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ABSTRACT

To determine if differing ability levels will affect the acquisition of problem-solving skills and self-esteem as a result of participation in two approaches to teaching problem-solving skills, a study was conducted with sixth graders in a posttest-only control group experimental design. Subjects were 102 sixth graders randomly assigned to 5 classes. Two classes participated in the Creative Problem Solving (CPS) for Kids approach to teaching problem solving. Two classes received computer-assisted instruction in problem-solving designed by the Minnesota Educational Computing Consortium, and one class was a control group. Both approaches consisted of five 3-minute lessons per week for 6 weeks. Results suggest that thinking-skills instruction does impact the development of creative and critical thinking and that the acquisition of these skills has a positive effect on self-esteem. The study also provides evidence that the length of training is an important consideration in providing thinking-skills instruction, and that such instruction should be an integral part of the curriculum rather than a supplementary or isolated program. In addition, thinking-skills instruction is appropriate for students at all ability levels. Seven figures and 12 tables present study findings. (Contains 17 references.) (SLD)

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EFFECTS OF PROBLEM-SOLVING STRATEGIES ON DIFFERENT ABILITY LEVELS

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EFFECTS OF PROBLEM-SOLVING STRATEGIES ON DIFFERENT ABILITY LEVELS

In an effort to prepare students for success in a world of change, curricula that emphasizes the development of process skills, or learning how-to-learn skills, is appropriate. It is through the acquisition of process skills--those skills of inference, of visualization, of extrapolation, of locating and solving problems--that individuals are able to cope with the problems that they face in the present world.

The process skills curriculum orientation has its roots in Dewey's (1916) progressive era in American education in which educators were encouraged to equip children to become problem solvers. Bloom's (1956) taxonomy of educational objectives provided a hierarchy of cognitive skills to include knowledge, comprehension, application, analysis, synthesis, and evaluation, and Bruner (1960) claimed that through the exercise of problem solving--acquisition, transformation, and evaluation--actual learning takes place.

The work of Guilford (1967) is the basis for the modern-day resurgence of interest in the process skills curriculum design. Guilford's Structure of the Intellect model described 120 intellectual operations which have been used as bases of a process-oriented curriculum. A process-orientated curriculum aims to assure that the individual will develop the ability to use the mental operations on which he/she will eventually depend.

As Taylor (1968) built upon the work of Guilford, he sought to encourage educators to implement a multiple talent approach in the educational process to assure that greater numbers of students are successful both in and out of school. Taylor (1986) further maintained that a major goal for educators is that educational programs should be designed to give persons greater self-understanding, self-esteem, and self-confidence.

Talents Unlimited (Schlichter, 1985), a teaching/learning model for thinking skills instruction based upon Taylor's multiple talent approach to teaching, presented a highly effective research-based implementation of a process skills curriculum design. One of the underlying assumptions of this approach was that training in the use of thinking processes can not only enhance potential in varied talent areas but, at the same time, foster positive feelings about self (Schlichter, 1986). McLean and Chissom (1980), in a technical report on the research findings of the Talents Unlimited program, found that self-esteem was affected significantly as a result of participation in the thinking skills instruction in the Talents Unlimited model.

Renzulli and Reis (1985) presented process skills as Type II enrichment activities in their schoolwide enrichment model. These activities are designed to promote the development of thinking and feeling processes delineated as creative thinking and problem solving; critical thinking; and affective processes such as sensing, appreciating, and valuing. These provide students with experiences in cognitive and affective processes that are necessary in developing skills in more advanced types of problem solving (Schlichter, 1986).

Osborn (1963) developed the Creative Problem-Solving model in response to concerns about a lack of problem-solving ability on the part of students. Eberle and Stanish (1980) maintained that creative problem solving is a basic skill and a good sense approach to modern-day living and learning and one that can be taught in the classroom as an instructional method to assist children in becoming resourceful, self-sufficient, and productive. It is within the context of these concerns that educators must attend to the development of a curriculum that addresses the acquisition of process skills.

THE PROBLEM AND ITS SIGNIFICANCE

The problems addressed in this study were to determine if the teaching of problem-solving process skills affect the development of problem-solving skills and to determine if self-esteem is positively affected by the exposure to problem-solving skills strategies across varied ability levels in sixth-grade elementary school students. The problem focused on the question of whether differing ability levels impact the acquisition of problem-solving skills and self-esteem as a result of participation in activities and training sessions which teach specific problem-solving skills. This study attempted to determine if differences exist among varied ability levels of sixth-grade students in the acquisition of problem-solving skills through two teaching approaches and whether self-esteem is impacted among varied ability levels as a result of the two teaching approaches.

