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AUTHOR	Yusuf, Mian Muhammad
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ABSTRACT

The objective of this study was to investigate the effects of Logo Mathematics Tutorial Two (LMT2) for teaching polygons to minority students. The polygons were chosen to develop a sound foundation for further knowledge and exploration in geometry. The subjects (N=23) were middle and high school students that were trained using LMT2. The subjects formed two groups that experienced different amounts of traditional and computer-assisted instruction on polygons. Pre- and post-tests were administered three times to each subject. The results suggest that the students who were first taught polygons through LMT2 have a deeper conceptualization of polygons compared to those taught traditionally. The results support the effectiveness of using Logo Mathematics Tutorial Two for teaching polygons to minority students. Tables providing data on race, gender, and grade level distribution; an analysis of covariance for scores on tests, computer tests, drawings, and interview sheets; and distribution by percent for providing reasons are also included. Contains 29 references. (DDR)

COGNITION OF POLYGONS

By

Dr. Mian Muhammad Yusuf
Teacher Education Department
College of Education
Weber State University
1304 University Circle
Ogden, Utah 84408-1304

Phone: (801) 626-6625 (Office)
(801) 393-0930 (Home)
Fax: (801) 626-7427
E-Mail: myusuf@weber.edu

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COGNITION OF POLYGONS

Introduction

The objective of the study was to investigate the effects of Logo Mathematics Tutorial Two (LMT2) for teaching polygons to the minority students. The polygons were chosen for developing a sound foundation for further knowledge and exploration in geometry. LMT2 was used as an instructional tool for integrating Logo programming language into the mathematics curriculum implementing the **Curriculum and Evaluation Standards for School Mathematics** (NCTM, 1989), **Professional Standards for Teaching Mathematics** (NCTM, 1991) and **Assessment Standards for School Mathematics** (NCTM, 1995). The subjects had gone through LMT2 on Macintosh machines for teaching/learning polygon.

Perspective and Theoretical Framework

Clason (1991) described recursive Logo method for dissecting polygons into congruent parts (rep tiles) similar to the original polygon including suggestions and modifications that allowed extended student explorations for modifications into tile patterns. Happs & Manfield (1992) identified four strategies that students used to estimate sizes of angles. Strategies included utilization of the mental images of (i) a protractor; (ii) a right angle; (iii) a half turn; and (iv) angles of a polygon. Battista & Clements (1991) discussed student reasoning while using Logo to draw tilted squares and rectangles. They suggested that teachers recognized that many students used visual imagery to reason and discussed visual reasoning with students. Battista and Clements (1990) described how using Logo tools for manipulating embodiments of geometric objects helped students for constructing more abstract and coherent concepts. Clements (1991) reported the effects of the Logo computer programming environment on creativity. Overall the Logo group significantly outperformed a comparison group receiving non-Logo creativity training and a non-treatment control group. Logo programming activities can be directed more specifically at understanding mathematical concepts (Feurzeig, Papert, Bloom, Grant, and Solomon, 1969; Feurzeig et al., 1971). Thompson and Walle (1985) believed that Logo computer language provides mathematical activities that are geometric in nature. It is written to create an environment in which children can explore mathematical ideas and learn from their explorations (Papert, 1980). Several researches have stressed the usefulness of Logo in teaching problem solving, making it a natural choice for teaching geometry (Battista & Clements 1988a; Clements & Battista, 1989, & 1990; Ernest, 1988; Silver, 1988, Yusuf, 1988, 1990, 1991a, 1991b, 1994a, 1994b, 1995a, & 1995b). In addition, Silver (1988) explained how the flexibility of Logo computer language can be used to stimulate children's creativity. Battista and Clement (1988b) created special Logo procedures, called pseudoprimitives, so that traditional topics in geometry could be treated within the context of the exciting environment of Logo. They described how these procedures could be extended and used in junior and senior high school geometry. National Council of Teachers of Mathematics (NCTM) devoted its 1984 yearbook to **Computers in Mathematics Education** emphasizing the importance of computers in mathematics education, and advocated the use of computers in mathematics in NCTM Standards (NCTM, 1989, 1991, & 1995). NCTM has called for a new mathematics curriculum, new mathematics text books, various new techniques for assessment, and integration of the computer into the curriculum to fulfill the demands of society (including minority groups) and the future (NCTM, 1989, 1991 & 1995).

Middle and high school students have misconceptions about polygons. Lindquist and Kouba (1989) reported, from the results of the Fourth Mathematics Assessment of the National Assessment of Educational Progress (NAEP), that the 7th grade students did not understand the squares are rectangles, that rectangles are parallelograms, and thus, squares are parallelograms. Fewer than half of the 11th grade students were able to give the length of a diagonal of a square when given the area. Cognition of other properties of the polygons were also similar. Therefore, it is considered essential to develop new methods and techniques using Logo computer language for teaching/learning polygons.

