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AUTHOR Dalton, David W.

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ABSTRACT

This comparison of the effects of LOGO use with the use of teacher-directed problem-solving instruction, and with conventional mathematics instruction, focused on the problem-solving ability, basic skills achievement, and attitudes of junior high school learners. Students (N=97) in five seventh grade mathematics classes were systematically assigned to three treatments: a problem-solving strategies instructional treatment that used printed worksheets, a structured LOGO treatment, and a control group. Learners were then assessed on their achievement, attitudes, and higher-level thinking skills using the Program Criterion Reference Test (PCRT), the Comprehensive Test of Basic Skills, the Revised Math Attitude Scale, the School Attitude Measure (SAM), the Test of Cognitive Skills (TCS), and the Test of Non-Routine Problem-Solving Skills. Results indicated that: (1) neither the LOGO group nor the problem-solving strategies group demonstrated any improvement in basic skills achievement as the result of the experimental intervention; (2) the problem-solving group scored significantly higher than the other two groups on both measures of problem-solving skills; and (3) while learners in the LOGO and problem-solving groups scored significantly higher than their counterparts in the control group in the Revised Math Attitude Scale, this can be, in part, attributable to a novelty effect. It is noted that the problem-solving skills fostered through LOGO use may not transfer outside the context of LOGO, since LOGO provides only a single algorithm which may not apply to many types of non-routine problems. A list of references, one graph, and 12 data tables are appended. (JB)

A Comparison of the Effects of LOGO Use and Teacher-Directed Problem-Solving Instruction on the Problem-Solving Skills, Achievement, and Attitudes of Low, Average, and High Achieving Junior High School Learners

by

David W. Dalton
Instructional Systems Technology
School of Education
Indiana University
Bloomington, Indiana

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With the advent of basic skills curricula throughout the United States, many educators have become increasingly concerned with an apparent lack of emphasis on higher-level thinking skills, specifically, problem-solving skills.

To address this concern, many school districts and individual teachers have adopted the use of the LOGO programming language to teach problem-solving skills. The many assertions regarding the efficacy of LOGO in improving learner achievement, attitude, and problem-solving skills made by the proponents of LOGO have made LOGO seem ideally suited for classroom application. Unfortunately, many of these assertions have yet to be tested empirically.

In this study, the effects of LOGO use were compared with a program that provides instruction in problem-solving strategies, as well as with a control group, using six dependent measures, two on each of the following constructs: achievement, attitude, and problem-solving skills.

The results of the study indicate that neither LOGO nor the Problem-Solving treatments produced significant improvement in basic skills proficiency or general attitudes. However, both LOGO and the Problem-Solving group were successful in improving learner attitudes related to mathematics.

In addition, the Problem-Solving group scored significantly higher on both measures of problem-solving skills than did the LOGO group, demonstrating that the benefits of LOGO may not transfer beyond the LOGO environment.

A Comparison of the Effects of LOGO Use and Teacher-Directed Problem-Solving Instruction on the Problem-Solving Skills, Achievement, and Attitudes of Low, Average, and High Achieving Junior High School Learners

There is considerable evidence to suggest that computer-assisted instruction (CAI) is a highly effective mode of delivery for instruction in a wide variety of instructional settings (Kulik, 1983).

Yet, Papert (1980), the creator of the LOGO programming language and author of the controversial text Mindstorms, argues that CAI is not an appropriate use of the microcomputer. Papert argues that CAI does not allow the learner to control the learning, so the learning content becomes separated from the child's reality, and hence, insignificant.

Papert believes that LOGO's turtle geometry is an ideal vehicle for teaching problem-solving skills. It is Papert's contention that children are able to "relate to the turtle," and that learning becomes more concrete and hence, easier and more relevant. Because the learning is more relevant, Papert and other proponents of LOGO (Lawler, 1980, Watt, 1982) believe that LOGO use leads to improved learner attitudes. In addition, because the learner is able to articulate his/her thinking, they assert that LOGO has meta-cognitive benefits that enable the learners to improve their performance with basic skills and transfer newly acquired problem-solving skills to new learning situations.