While the teaching of creative and critical thinking skills pertinent to problem-solving process skills is prevalent in programs for high-ability or gifted children (Schlichter, 1983) and research provides evidence for the effectiveness of these programs, average- and low-ability children are not, as a rule, provided opportunities for this skill development. Cyert (1980) maintained that there is a need for more emphasis on problem solving in the curriculum and contended that it would be appropriate to teach the problem-solving process to all students in all disciplines. Maier (1981) contended that all children should be provided opportunities to develop mental dexterity to become pro-active learners and to think creatively. Since research indicates that high-ability children benefit from the teaching of problem-solving skills (Parnes & Brunelle, 1967), it is conceivable that average- and low-ability children may also benefit for, indeed, they have the same need as high-ability children to develop problem-solving skills to prepare them for coping in a world of change.

It is also conceivable that self-esteem is impacted by the development of problem-solving skills at all ability levels. Eberle and Stanish (1980) claimed that when children become more creative, there appear to be gains in measures of selfsufficiency as they gain self-confidence in approaching, coping, and dealing with social pressures and negative influences. If, indeed, the development of problem-solving skills and the elevation of self-esteem are possible for all ability levels as a result of process skills teaching approaches, this should be a major consideration of those who have input into curriculum design.

PURPOSE OF THE STUDY

The purpose of this study was to determine if differing ability levels impact the acquisition of problem-solving skills and self-esteem as a result of participation in two approaches to teaching problem-solving skills. In order to achieve the stated purpose of this study, the following research questions were posed:

1. Do differing ability levels impact the development of problem-solving skills among sixth-grade students who participate in problem-solving instruction as measured by the productive thinking (imaginary) flexibility and originality, forecasting, and decision-making subtests of the Criterion Reference Tests of Talent?

2. Do differing ability levels impact the development of self-esteem among sixth-grade students who participate in problem-solving instruction as measured by the Self-Appraisal Inventory?

METHODOLOGY

The research design was the posttest-only control group experimental design. This design was chosen because there was concern that the pretest might be reactive, and this design was possible because of random assignment to strategies and to treatment (Chissom, McLean, & Hoenes, 1980). A two-way factorial design was used for each of the dependent measures as depicted in Figure 1. The two factors considered in the design were ability levels (determined by Otis-Lennon School Ability Indexes after assignment to groups) and strategies (Creative Problem Solving (CPS) for Kids, computer-assisted instruction, and a control group. Two-way analysis of variance was used for each of the dependent measures as depicted in Figures 2 through 6 to compare among group differences for each of the two independent variables simultaneously and to determine if the interact (Chissom et al, 1980). Figure 7 depicts the partitioning diagram and the derivation of the model and error terms.

The subjects were 102 sixth-grade students who were randomly assigned to five classes. The five classes were then randomly assigned to three treatment groups. Two classes participated in the CPS for Kids model approach for teaching problem solving (Strategy 1). Two classes received computer-assisted instruction in problem-solving strategies designed by the Minnesota Educational Computing Consortium (Strategy 2), and one class was a control group (Strategy 3).

Strategy 1, the CPS for Kids model, consisted of five 30-minute lessons per week for 6 weeks. Strategy 2 consisted of five 30-minute lessons of computer-assisted instruction per week for 6 weeks, while Strategy 3, the control group, received neither treatment during the 6 weeks. At the end of the 6-week experiment, student participating in Strategy 1 and the control group received the computer-assisted instruction, and students participating in Strategy 2 and the control group received the CPS for Kids instruction. No data were gathered after these experiences, but they were provided to insure fairness and equal opportunities for all students.

Teachers of the experimental groups participated in formal in-service training led by the researcher. Six hours of training for teachers of the CPS for Kids involved an overview of the creative problem-solving process for children, a presentation of the six levels of creative problem solving, a presentation of the teaching strategies involved in teaching the creative problem-solving process to children, and modeling by the instructor of the teaching strategies. Teachers of these experimental groups were given take-home study assignments for practice teaching and follow-up evaluation was provided.