Sample

Twenty-three subjects (8th-11th graders; 16 female, 7 male; 19 African American, 4 Hispanic American) were divided into two groups using the merit list prepared on the basis of the pretest. Twelve students on merit numbers 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23 were placed in section one and the others eleven were placed in section two. The sections were assigned randomly to Group A and Group B (Table 1).

Insert Table 1 here

Methods and Techniques

The pretest and the post-test were parallel tests for testing knowledge about polygons. The subjects were interviewed before the experiment and after the experiment to investigate the change in the thought process, reasoning and the conceptualization of polygons. The study reported in this paper used a Quasi-Experimental Counterbalanced Design (Campbell & Stanley, 1963):

Group A	O_1	X_1	O_2	X_2	O_3
Group B	O_1	X_2	O_2	X_1	O_3

Data Source

Group A was taught through Logo Mathematics Tutorial (LMT2) in the first part (X_1) and by the teacher in the second part of the experiment (X_2), while Group B was taught by the teacher in the first part (X_2) and through LMT2 in the second part of the experiment (X_1). The researcher created LMT2 using Logo computer language as a tool for instruction. The subjects of the study used Macintosh machines in the computer laboratory (one student per computer). The teacher was an experienced computer user and knew Logo. She was given training for two days, for an hour each day, on how to use Logo programs and LMT2. She taught Logo computer language to both groups together in the first three lessons (3*60=180 minutes). The X_1 was the treatment for teaching polygons through LMT2, while X_2 was the traditional teaching of polygons using lecture method, text books, handouts (prepared by the teacher with consultation of the researcher), rulers, protractors, compasses, and paper and pencil activities. Each group spent 180 minutes of class time for learning polygons. The instruments administered at O_1, O_2, and O_3, took 50, 20, and 50 minutes respectively. The experiment was completed in a week using 480 minutes of class time. Pretest and Post-test, Interview Sheets, Test1, Test2, Test3, LMT2, and teaching materials were tried out twice and modified. Three mathematics teachers and two professors in the field were consulted throughout the research study.

Logo Mathematics Tutorial Two (LMT2)

This is a tutorial program written in Logo computer language for teaching/learning polygons on Macintosh machines. It consists of two sections, (i) Names of Polygons, (ii) Types of Polygons. A menu appears at the screen for selection. In the beginning the user is addressed with her/his first name and informed as follows: 1) Learn with your own speed. 2) You will be tested at the end of each section. 3) Macintosh will record your performance. 4) Feedback of your performance will be given at the end of each section. 5) You may repeat each section as many times as you like. 6) You will get a take home **Certificate of Performance** at the end of section two. 7) Try to score 90% or more points for each section in order to obtain a very good/an excellent **Certificate of Performance**. These instructions were so motivational that section one was repeated up to maximum 4 times and section two was repeated up to maximum 5 times.

Results and Conclusions

Tests

All students were tested three times (Test1 at O_1, Test2 at O_2, & Test3 at O_3). Each test consisted of 32 items. Test1 at the beginning of the first part, Test2 in the middle, and Test3 at the end of second part were administered. ANCOVA was applied with Test1 as covariate to Test2 (Table 2).

Insert Table 2 here

The significant difference found in favor of Group A at 0.05 level ($F = 11.80$ $p < 0.05$) provided the evidence that the students taught polygons through Logo Mathematics Tutorial Two would have a better conceptualization of polygons as compared with those who were taught traditionally. ANCOVA was also applied with Test1 as covariate to Test3 (Table 3).

Insert Table 3 here

The significant difference was found again in favor of Group A at 0.05 level ($F = 6.17$ $p < 0.05$) and provided the evidence that the students who were first taught polygons through Logo Mathematics Tutorial Two would have a better conceptualization of polygons as compared with those in Group B who were first taught traditionally.

Computer Test

Analysis of Covariance (ANCOVA) was applied with Test1 scores as covariate and Computer Test scores as independent variable (Table 4).

Insert Table 4 here

The insignificant difference found at the 0.05 level ($F = 1.07$ $p > 0.05$) provided the evidence that the students who were first taught polygons through Logo Mathematics Tutorial Two might not have a better conceptualization of polygons as compared with those who were first taught traditionally due to the switched treatments. It should be noted that the students were allowed to repeat as many times as they liked for improving the Computer Test scores.

Figures

The subjects were asked to draw a polygon, a convex polygon, and a concave polygon (Table 5).

Insert Table 5 here

Group A drew 39% figures correct, 43% figures incorrect, and 18% figures were not drawn, while Group B drew 36% figures correct, 19% figures incorrect, and 45% figures were not drawn before the experiment. Group A drew 76% figures correct, 12% figures incorrect, and 12% figures were not drawn, while Group B drew 58% figures correct, 17% figures incorrect, and 25% figures were not drawn after the experiment. Group A performed better than Group B in drawing the correct figures at the end of the experiment.

