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ABSTRACT

The purpose of this study was to investigate the effect of an eclectic thinking processes model on the logical reasoning abilities of students in grades six through twelve. The experimental school consisted of 159 students whereas the control school had 111 students. The Group Assessment of Logical Thinking (GALT) was administered to the sample as a post-test. The thinking processes model incorporated logical, critical, and creative thinking skills. Teachers in the experimental school were presented with the model during workshops during the summers of 1986 and 1987. These teachers were encouraged to infuse the thinking processes into the mandated curricula during the 1986-1987 school term and were expected to do so in the fall of 1987. The control district neither participated in the two summer workshops nor were expected to infuse thinking processes into the mandated curricula. For both the experimental and the control school, correlational reasoning followed by probabilistic reasoning was the most difficult. The experimental school performed significantly higher than the control in controlling variables, correlational reasoning, and the total GALT score. Classification of the students according to reasoning levels revealed that only 3% of the total sample performed at the formal operational reasoning level. The significant differences favoring the experimental school seemed to indicate that the eclectic thinking processes model was effective. (CW)

Thinking Processes Model: Effect on Logical Reasoning Abilities of Students in Grade Six through Twelve

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Running Head: Thinking Model

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Thinking Processes Model: Effect on Logical Reasoning Abilities of Students in Grade Six through Twelve

Abstract

The purpose of this experimental study was to investigate the effect of an eclectic thinking processes model on the logical reasoning abilities of students in grades six through twelve. The relevant research literature reviewed included (a) the development of thinking processes, (b) formal operational reasoning modes as predictors of academic success and critical thinking, and (c) strategies for teaching thinking processes. The sample (N = 270) consisted of students in grades six through twelve in two rural Arkansas consolidated school districts. Although the total enrollment K-12 differed in the two schools, both school districts were quite homogeneous in the following aspects: (a) the socioeconomic level, (b) standardized test scores, (c) inclusion of mainstreamed students in the samples, (d) curricula mandated by the Arkansas Education Standards of 1984, and (e) geographical region. The science and mathematics curriculum, as mandated by the Arkansas Education Standards of 1984, included a total of five courses (two courses in one discipline and three in the other discipline). The experimental school consisted of 159 students in grades six through twelve, whereas the control school had 111 students in the same grades. The Group Assessment of Logical Thinking (GALT) was administered to the sample as a post-test. The GALT measures six reasoning modes (i.e., conservation, proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning, and combinatorial reasoning). Construct, criterion-related, and internal consistency reliabilities were established by the authors of the GALT. The teachers and administrators of the experimental school received two intensive week-long workshops on the thinking processes model. The thinking processes model incorporated logical, critical, and creative thinking skills. A consultant presented the 1986 summer workshop, whereas core teachers in the experimental school provided the 1987 summer workshop. The format of 1986 workshop included the following steps: (a) oral dissemination of the theories accompanied by research articles relevant to the theories and ways of applying the theories, (b) engagement of the participan applying the theories in their subject-matter and grade level; and (c) feedback, reaction, and evaluation. The focus of the 1987 workshop was review of the thinking processes presented during the 1986

workshop and development of model lessons for the teachers' individual classrooms. These teachers were encouraged to infuse the thinking processes into the mandated curricula during the 1986-1987 school term and were expected to do so during the fall of 1987. The control school district neither participated in the two summer workshops nor were expected to infuse thinking processes into the mandated curricula. A .80 internal consistency reliability coefficient was found on the GALT using Cronbach's alpha. For both the experimental (n = 159) and the control school (n = 111), correlational reasoning followed by probabilistic reasoning was the most difficult. The experimental school performed significantly higher than the control school in controlling variables, correlational reasoning, and the total GALT score. Classification of the students according to reasoning levels revealed that only 3% of the total sample performed at the formal operational reasoning level. The significant differences in controlling variables, correlational reasoning, and total GALT score in favor of the experimental school seem to indicate that the eclectic thinking processes model was effective. In particular, the significant difference in correlational reasoning performance should be noted since correlational reasoning has been identified as the most difficult by other researchers. It is recommended that the same approach be implemented with tighter control.