On the other hand, other authors have noted what they feel is a lack of applicability of the LOGO language in the framework of the traditional public school curriculum (Steffin, 1983).

Although it has been used and tested extensively at the Artificial Intelligence Laboratory of the Massachusetts Institute of Technology since the late 1960s, LOGO is relatively new in the public school system, appearing in microcomputer form around 1980. Because of this late start, little research has been conducted on the efficacy of the LOGO language. Much of the writings concerning LOGO to date are very "soft" in nature, typically describing an author's experience in integrating LOGO into his/her classroom.

Until recently, the only empirical data available on LOGO had come only from the M.I.T. researchers themselves. Although these studies are objective in nature, many serious questions as to their external validity exist, especially considering much of this research has been conducted on large, main frame computers, rather than the microcomputers in use in the schools. Hence, to date, many of the propositions surrounding the use of LOGO and its benefits are virtually untested.

Clearly, many questions concerning the efficacy of LOGO remain unanswered and more research is required. This study compared he effects of LOGO use with teacher-directed problem-solving instruction and conventional mathematics instruction on the problem-solving ability, basic skills achievement, and attitudes of junior high level learners.

Methods

Subjects

The subjects chosen for this study were 97 seventh grade learners, selected from five sections of a seventh grade mathematics course. Few of the learners in this sample had previous experience with LOGO and none of the learners had been exposed to the problem-solving strategies employed in the problem-solving treatment.

There was an approximately equal distribution of males and females in the group. The sample was composed primarily of Anglo students (n = 85) with only s small amount of minority students (n = 12)

Materials

Three instructional treatments were employed: a problem-solving strategies instructional treatment, a structured LOGO treatment, and a control.

Problem-Solving. This treatment consisted of approximately 20 hours of instruction in problem-solving strategies. The lessons in this treatment consisted of self-contained, print-based worksheets, designed to function entirely as stand-alone instruction. The learners were given the appropriate worksheets and directed to work independently.

The lessons of this treatment focused on six problem-solving strategies: "Guess and Check," "Make a Table," "Patterns," "Make a Model," "Elimination," and "Simplify." Materials for all of the six strategies were adapted from Teaching Problem-Solving Skills (Dolan & Williamson, 1983).

LOGO. In this treatment, the learners were provided with approximately 20 hours of computer time in which to explore the turtle graphics capabilities of the Terrapin LOGO language on the Apple II microcomputer system. Each learner was provided with a lesson which contained a list of new commands and exercises which guided exploration of these commands. Each learner worked independently to complete the lesson. Each lesson also contained a difficult, culminating activity on which the learner focused after completion of the preliminary activities of the lesson.

Prior to the beginning of the study, all teachers involved were given a briefing on the type of intervention that should occur so that the types of suggestions given to the learners would be consistent across all groups.

Control. Learners in this group were given additional time for completing any school assignments and/or recreational reading.

Dependent Measures

In addition to the three treatments described, the learners were assessed on their achievement, attitudes, and higher-level thinking skills.

Achievement Measures. There were two measures of achievement used in this study. The first of these measures was the district administered Program Criterion Reference Test (PCRT). This test is a measure of the student's mastery of the grade level objectives The test contained 80 multiple choice items, four for each of the 20 objectives. Using data obtained from this study yielded a split-half reliability coefficient of 0.78.

The second achievement measure used in this study was mathematics subtests of the Comprehensive Test of Basic Skills The split-half reliability coefficient for the combined scales was found to be 0 90, using data from this study.

Attitude Measures. Student attitude was also evaluated with two measures. The first of these two measures was the Revised Math Attitude Scale, a Likert-type questionnaire Learners were asked to respond to 20 statements on a five part scale, ranging from "Strongly Agree" to "Strongly Disagree." The split-half reliability coefficient of the survey was found to be 0 93

The second attitude scale used in this study was the School Attitude Measure (SAM). The SAM is also a Likert-type survey that contains 85 questions pertaining to attitudes toward school, teachers, and attitudes towards education in general. Data collected in this study indicated that the split-half reliability coefficient of the SAM was 0.78.

Prior to administering the attitude scales, the learners were assured that their responses would be judged "blindly," and that their annonymity would be protected. They were then encouraged to respond honestly to the scales' items.

