty-six subjects were randomly assigned into either experimental or control groups.

The experiment was conducted using a computer-based instructional system which (a) generated randomized pretest and posttest conditions, (b) administered a mastery procedure in the treatment condition, and (c) measured and stored various parameters (e.g., correct rate, error rate, percentage correct) of the subject's responses. The mastery treatment is an algorithm involving many embedded feedback loops which insure that subjects with weak backgrounds become competent with each relationship before proceeding, while others can move quickly through relationships with which they are already familiar.

Recent investigation of cognitive processes in college students has indicated that few students enter college with developed analytical reasoning or problem-solving skills (Renner & Lawson, 1973; Whimbey, 1977). One particularly difficult but necessary- skill for many undergraduates is the ability to both generate and comprehend analogies (McDade & Gray, 1977).

Several researchers (Egan & Greeno, 1974; Greeno, 1978; Reitman, 1965) have analyzed the process of solving verbal and pictorial analogies. All conclude that analogizing involves comprehending the relation between A and B is the same as the relation between C and D.

There are at least five reasons for undergraduate students to master analogizing as a shorthand communication and storage device (Reitman, 1965), analogies are frequently used by college professors in attempting to clarify material to their students. Analogizing can be an extremely effective learning technique, specifically when a student has incomplete knowledge of a topic (Glass, Holyoak, Santa, 1979; Collins, Warnock, Aiello, and Miller, 1975). Analogies exemplify problems of inducing structure, one of the three classes of problems humans are faced with solving (Greeno, 1978). Additionally, the use of analogies is often required in creative thinking (Anderson, 1980; Glass, et al., 1979). Perhaps the most pragmatic reason for college students' mastering analogies is their appearance on standardized entrance exams for graduate and professional schools.

The impact of cognitive process instruction, attempting to teach specific cognitive skills at the college level, is being felt

nationwide (Lochtread & Clement,, 1979; Lockhead & Whimbey, 1980). Students actually can be taught to solve problems and to reason more effectively (Samson, 1970, 1975; Whimbey, 1975). Simultaneously, the electronic revolution is changing education with the increasing use of computer-assisted-instruction (CAI) and computer-assisted-testing (CAT). Software is currently being developed and marketed for cognitive process instruction such as the Microsystem 80 College Entrance Preparation Program (Scandura, 1981) or Critical Reading Program (Scandura, 1980). The present study attempted to use cognitive process instruction in a CAI-Mastery approach to teach college students to analogize more effectively.

Method

A pilot study was conducted with 50 undergraduate students at Jacksonville State University who volunteered, motivated to improve their ability to analogize. Fifteen categories of analogies were developed (Belth, 1977; Turner, 1973) along with examples and questions from each category. A pretest and a posttest were devised, each with one question per category for a total of 15 questions per test. Treatment consisted of showing S one example in a category, as well as the category name; then S was given four questions to answer from that category. Attempts were made to equate and simplify vocabulary throughout the program. A mastery procedure was used with a criterion of 75% correct in order to advance to the next category; failure to achieve mastery required that S return to the original example in that category. Due to time constraints, mastery was limited in that Ss were sent back through a given category no more than two times.

The analogies program was presented on Apple II microcomputers in the Center for Individualized Instruction at Jacksonville State University. Subjects were allowed to work through the entire program in one session without time constraint on their own schedule.

Results of the pilot study were useful in computer program modifications and in determining which analogy categories were most difficult to master. The current study was modified to restrict testing and treatment questions to the 5 most difficult analogy categories--degree, characteristic, sequence, synonyms, and antonymns. Pretests and posttests consisted of 15 questions, each with 3 questions per analogy category. The same limited mastery procedure as in the pilot study was used.

The microcomputers recorded percent correct, testing time, rate correct (i. e., number correct per minute), error rate (i. e., number incorrect per minute), record floor (i. e., the reciprocal of test time), question identification, S's response, correct response, latency of response, date, and clock time for pretests, mastery checks, and posttests. During the treatment phase an additional datum, the time spent studying the analogy category example, was recorded. Data were retrieved to hard copy and scrutinized for confounding. Posttest data were eliminated for any S who inadvertently pushed the "Reset" or "Return" Key or who received portions of the program out of sequence. Since the purpose of the study was to determine whether mastery of the analogizing categories results in improved performance on a posttest of those categories, data for Ss who did not achieve mastery were also eliminated.