Teachers of the experimental groups involved with the computer-assisted instruction participated in 6 hours of formal in-service training also provided by the researcher. Documentations of the software of the MECC programs were procured form the Consortium and were presented to the teachers. The teachers participated in the same hands-on computer activities that were made available to students. Teachers were given take-home study assignments for practice teaching, and follow-up

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evaluation was also provided.

Teachers of all groups also received a 1-hour training session in the administration of the posttests. They received instructions, including modeling by the trainer, in standardizing the administration of the productive thinking (imaginary), forecasting, and decision-making subtests of the Criterion Referenced Tests of Talent and the Self-Appraisal Inventory.

The Criterion Referenced Tests of Talent were administered by classroom teachers simultaneously in group situations to all five classes the week following the experiment. The test were collected and mailed to a scorer certified by Talent Unlimited in Mobile, Alabama.

The Self-Appraisal Inventory was administered by the classroom teachers in group settings. Directions were read to the students prior to the administration. The students responded to orally read statements on computer scorable answer sheets. The answer sheets were scored on a Scan-Tron machine.

DATA ANALYSIS

The data were analyzed by two-way analysis of variance to test the four null hypotheses dealing with Criterion Referenced Tests of Talent measures and a two-way ANOVA to test the null hypothesis dealing with the Self-Appraisal Inventory.

In order to achieve the state purpose, the following null hypotheses were tested at the .05 level of significance:

Null Hypothesis 1: There is no significant difference in problem-solving ability among strategies or ability levels of sixth-grade children who participate in problem-solving instruction as measured by the productive thinking flexibility subtest of the Criterion Referenced Tests of Talent.

Problem-solving ability was tested using analysis of variance. The sample consisted of 97 students (Table 1).

The analysis indicated that there was no significant interaction between strategies and ability levels. The data yielded an F statistic of 0.861 (4, 77), $p > .05$ (Table 2). The main effects, strategies (CPS for Kids, computer-assisted instruction, and control), and ability levels (high, average, and low) indicated no significant differences with F statistics of 1.296 (2, 77), $p > .05$ and 0.061 (2, 77), $p > .05$, respectively.

Null Hypothesis 2: There is no significant difference in problem-solving ability among strategies or ability levels of sixth-grade students who participate in problem-solving instruction as measured by the productive thinking originality subtest of the Criterion Referenced Tests of Talent.

An analysis of variance was used to assess the productive thinking originality scores. The sample consisted of 97 students (Table 3). This test revealed no interaction between strategies and ability levels with an F ratio of 0.597 (4, 77), $p > .05$.

For the main effects, strategies and ability levels, F ratios were 0.410 (2, 77), $p > .05$ and 0.121 (2,77), $p > .05$, respectively. This indicated no significant differences. Null Hypothesis 2, therefore, was not rejected (Table 4).

Null Hypothesis 3: There is no significant difference in problem-solving ability among strategies or ability levels of sixth-grade students who participate in problem-solving instruction as measured by the forecasting subtest of the Criterion Referenced Tests of Talent.

An analysis of variance was used to assess the forecasting scores. The sample consisted of 96 students (Table 5).

The analysis indicated that there was no significant interaction between strategies and ability levels. The data yielded an *F* ratio of 0.993 (4, 77), *p* > .05, thus allowing for the testing of main effects. The *F* ratio for strategies was 0.161 (2, 77), *p* > .05, and for ability levels, the *F* ratio was 2.016 (2, 77), *p* > .05. Based on this test, Null Hypothesis 3 was not rejected (Table 6).

Null Hypothesis 4: There is no significant difference in problem-solving ability among strategies or ability levels of sixth-grade students who participate in problem-solving instruction as measured by the decision-making subtest of the Criterion Referenced Tests of Talent.

An analysis of variance was used to assess the decision-making scores. The sample consisted of 95 students (Table 7).

The analysis indicated that there was no significant interaction between strategies and ability levels. The data yielded an *F* ratio of 0.449 (4, 77), *p* > .05, thus allowing the testing of main effects. The main effect, strategy, *F* ratio was 0.524 (2, 77), *p* > .05; therefore, no statistical significance was found (Table 8).