Significance and Purpose of the Study

The development of thinking processes has been endorsed (Costa, 1989; Educational Policies Commission, 1961; Lawson & Lawson, 1980; Lawson, Abraham, & Renner, 1989; Marzano & Arredondo, 1986). Specifically, five formal operational reasoning modes (Capie, Newton, & Tobin, 1981; DeCarcer, Gabel, & Staver, 1978; Inhelder & Piaget, 1958; Lawson, 1982; Lawson, 1985; Linn, 1982) have been identified as essential abilities for success in advanced secondary school science and mathematics courses. Of the five formal operational reasoning modes, Bitner (1989) identified correlational reasoning as the most difficult for students in grades six to ten (N = 84). Formal operational reasoning has been found to be a predictor of achievement in science and mathematics (Bitner, 1986, 1988, in press; Hofstein & Mandler, 1985; Howe & Durr, 1982; Lawson, 1983; Lawson, Lawson, & Lawson, 1984) and critical thinking (Bitner, 1988, in press). Studies investigating the effect of an eclectic thinking model (i.e., one which incorporates logical, critical, and creative processes) on logical reasoning abilities are needed. Therefore, the purpose of this experimental study was to investigate the effect of an eclectic thinking processes model on the logical reasoning abilities of students in grades six through twelve.

Method

Sample

The sample (N = 270) for this e· imental study consisted of students in grades six through twelve in two rural Arkansas consolidated school districts. Although the total enrollment K-12 differed in the two schools, both school districts were quite homogeneous in the following aspects: (a) the socioeconomic level, (b) standardized test scores, (c) inclusion of mainstreamed students in the samples, (d) curricula mandated by the Arkansas Education Standards of 1984, and (e) geographical region. The science and mathematics curricula, as mandated by the Arkansas Education Standards of 1984, included a total of five courses (two in one discipline and three courses in the other discipline). Included in the science curriculum were general science, earth science, biology, chemistry, and physics. The experimental school consisted of 159 students in grades six through twelve; the control school included 111 students in grades six through 12.

Instrument

The twenty-one item Group Assessment of Logical Thinking (GALT) (Roadrangka, Yeany, & Padilla, 1982) was administered to the sample (N =270) as a post-test. The GALT measures six reasoning modes (i.e., conservation, proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning, and combinatorial reasoning). The GALT was selected to measure logical thinking because of the validity and reliability results obtained by Roadrangka, Yeany, & Padilla (1983) on a sample of students ranging from sixth grade through college level and its predominantly objective format. Of the twenty-one items on the GALT, only the last three require students to supply logical combinations for the illustrated problems. Construct validity was established by determining convergent validity with Piagetian Interview Tasks (.80) and by using the principal components method of factor analysis. The scores on the Test of Integrated Process Skills (TIPS II) were used to establish the criterion-related validity of the GALT. The correlation coefficient between the total GALT score and the total TIPS II score was .71. A .85 reliability coefficient was found for internal consistency by calculating Cronbach's alpha.

Treatment

The consultant engaged the teachers and administrators in the experimental school district in an intensive week-long workshop in thinking processes (i.e., logical, creative, and critical) during the summer of 1986. The format of the workshop included the following steps: (a) oral dissemination of the theories accompanied by research articles relevant to the theories and ways of applying the theories; (b) engagement of the participants in applying the theories in their subject-matter; and (c) feedback, reaction, and evaluation. The eclectic thinking processes model, consisting of twelve steps with suggested procedures for accomplishing each step, was based on the theoretical and applied research on developmental psychology (Inhelder & Piaget); methods for producing holistic learning (Samples & Hammond, 1985); generic thinking processes or tools (Chuska, 1986; de Bono, 1973, 1983a, 1983b); repertoire of teaching critical thinking and problem solving processes; creative, logical, and reflective, and critical thinking skills; the spiralling curriculum (Bruner, 1966); and relevancy of the curriculum (Bruner, 1971). Strategies for producing holistic learning included the use of (a) modalities of learning; (b) learning and teaching styles