Subjects were randomly assigned to groups. The experimental group received the pretest, limited mastery treatment, and the posttest, while the control group received the pretest and posttest only. Data were analyzed for 13 Ss in each group with a one between-subjects and one within-subjects analysis of variance.

Results and Conclusions

A one between-subjects and one within-subjects analysis of variance was performed with significant interactions on two dependent variables - percent correct responses and error rate. It is apparent that undergraduate students can improve their analogizing performance with a CAI- Mastery Treatment.

The analogies program was used in the Center for Individualized Instruction at Jacksonville State University as a service to students planning to schedule entrance exams for graduate or professional schools who recognize the need to improve their analogizing performance.

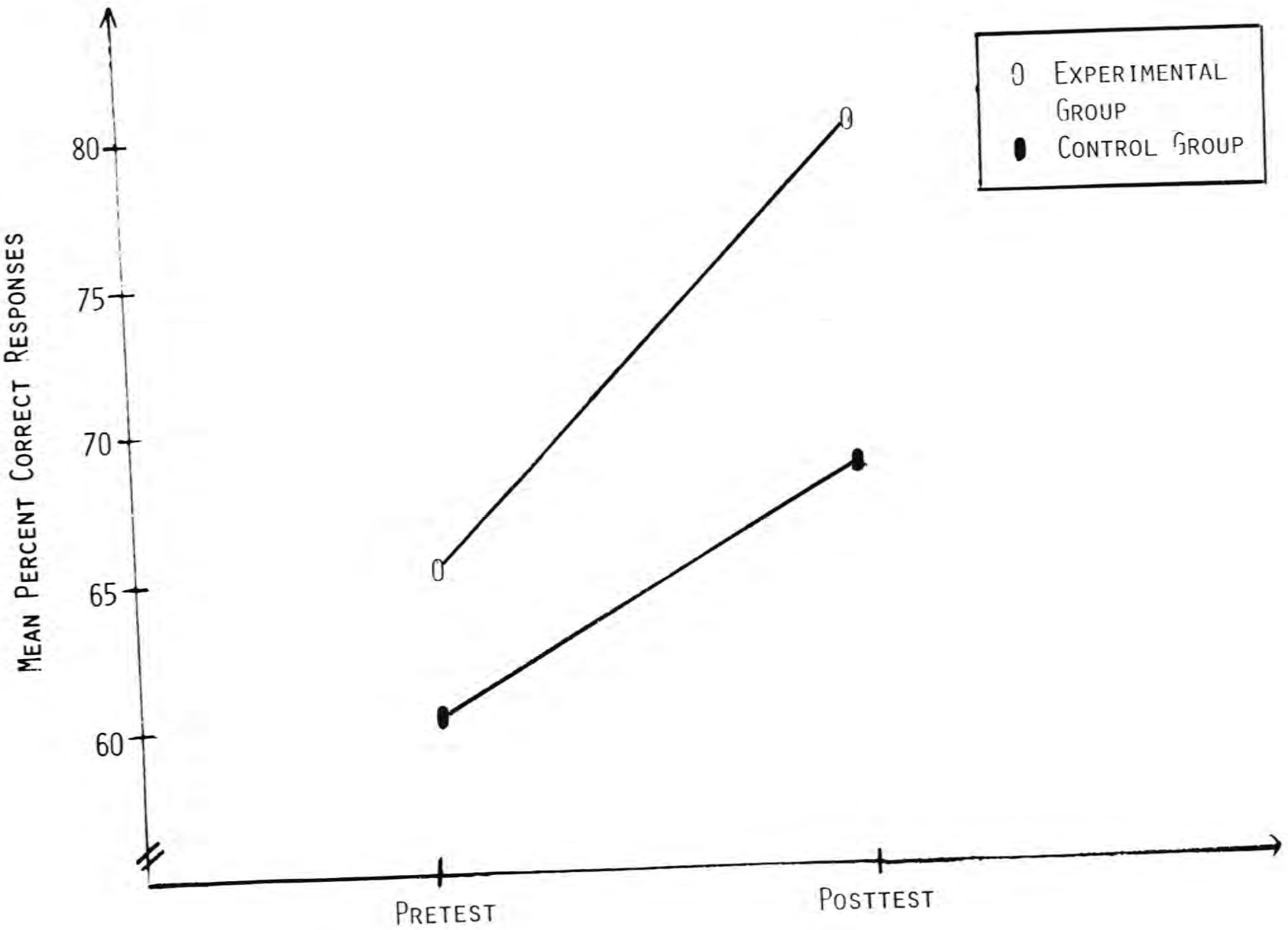

Figure 1. Mean percent correct responses for pretest and posttest.