There was, however, significant difference indicted among ability levels. The F ratio for ability groups was 3.860 (2, 77), $p < .05$. Utilizing Tukey's Honestly Significant Difference post-hoc test for multiple comparison,s the significant difference was found between high-ability level students and low-ability level students (Table 9). These data indicate that high-ability level students score higher in decision-making skill assessment--which measures critical (convergent) thinking--than do students of low-ability levels.

Null Hypothesis 5: There is no significant difference in self-esteem among strategies of ability levels of sixth-grade students who participate in problem-solving instruction as measured by the Self-appraisal Inventory.

Self-esteem was tested using analysis of variance. the same consisted of 95 students (Table 10).

The results indicated no significant interaction between strategies and ability levels. The data yielded an F statistic of 0.467 (4, 77), $p > .05$ (Table 11). The main effect strategy indicated no significant difference with an F statistic of 0.290 (2, 77), $p > .05$.

There was, however, a significant difference among ability levels indicated by an F statistic of 10.972 (2, 77), $p < .05$. Using Tukey's Honestly Significant Difference post-hoc test for multiple comparisons, significant differences were found between high-ability students and low-ability students and between average-ability students and low-ability students (Table 12).

These data indicate that high-ability level students and average-ability level students score higher on measures of self-esteem than do students of low-ability levels.

CONCLUSIONS

The results of this study suggest three major conclusions which support current trends in the focus on thinking skills instruction. There continues to be evidence that thinking skills instruction does impact the development of creative and critical thinking and that the acquisition of these skills has a positive effect on self-esteem. This study provides evidence that the length of training is an important consideration in providing thinking skills instruction, that thinking skills instruction should be an integral part of the curriculum rather than a supplementary, isolated program, and that thinking skills instruction is appropriate for all ability level students.

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	CPS for Kids	CAI	Control group
High	Posttest	Posttest	Posttest
Average	Posttest	Posttest	Posttest
Low	Posttest	Posttest	Posttest

Figure 1. Research design.

Ability	CPS for Kids Productive thinking flexibility	CAI Productive thinking flexibility	Control group Productive thinking flexibility
High	Posttest	Posttest	Posttest
Average	Posttest	Posttest	Posttest
Low	Posttest	Posttest	Posttest

Figure 2. Two-way analysis of variance--productive thinking flexibility.

Ability	CPS for Kids Productive thinking originality	CAI Productive thinking originality	Control group Productive thinking originality
High	Posttest	Posttest	Posttest
Average	Posttest	Posttest	Posttest
Low	Posttest	Posttest	Posttest

Figure 3. Two-way analysis of variance--productive thinking originality.

Ability	CPS for Kids Forecasting	CAI Forecasting	Control group Forecasting
High	Posttest	Posttest	Posttest
Average	Posttest	Posttest	Posttest
Low	Posttest	Posttest	Posttest

Figure 4. Two-way analysis of variance--forecasting.

Ability	CPS for Kids Decision making	CAI Decision making	Control group Decision making
High	Posttest	Posttest	Posttest
Average	Posttest	Posttest	Posttest
Low	Posttest	Posttest	Posttest

Figure 5. Two-way analysis of variance--decision making.

Ability	CPS for Kids Self-Appraisal Inventory	CAI Self-Appraisal Inventory	Control group Self-Appraisal Inventory
High	Posttest	Posttest	Posttest
Average	Posttest	Posttest	Posttest
Low	Posttest	Posttest	Posttest

Figure 6. Two-way analysis of variance--Self-Appraisal Inventory.

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Figure 7

Partitioning Diagram to Determine Model and Error Terms

SS Total

SS Among

SS Strategy

SS Ability

SS Strategy

SS Within

Thus, the model is

$$X = M + S_s + A_a + (SA)_{sa} + E$$

The sources and error terms are thus:

Sources	Error Terms
S	Within group
A	Within group
SA	Within group
Within group	Within group

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Table 1

Descriptive Statistics Productive Thinking Flexibility

Ability levels/strategy	M	SD	N
High ability			
CPS for Kids	15.385	6.319	13
Computer-assisted instruction	16.938	4.293	16
Control	14.444	6.220	9
Average ability			
CPS for Kids	15.889	7.745	18
Computer-assisted instruction	17.294	5.849	17
Control	14.091	4.316	11
Low ability			
CPS for Kids	18.000	4.517	5
Computer-assisted instruction	15.333	5.344	6
Control	8.000	8.000	2

Table 2

Analysis of Variance Productive Thinking Flexibility

Source	SS	df	MS	F	Significance of F
Strategies	95.395	2	47.698	1.296	0.279
Ability	4.509	2	2.255	0.061	0.941
S*A	126.786	4	31.697	0.861	0.491
Error	2833.061	77	36.793		

$p > .05$.