(Dunn & Dunn, 1979; McCarthy, 1980; Samples & Hammond, 1985); (c) dissonance or discrepancy (Inhelder & Piaget, 1958; Wright, 1981); and (d) questioning strategies (Bloom, 1956; Blosser, 1973), especially wait-time (Rowe, 1969). Generic thinking processes or tools consisted of the science process skills and thinking tools (de Bono, 1973). The following were included in the strategies for teaching critical thinking and problem solving processes: (a) the Learning Cycle (Atkins & Karplus, 1962; SCIS, 1974); (b) the learning hierarchy (Gagne, 1985); (c) Structure-of-the-Intellect (Guilford, 1960); (d) creative process and thinking (Bruner, 1962; Torrance, 1979), (e) analytical or higher-order reasoning (Whimbey, 1977, 1984; Whimbey & Lockhead, 1980); (f) lateral and vertical thinking (de Bono, 1970); (g) creative process (Eberle & Stanish, 1985; Isaksen & Parnes, 1985; Osborn, 1963; Parnes, Noller, & Biondi, 1977; Stanish & Eberle, 1984; Wallas, 1926); the role of sensitivity, synergy, and serendipity in the thinking process (Parnes et al., 1977); and the conceptual framework (Marzano & Hutchins, 1985).

Throughout the 1986-1987 school term, teachers in the experimental school district on a voluntary basis infused the thinking skills into the state mandated curricula. Upon request, the Advanced Photography Club videotaped teachers using the thinking strategies. The consultant viewed the tapes and provided feedback to the teachers. In addition, the consultant remained in close contact with the five core teachers, master teachers with expertise in the humanities, gifted and talented education, special education, counseling, and physical education. The five core teachers presented a week-long workshop on thinking skills to the faculty and administrative staff of the experimental school district during the summer of 1987. The focus of 1987 workshop was review of the thinking processes presented during the 1986 workshop and development of model lessons for the teachers' individual classrooms. All teachers were expected to infuse thinking processes into the curricula during the fall of 1987. The teachers in the control school district ($n = 111$) neither participated in the two summer workshops nor were expected to infuse thinking processes into the curricula.

Results

Cronbach's alpha was used to determine the internal consistency reliability of the GALT. A .80 correlation coefficient was found.

The means and standard deviations for the twenty-one items, six reasoning modes, and GALT total score are reported in Table 1. For both the experimental school (n = 159) and the control school (n = 111), correlational reasoning followed by probabilistic reasoning was the most difficult. The experimental school performed significantly higher (M = 1.82, SD = 1.33) than the control school (M = .87, SD = 1.05) in controlling variables, t = 2.10 (268), p < .05. Performance on the correlational reasoning items was significantly better for the experimental school (M = .28, SD = .53) than the control school (M = .11, SD = .31), t (268), 3.12, p < .01. A significant difference in the total GALT score was also found between the experimental school (M = 6.38, SD = 3.95) and the control school (M = 5.40, SD = 3.20), t (268) = 2.17, p < .05.

The classification of students according to reasoning levels is found in Table 2. Only 8 (3%) of the sample (N = 270) performed at the formal operational level. Six (3.8%) of the experimental group performed at the formal operational level, whereas only 2 (1.8%) of the control group were formal operational reasoners.

Conclusions

The significant differences in controlling variables, correlational reasoning, and the total GALT score in favor of the experimental school seem to indicate that the eclectic thinking processes model was effective. In particular, the significant difference in correlational reasoning performance should be noted since correlational reasoning has been identified as most difficult (e.g., Bitner, 1989).

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Table 1

A Comparison of Means and Standard Deviations and Two-tailed T-Test on the GALT for the Sample (N = 270)