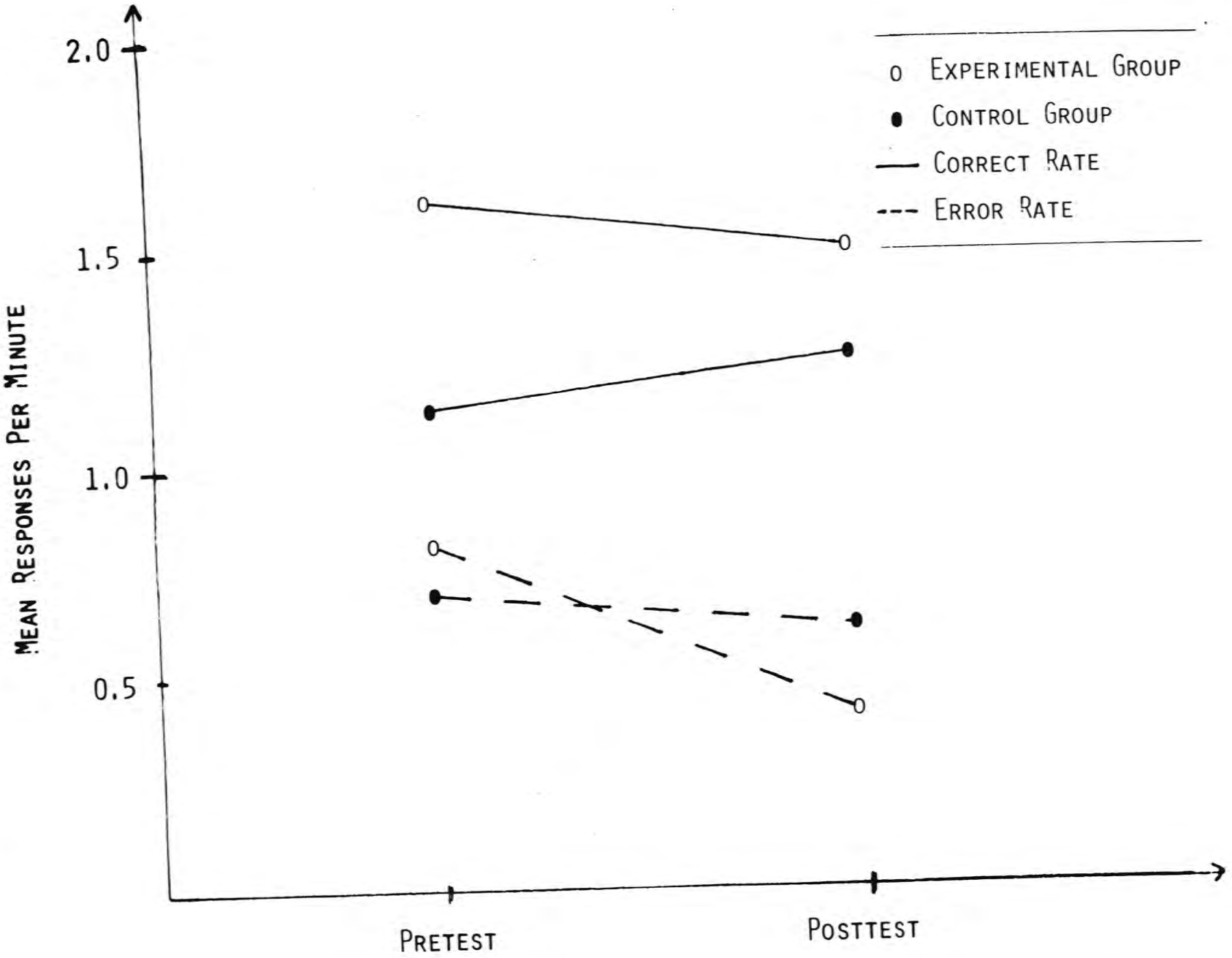

FIGURE 2. MEAN CORRECT RATE AND ERROR RATE FOR PRETEST AND POSTTEST

TABLE 1

MEAN PERCENTAGE CORRECT, CORRECT RATE, ERROR RATE FOR EXPERIMENTAL AND CONTROL GROUPS

	CONTROL		EXPERIMENTAL	
	PRETEST	POSTTEST	PRETEST	POSTTEST
$\bar{X}$ % CORRECT	60.00	66.66	65.13	80.01
$\bar{X}$ CORRECT RATE (# CORRECT/MIN)	1.11	1.23	1.59	1.55
$\bar{X}$ ERROR RATE (# INCORRECT/MIN)	.73	.62	.81	.38