Problem-Solving Skills Measures. Two measures of problem-solving skills were used in this study: the Test of Cognitive Skills (TCS) and the Test of Non-Routine Problem-Solving Skills (TNRPSS).

The TCS consists of four sections: "Memory," "Analogies," "Sequences," and "Verbal Reasoning." Data from this study yielded a split-half reliability coefficient of 0.88 for the TCS.

The Test of Non-Routine Problem Solving Skills was developed by this author in consultation with teachers familiar with teaching and assessing problem-solving skills. This scale consists of 20 items that measure non-routine problem solving skills. These problems are open-ended in nature with several possible solutions. The learner was able to select the solution strategy he/she wished to employ to solve the problem. This test was scored dichotomously, with the correct answer receiving one point and an incorrect answer receiving no points.

The final version of the TNRPSS was obtained by analyzing test-item data from an original pool of 85 items. The split-half reliability coefficient of the final version of the TNRPSS was found to be 0.76.

Procedure

Students in five seventh grade mathematics classes were systematically assigned to the three treatments previously described from the five class rosters.

Students were then designated as high, average, or low in prior achievement based on sixth grade CTBS scores.

Prior to the beginning of the study, the learners were informed that the treatment groups would be rotated after the initial assignments had been completed.

Each of the learners was then subjected to their respective treatments for two instructional periods, approximately 45 minutes each, per week over a period of two months, 20 sessions in all.

At the end of the experimental period, each learner was posttested on the dependent measures. The experimental data were analyzed as follows.

Experimental Design and Data Analysis

Data from this study was analyzed through a fixed-effects ANOVA for each of the dependent measures. The design of the experiment was a 3 x 3, two-factor design, featuring three levels each of treatment group, LOGO, Problem-Solving, and Control, and prior achievement, High, Average, and Low.

Dependent measures included two measures of posttest achievement (the mathematics subtests of the Comprehensive Test o Basic Skills and the seventh grade Program Criterion Referenced Test), two measures of student attitude (the School Attitude Measure and the Revised Math Attitude Scale), and two measures of problem-solving skills (the Test of Cognitive Skills and the Test of Non-Routine Problem-Solving Skills).

Results

Test of Cognitive Skills

The cell means for the TCS are shown in Table 1. Both achievement level means and treatment group means were significantly different ($p = .001$) as shown in Table 2, the ANOVA for this result.

The Problem-Solving Group differed significantly from the Control, but not from the LOGO group, while the High group differed significantly from the Low group, but not the Average Group.

Insert Tables 1 and 2 about here.

Test of Non-Routine Problem-Solving Skills

The cell means for the TNRPSS are listed in Table 3 and the ANOVA is found in Table 4. These means did not differ significantly (p = .05). However, the mean of the Problem-Solving group was significantly larger (p = .001) than the means of the Control and the LOGO groups, although the means of the LOGO and Control groups themselves did not differ significantly (p = .05).

Insert Tables 3 and 4 about here.

Comprehensive Test of Basic Skills

The cell means for the mathematics CTBS are given in Table 5. There was no signifificant treatment main effect (p = .05), as shown in the analysis of variance table, Table 6. However, the achievement means were significantly different (p = .001). Specifically, the High group scored significantly higher than either the Average or Low group. However, the means of the Average and Low groups were not significantly different (p = .05).

Insert Tables 5 and 6 about here.

Program Criterion Referenced Test

The means for the achievement level groups were all significantly different for the PCRT (p = .001). However, there were no significant differences among the treatment group means (p = .05).

Insert Tables 7 and 8 about here.

Revised Math Attitude Scale

The cell means for the RMAS are given in Table 9 and the ANOVA is shown in Table 10. The means for the treatment groups were significantly different (p = .001). Both the LOGO and Problem-Solving group means were significantly greater than that of the Control group. However, th[illegible] of the Problem-Solving and LOGO groups themselves were not statistically different (p = .05).

In addition, the mean for the Low group differed significantly from the mean of the High group (p = .05). However, the means of the Low and Average groups did not differ significantly, nor did the means of the Average and High groups (p = .05).