Reasoning Ability	Group 1 (n = 159)		Group 2 (n = 111)		Total (N =270)		
	M	SD	M	SD	M	SD	t value
Conservation	2.74	1.12	2.60	1.16	2.68	1.14	1.01
Item 1	.80	.40	.80	.40	.80	.40	
Item 2	.84	.37	.83	.38	.84	.37	
Item 3	.58	.50	.46	.50	.53	.50	
Item 4	.52	.50	.50	.50	.51	.50	
Proportionality	1.07	1.48	.87	1.05	.99	1.32	1.20
Item 5	.09	.29	.06	.24	.08	.27	
Item 6	.10	.30	.05	.21	.08	.27	
Item 7	.13	.33	.13	.33	.13	.33	
Item 8	.16	.37	.12	.32	.14	.35	
Item 9	.31	.46	.24	.43	.28	.45	
Item 10	.26	.44	.28	.45	.27	.45	
Controlling Variables	1.82	1.33	.87	1.05	1.05	1.23	2.10*
Item 11	.31	.47	.17	.38	.26	.44	
Item 12	.34	.48	.24	.43	.30	.46	
Item 13	.37	.48	.28	.45	.33	.47	
Item 14	.18	.39	.17	.38	.18	.38	
Probability	.37	.73	.36	.71	.37	.72	.12
Item 15	.18	.38	.14	.35	.16	.37	
Item 16	.19	.39	.20	.40	.19	.40	
Correlational	.28	.53	.11	.31	.21	.46	3.12**
Item 17	.21	.41	.10	.30	.16	.37	
Item 18	.08	.28	.10	.10	.05	.22	
Combinatorial	.72	.67	.60	.69	.67	.68	1.43
Item 19	.53	.50	.51	.50	.52	.50	
Item 20	.20	.40	.07	.26	.14	.35	
Item 21	.01	.16	.03	.16	.10	.16	
GALT Total	6.38	3.95	5.40	3.20	5.97	3.68	2.17*

$^{*}p < .05$. $^{**}p < .01$.

Table 2

Levels of Reasoning on the GALT (N = 270)

Grade/Group	Reasoning Level					
	Formal[a]		Transitional[b]		Concrete[c]	
	N	%	N	%	N	%
Grade 6 (n = 47)	0	0	2	4	45	96
Experimental (n = 32)	0	0	0	0	32	100
Control (n = 15)	0	0	2	13	13	87
Grade 7 (n = 49)	0	0	5	10	44	90
Experimental (n = 23)	0	0	3	13	20	87
Control (n = 26)	0	0	2	8	24	92
Grade 8 (n = 45)	2	4	4	9	39	87
Experimental (n = 28)	1	4	3	11	24	85
Control (n = 17)	1	6	1	6	15	88
Grade 9 (n = 35)	0	0	7	20	28	80
Experimental (n = 22)	0	0	6	27	16	73
Control (n = 13)	0	0	1	8	12	92
Grade 10 (n = 25)	1	4	9	36	15	60
Experimental (n =13)	0	0	7	54	6	46
Control (n = 12)	1	8	2	17	9	75
Grade 11 (n = 40)	4	10	11	28	25	62
Experimental (n = 22)	4	18	8	37	10	45
Control (n = 18)	0	0	3	17	15	83
Grade 12 (n =29)	1	3	8	28	20	69
Experimental (n = 19)	1	5	7	37	11	58
Control (n = 10)	0	0	1	10	9	90
Total (N = 270)	8	3	46	17	216	80

[a] Score = 16-21.

[b] Score = 9-15.

[c] Score = 0-8.

Appendix A

BITNER MODEL

I. The Focus

A. Critical thinking skills with definite approaches and/or [often called "well-structured" (Sternberg, 1984, p. 196), e.g., physics, chemistry problems, etc.]

B. Real life problems without definite approaches or definite solutions because of their contextual dependency [often called "ill-structured" (Sternberg, 1984, p. 196)]

II. The Process: It is an integration of a variety of thinking tools and processes and different categories of thinking. Throughout the process, one is encouraged to use the higher-order thinking skills and inductive and deductive logic.

A. Step 1: Find a problem. (At this stage, the individual will be given very little information. The individual will be encouraged to invent problems or discern a problem from the given information. Also, at this stage, the individual may conclude that definition of terms and additional information are needed.)

1. Suggestions:

a. Put students in a situation which creates dissonance, disequilibrium, or discrepancy (Piaget, Wright, etc.).

b. Be sensitive to the situation under investigation (Parnes, Nolier, & Biondi).

c. Use the modalities of learning to observe the situation (Bernice McCarthy).

d. Think in words as well as images (Marzano & Hutchins).

e. Determine the parameters of the situation.