TABLE 2

ONE BETWEEN-SUBJECTS AND ONE WITHIN-SUBJECTS
ANALYSIS OF VARIANCE FOR PERCENT CORRECT RESPONSES

SOURCE OF VARIATION	DF	SS	MS	F
BETWEEN Ss	25	6757.47		
A	1	720.04	720.04	2.86
S/A	24	6037.43	251.60	
WITHIN Ss	26	3089.80		
B	1	1436.40	1436.40	24.51**
A*B	1	247.74	247.74	4.23*
SB/A	24	1405.66	58.57	
TOTAL	51	9847.27		

** $F_{.005}$ (1,24) = 9.55

* $F_{.05}$ (1,24) = 4.26

TABLE 3

One Between-Subjects and One Within-Subjects
Analysis of Variance for Error Rate

Source of Variation	df	SS	MS	F
Between Ss	25	3.24		
A	1	.05	.05	.38
S/A	24	3.19	.13	
Within Ss	26	2.01		
B	1	.96	.96	32.00**
A*B	1	.34	.34	11.33**
SB/A	24	.03	.03	
Total	51	5.25		

** $F_{.005}\ (1,24) = 9.55$

References

Anderson, B. F., The complete thinker. Englewood Cliffs, NJ: Prentice-Hall, 1980.

Belth, M., The process of thinking. New York, NY: David McKay, 1977.

Collins, A. M., Warnock, P. T., Aiello, C., and Miller, K. Reasoning from incomplete knowledge. In D. G. Bobrow and A. Collins (Eds.), Representation and understanding. New York: Academic Press, 1975

Egan, D. E. and Greeno, J. G., Theory of rule induction: Knowledge acquired in concept learning, serial pattern learning, and problem solving. In Gregg, L. W. (Ed.), Knowledge and cognition. Potomac, MD: Lawrence Erlbaum Associates, 1974.

Glass, A. L., Holyoak, K. J., and Santa, J. L., Cognition. Reading, MA: Addison-Wesley, 1979.

Greeno, J. G., The nature of problem-solving abilities. In Estes, W. K. (Ed.), Handbook of learning and cognitive processes: Volume 5 - Human information processing. Hillsdale, NJ: Lawrence Erlbaum Associates, 1978.

Lochhead, J. and Clement, J. (Eds.), Cognitive process instruction: Research on teaching thinking skills. Philadelphia, PA: Franklin Institute Press, 1979.

Lochhead, J. and Whimbey, A., Problem-solving and comprehension: A short course in analytic reasoning. Philadelphia, PA: Franklin Institute Press, 1979.

McDade, C. E. and Gray, M. M., Specific cognitive skills associated with formal reasoning. Journal of the Alabama Academy of Science, 48, 1977, 106.

Reitman, W. R., Cognition and thought: An information-processing approach. New York, NY: John Wiley & Sons, 1965.

Reuner, J. W. and Lawson, A. E., Promoting intellectual development through science teaching. The Physics Teacher, 11, 1973, 273-276.

Samson, R. W., Problem solving improvement: A program for self-instruction. New York, NY: McGraw-Hill, 1970.

_____., Thinking skills: A guide to logic and comprehension. Stanford, CT: Innovative Sciences, Inc., 1975.

Scandura, J. M., MicroSystem 80: Critical reading. Arlington Heights, IL: Borg-Warner Educational Systems, 1980.

_____., MicroSystem 80: College entrance examination preparation Arlington Heights, IL: Borg-Warner Educational Systems, 1981.

Turner, D. R., Miller analogies test: 1400 questions. New York, NY: Arco, 1973.

Whimbey, A., Intelligence can be taught. New York, NY: E. P. Dutton & Co., Inc., 1975.

Whimbey, A., Teaching sequential thought: The cognitive - skills approach. Phi Delta Kappan, Dec. 1977.