In addition to these main effects, there was also a significant (p = .001) interaction between treatment and achievement. This interaction is plotted in Figure 1.

Insert Tables 9 and 10 and Figure 1 about here.

<u>School Attitude Measure</u>

Cell means for the SAM are given in Table 11. Neither treatment group means nor the achievement group means differed significantly ($p = .05$), as shown in Table 12, the ANOVA table for this measure.

Insert Tables 11 and 12 about here.

Discussion

There are three main results from this study that warrant further discussion and analysis. First, neither treatment group, LOGO or The Problem-Solving strategies group, demonstrated any improvement in basic skills achievement as the result of the experimental intervention.

Much of the research on mastery based instructional programs has supported the notion that the learner must actively become immersed in the knowledge or skill that is being learned for mastery to become a reality. In this study, no such intensive basic skills learning took place. Although this type of basic skills instruction is not the aim of LOGO there have been many assertions made as to the efficacy of LOGO in improving the basic skills achievement of learners. The results of this experiment indicate that neither LOGO, nor more conventional problem-solving instruction, produce improved learner achievement., principally due to the lack of focus on these skills.

Second, the Problem-Solving group scored significantly higher than did the Control or LOGO groupon both measures of problem-solving skills. In this case, learners given specific instruction in problem-solving strategies were able to apply this new knowledge to a variety of new problems, whereas learners subjected to a more general learning experience such as LOGO were not able to respond appropriately to new situations. This result again supports the body of conventional research that asserts that specific, well-designed instructional interventions can have positive impacts on learning outcomes. In addition, this result suggests that LOGO's "top-down" thinking model may not transfer to problems outside of the LOGO context.

Finally, although there were no significant results on the <u>School Attitude Measure</u>, there were highly significant differences on the <u>Revised Math Attitude Scale</u>. The SAM measures a variety of general attitudes towards school, teachers, and learning. These attitudes are influenced by years of development, as well as a variety of factors outside of the school itself. It may therefore be logical to conclude that a much more dramatic treatment must be employed over a longer time frame in order to produce significant changes in this type of evolved attitude trait.

However, learners in the LOGO and Problem-Solving groups scored significantly higher than their counterparts in the Control group on the Revised Math Attitude Scale. Yet, neither treatment, LOGO nor Problem-Solving, scored significantly better than the other. Both of these treatments represented something different from the normal classroom routine of these students. Therefore, it is likely that these improved attitudes are, in some part, attributable to a novelty effect.

Finally, the significant Achievement by Treatment interaction present with the RMAS indicates that Low learners in the LOGO and Problem-Solving groups scored far higher than High or Average level learners, while Average-level learners seemed to prefer the Problem-Solving treatment overall, while High learners responded favorably only to the LOGO treatment.

These results, coupled with observations made during data collection indicate that the novelty effect earlier mentioned is most pronounced for the Low learners, who have generally been unsuccessful with conventional classroom instructional practices. It is this type of student that Papert (1980) suggests is benefited most greatly by LOGO. However, the results from this study indicate that virtually <u>any</u> new intervention, especially one in which success comes quickly and easily, is likely to produce substantial improvements in the attitudes of low learners.

The favorable attitudes of Average-ability students toward the material in the Problem-Solving treatment may result from the fact that these materials were designed specifically for "average" learners. In addition, many of these learners have had a variety of computer experiences in previous math classes and in other content areas. Therefore, the novelty effect may have been less strong for these learners.

High learners also responded favorably to LOGO, but less favorably to the Problem-Solving treatment. This result is likely due to the materials of the Problem-Solving treatment were somewhat simplistic for their ability level. Observations indicated that high level learners often developed their own problems to solve in the LOGO environment. Solving this type of personal problem was undoubtedly more challenging and rewarding to these students.

In summary, the results of this study suggest that the problem-solving skills fostered through LOGO use may not transfer outside the context of LOGO, since LOGO apparently provides only a single algorithm which may not apply to many types of non-routine problems. In contrast, the problem-solving strategies taught as part of the Problem-Solving treatment were highly effective in improving the problem-solving skills of these learners. Both the LOGO group and the Problem-Solving group demonstrated an improvement in attitudes related to mathematics instruction. This improvement was, in part, attributed to a novelty effect.