2. Checks (Cagle):

a. Evaluate the problem.

(1) Do I really have a problem?

(2) What kind of a problem do I have? ("well-structured" or ill-structured")

b. Verify the problem.

(1) If you have a problem, proceed.

(2) If not, return to Step 1.

B. Step 2: Define the problem (Use convergent and divergent thinking.)

1. Suggestions:

a. Determine the ownership of the problem. Ask who, what, when, where, how, and why?

b. Analyze the problem; determine its possible components. (Use the generic tools/processes recommended by Chuska.)

c. Define the problem completely, intently, and clearly (Wallas).

2. Checks (Cagle):

a. Evaluate the definition of the problem.

(1) Is it an accurate definition of the problem?

(2) Is it free from bias?

(3) Do I want (its value-personal and societal) to solve it?

(4) Do I have the resources to solve it? (money, time, and ability)

b. Verify the definition of the problem.

(1) If positive responses to questions in Step 2, proceed.

(2) If negative responses, re-evaluate definition.

C. Step 3: Brainstorm to come up with possible solution approaches to the identified problem.

1. Suggestions:

a. Use divergent and convergent thinking.

b. Refer to CPS brainstorming process SCAMPER. (SUBSTITUTE; COMBINE; ADAPT; MODIFY, MAGNIFY, AND MINIFY; PUT TO OTHER USES; ELIMINATE; AND REVERSE) (Eberle & Stanish)

c. Use Edward deBono's PMI (Plus, Minus, and Interesting) and CAF (Consider All Factors) (CoRT I)

2. Checks:

a. Evaluate the list of solution approaches.

(1) Have all possibilities been considered?

(2) Have I then weeded out the non-essentials?

b. Verify solution approaches.

(1) If you judged that all possibilities have been weeded out, proceed.

(2) If not satisfied with the brainstorming process, consider ways to improve it or return to Step 1 or 2.

D. Step 4: Determine the short and long term consequences of each solution in context.

1. Suggestions:

   a. Use de Bono's C & S.

   b. Classify them; put them in a priority order, etc.

   c. Consider resources (monetary, time, and ability) needed to solve the problem and value of the solution.

E. Step 5: Incubate.

1. Checks:

   a. Evaluate short and long-term consequences of each solution.

      (1) Use the generic tools/process.

      (2) Perhaps re-order them.

   b. Verify the solution approach(es).

F. Step 6: Select the solution approach.

1. Suggestions:

   a. Is it the best solution approach? (Use CAF.)

   b. Devise a time-line for the solution approach.

   c. Devise a detailed plan.

   d. Devise an evaluation plan.

2. Checks:

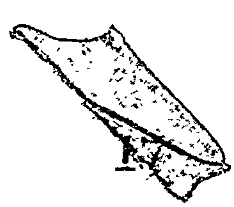
   a. Evaluate the time-line for the solution approach.

      (1) Do I have the resources?

      (2) Is this time frame realistic?

      (3) Is the plan complete? (N.B.: Control is essential if you really want to find out if you found the solution to the problem.)

   b. Verify the solution approach.



G. Step 7: Formulate the hypothesis or hypotheses to test the solution approach.

H. Step 8: Implement the solution-solving approach, i.e., test the hypothesis or hypotheses.*

1. Suggestions:

   a. Follow the plan and time-line.

   b. Control if a scientific experiment.

   c. Keep accurate records. Record data accurately.

I. Step 9: Evaluate the solution-solving approach.

1. Did you solve the problems?

2. What are the results?

3. Can the approach be replicated?

J. Step 10: Verify the results.

1. If you did not solve the problem, consider modification of the solution approach.

2. If the problem is solved, proceed.

K. Step 11: Communicate the results by explicating the process (Torrance). This is an important step for personal and societal relevance (Bruner).

1. Use tables, graphs, etc., in the reporting.

2. Be precise and concise.

L. Step 12: If not satisfied with the results, analyze why. Return to the appropriate step.

* This is the point at which I believe discipline plays a vital role. No matter what discipline, reliability and validity are essential. Someone else ought to be able to replicate the process.