Table 3

Descriptive Statistics Productive Thinking Originality

Ability levels/strategy	M	SD	N
High ability			
CPS for Kids	25.923	9.034	13
Computer-assisted instruction	25.875	7.296	16
Control	23.222	9.953	9
Average ability			
CPS for Kids	24.778	13.439	18
Computer-assisted instruction	25.706	9.335	17
Control	23.545	8.938	11
Low ability			
CPS for Kids	27.200	9.108	5
Computer-assisted instruction	23.500	9.878	6
Control	12.500	12.500	2

Table 4

Analysis of Variance Productive Thinking Originality

Source	SS	df	MS	F	Significance of F
Strategies	88.453	2	44.227	0.410	0.665
Ability	26.164	2	13.082	0.121	0.886
S*A	257.454	4	64.363	0.597	0.666
Error	8299.645	77	107.788		

$p > .05$.

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Table 5

Descriptive Statistics Forecasting

Ability levels/strategy	*M*	*SD*	*N*
High ability			
CPS for Kids	3.200	1.166	15
Computer-assisted instruction	3.142	.639	14
Control	2.889	.875	9
Average ability			
CPS for Kids	2.812	1.130	16
Computer-assisted instruction	2.556	.598	18
Control	3.000	.816	9
Low ability			
CPS for Kids	2.400	.800	5
Computer-assisted instruction	2.714	.699	7
Control	2.000	.000	2

Table 6

Analysis of Variance Forecasting

Source	*SS*	*df*	*MS*	*F*	Significance of *F*
Strategies	0.267	2	0.134	0.161	0.852
Ability	3.358	2	1.679	2.016	0.140
S*A	3.307	4	0.827	0.993	0.417
Error	64.125	77	0.833		

$p > .05$.

Table 7

Descriptive Statistics Decision Making

Ability levels/strategy	M	SD	N
High ability			
CPS for Kids	2.867	1.147	15
Computer-assisted instruction	3.000	.866	16
Control	3.333	.667	9
Average ability			
CPS for Kids	2.812	1.130	16
Computer-assisted instruction	2.438	.601	16
Control	2.667	.816	9
Low ability			
CPS for Kids	2.400	.489	5
Computer-assisted instruction	2.429	.494	7
Control	3.000	.000	2

Table 8

Analysis of Variance Decision Making

Source	SS	df	MS	F	Significance of F
Strategies	0.848	2	0.424	0.524	0.594
Ability	6.243	2	3.121	3.860	0.025*
S*A	1.454	4	0.363	0.449	0.772
Error	62.271	77	0.809		

*$p > .05$.

Table 9

Tukey's Honestly Significant Difference Decision Making--Ability Levels

Ability	Strategy 1	Strategy 2	Strategy 3
1		.5	.69*
2			.19
3			

*p = .05; Honestly Significant Difference = .642.

Table 10

Descriptive Statistics Self-Appraisal Inventory

Ability levels/strategy	M	SD	N
High ability			
CPS for Kids	57.533	12.701	15
Computer-assisted instruction	60.200	11.432	15
Control	55.625	13.928	8
Average ability			
CPS for Kids	48.500	11.072	18
Computer-assisted instruction	51.176	15.531	17
Control	53.889	16.017	9
Low ability			
CPS for Kids	38.400	11.977	5
Computer-assisted instruction	34.000	10.770	6
Control	35.500	2.500	2

Table 11

Analysis of Variance Self-Appraisal Inventory

Source	SS	df	MS	F	Significance of F
Strategies	113.415	2	56.708	0.290	0.749
Ability	4286.336	2	2143.168	10.972	0.000*
S*A	364.742	4	91.186	0.467	0.760
Error	15040.223	77	195.328		

*$p < .05$.

Table 12

Tukey's Honestly Significant Difference Self-Appraisal Inventory

Ability	Strategy 1	Strategy 2	Strategy 3
1		6.67	21.50*
2			14.83*
3			

*$p = .05$; Honestly Significant Difference = 9.975.