Neither treatment group demonstrated an improvement in more general attitudes or basic skills achievement. This lack of improvement was attributed to the lack of a specific focus on these two constructs. by the materials in these treatments. The results of this study suggest that specific, well designed interventions targeted at specific types of learning can be effective in producing improvements in these learnings. However, non-specific interventions such as LOGO may not be nearly as effective.

It should be noted that the LOGO treatment used in this study was only one of many possible applications of LOGO and it is possible that other applications of LOGO, over longer periods of time, would produce different results and more research with these applications should be conducted. However, based on the results of this study, LOGO does not produce the effects often suggested by its proponents.

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Table 1. Mean percent scores for the Test of Cognitive Skills (TCS).

	Control	PS	LOGO	TOTAL
Low	43.05 (N=9)	59.07 (n=[illegible]	52.50 (n=8)	51.49 (n=26)
Average	60.18 (n=7)	76.81 (n=11)	67.19 (n=8)	69.38 (n=26)
High	74.75 (n=10)	78.58 (n=7)	75.62 (n=12)	76.04 (n=29)
TOTAL	59.85 (n=26)	71.34 (n=27)	66.61 (n=28)	66.01 (n=81)

Table 2. Fixed-effects analysis of variance for the Test of Cognitive Skills (TCS).

SV	ss	df	MS	F
Treatment (T)	1217.21	2	608.60	7.22[a]
Achievement (A)	5409.43	2	2704.72	32.08[b]
TA	305.77	4	76.44	0.91
s:TA	6070.32	72	84.31	

[a] $p < .001$

[b] $p < .001$

Table 3. Mean percent scores for the Test of Non-Routine Problem-Solving Skills (TNRPSS).

	Control	PS	LOGO	TOTAL
Low	25.00 (n=9)	50.56 (n=9)	21.25 (n=8)	32.69 (n=26)
Average	21.43 (n=7)	47.27 (n=11)	27.50 (n=8)	34.23 (n=26)
High	33.00 (n=10)	54.29 (n=7)	29.58 (n=12)	36.72 (n=29)
TOTAL	27.12 (n=26)	50.19 (n=27)	26.61 (n=28)	34.63 (n=81)

Table 4. Fixed-effects analysis of variance for the Test of Non-Routine Problem-Solving Skills (TNRPSS).

SV	ss	df	MS	F
Treatment (T)	10388.95	2	5194.47	20.31[a]
Achievement (A)	825.27	2	412.64	1.61
TA	331.24	4	82.81	0.32
s:TA	18417.96	72	255.81	

[a] $p < .001$

Table 5. Mean percent scores for the mathematics <u>Comprehensive Test of Basic Skills</u> (CTBS).

	Control	PS	LOGO	TOTAL
Low	58.39 (n=8)	58.04 (n=9)	62.35 (n=7)	59.41 (n=24)
Average	68.24 (n=6)	74.01 (n=11)	80.15 (n=8)	74.59 (n=25)
High	87.69 (n=13)	91.47 (n=8)	88.24 (n=10)	88.85 (n=31)
TOTAL	74.68 (n=27)	73.87 (n=28)	78.40 (n=25)	75.55 (n=80)

Table 6. Fixed-effects analysis of variance for the mathematics Comprehensive Test of Basic Skills (CTBS).

SV	ss	df	MS	F
Treatment (T)	266.07	2	133.03	0.71
Achievement (A)	8376.86	2	4188.43	22.43[a]
TA	270.26	4	67.57	0.36
s:TA	13256.39	71	212.09	

[a] $p < 001$

Table 7. Mean percent scores for the Program Criterion Referenced Test (PCRT).

	Control	PS	LOGO	TOTAL
Low	49.63 (n=8)	49.33 (n=9)	53.00 (n=7)	50.50 (n=24)
Average	58.00 (n=6)	62.91 (n=11)	68.13 (n=8)	63.40 (n=25)
High	74.54 (n=13)	77.75 (n=8)	75.00 (n=10)	75.52 (n=31)
TOTAL	63.48 (n=27)	62.79 (n=28)	66.64 (n=25)	71.01 (n=80)

Table 8. Fixed-effects analysis of variance for the Program Criterion Referenced Test (PCRT).

SV	SS	df	MS	F
Treatment (T)	665.87	2	332.94	1.91
Achievement (A)	16253.54	2	8126.77	46.73[a]
TA	1242.17	4	310.54	1.79
s:TA	12347.31	71	173.91	

[a] $p < .001$

Table 9. Mean percent scores for the <u>Revised Math Attitude Scale</u> (RMAS).

	Control	PS	LOGO	TOTAL
	57.50	73.00	74.00	67.97
Low	(n=10)	(n=10)	(n=9)	(n=29)
	62.90	69.15	67.44	66.72
Average	(n=10)	(n=13)	(n=9)	(n=32)
	62.08	61.22	68.69	64.31
High	(n=13)	(n=9)	(n=13)	(n=35)
	60.94	68.13	69.87	69.22
TOTAL	(n=33)	(n=32)	(n=31)	(n=96)

Table 10. Fixed-effects analysis of variance for the Revised Math Attitude Scale (RMAS).

SV	SS	df	MS	F
Treatment (T)	1417.25	2	708.62	22.32[a]
Achievement (A)	208.01	2	104.00	3.28[b]
TA	859.59	4	214.90	6.77[c]
s:TA	2761.64	87	31.74	

[a] $p < .001$

[b] $.01 < p < .05$

[c] $p < .001$

Table 11. Mean percent scores for the <u>School Attitude Measure</u> (SAM).

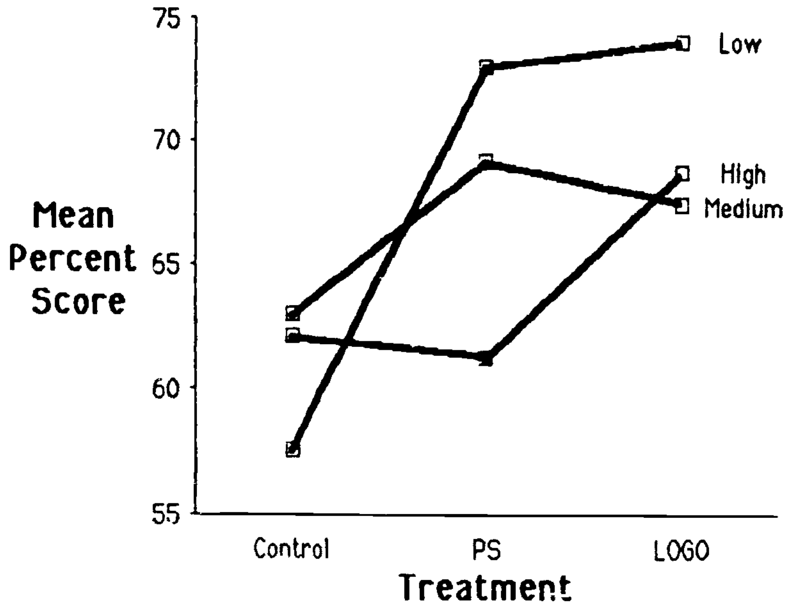
	Control	PS	LOGO	TOTAL
Low	69.63 (n=10)	70.66 (n=10)	67.01 (n=9)	69.17 (n=29)
Average	70.53 (n=10)	72.43 (n=13)	72.53 (n=9)	71.87 (n=32)
High	71.56 (n=13)	69.10 (n=9)	73.46 (n=13)	71.63 (n=35)
TOTAL	70.66 (n=33)	70.94 (n=32)	71.32 (n=31)	70.97 (n=96)

Table 12. Fixed-effects analysis of variance for the School Attitude Measure (SAM).

SV	SS	df	MS	F
Treatment (T)	30.24	2	15.12	0.02
Achievement (A)	1311.86	2	655.93	0.97
TA	1914.78	4	478.69	0.71
s:TA	58673.83	87	674.41	

Figure Caption

Figure 1. Achievement-by-Treatment Interaction for the Revised Math Attitude Scale (RMAS).



75
70
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