Interview Sheet Scores

The interview sheets completed before and after the experiment were scored out of maximum 20 points. The students were asked ten questions about the figures, convex and concave polygons, regular and irregular polygons, triangles, rectangles, squares, rhombi, and parallelograms. All the interviews of the students were audio taped. Each question was allotted one point for the correct answer and another point was awarded for providing the correct reason. Analysis of Covariance (ANCOVA) was applied (Table 6).

Insert Table 6 here

The significant difference found in favor of Group A at 0.05 level ($F = 66.36$ $p < 0.05$) provided the evidence that the students taught polygons first through Logo Mathematics Tutorial Two would have a better conceptualization of polygons as compared with those in Group B who were first taught traditionally.

Reasoning for Responses

The subjects were asked to provide reasons for their responses. Their answers were analyzed (Table 7).

Insert Table 7 here

Group A provided 7% correct reasons, 50% incorrect reasons, and 43% no reasons, while Group B provided 6% correct reasons, 33% incorrect reasons, and 61% no reasons before the experiment. Group A provided 33% correct reasons, 40% incorrect reasons, and 27% no reasons, while Group B provided 25% correct reasons, 39% incorrect reasons, and 36% no reasons after the experiment. Group A provided more correct reasons. Both groups were more responsive at the end of the experiment. None of the students from both of the groups could provide any correct reason for questions 2, 3, 4, 5, & 7 before the experiment, while none of the students from Group B could provide correct reason for question number 5 at the end of the experiment. Hence the questions about convex and concave polygons, regular and irregular polygons, and whether a parallelogram is a rectangle were the most difficult in the beginning of the experiment, while whether convex polygon could be a regular polygon and whether a parallelogram could be a rectangle were still difficult for students to provide correct reasons at the end of the experiment.

Pretest and Post-test

ANCOVA was applied with pretest scores as covariate and post-test scores as independent variable (Table 8).

Insert Table 8 here

The insignificant difference found at 0.05 level ($F = 2.24$ $p > 0.05$) provided the evidence that the students taught polygons first through Logo Mathematics Tutorial Two might not have a better conceptualization of polygons as compared with those who were first taught traditionally. However, it was significant at 0.18 level and provided the evidence that the students who were first taught polygons through Logo Mathematics Tutorial Two might have a better conceptualization of polygons as compared with those who were first taught traditionally.

Importance

The results indicated that the students taught polygons through Logo Mathematics Tutorial Two would have a deeper conceptualization of polygons as compared with those who were taught traditionally. However, on the switch of the treatments, interview scores and LMT2 tests scores provided significant results while post-test and computer test scores provided insignificant results at 0.05 level. Group A performed better in drawing the figures and provided more correct reasons for responses. Therefore, it can be concluded that, due to switched treatments, the students who were first taught polygons through the Logo Mathematics Tutorial Two might have a better conceptualization of polygons as compared with those who were first taught traditionally. These results are encouraging and support the use of Logo Mathematics Tutorial Two for teaching polygons to the minority students. It is recommended that the research study should be replicated and extended to different situations to verify the effects of Logo Mathematics Tutorial Two. If in the future such research studies would confirm the effectiveness of LMT2 for teaching and learning polygons then LMT2 could be integrated into the geometry curriculum.

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Table 1

Race, Gender, and Grade Level Distribution of the Sample

Group	Sex	Grade					Race		
		8	9	10	11	Total	Black	Hispanic	Total
A	F	7	1	0	0	8	7	1	8
	M	0	1	1	1	3	1	2	3
B	F	5	2	1	0	8	7	1	8
	M	2	1	0	1	4	4	0	4
Total		14	5	2	2	23	19	4	23

Table 2

Analysis of Covariance for Test1 and Test2 for Group A and Group B

Covariate	Independent Variable	Source	SS'	v	MS'	F	S=Sig./ NS=Not Sig.
Test1	Test2	Between	151.16	1	151.16	11.80	S
		Within	256.30	20	12.81		

${}_{.95}F_{1,20=4.35}$ $p<.05$ ${}_{.99}F_{1,20=8.1}$ $p<.01$

Table 3

Analysis of Covariance for Test1 and Test3 for Group A and Group B

Covariate	Independent Variable	Source	SS'	v	MS'	F	S=Sig./ NS=Not Sig.
Test1	Test3	Between	52.69	1	52.69	6.17	S
		Within	170.81	20	8.54		

$_{.95}F_{1,20=4.35}$ $p<.05$

Table 4

Analysis of Covariance for Computer Test Scores for Group A and Group B

Covariate	Independent Variable	Source	SS'	v	MS'	F	S=Sig./ NS=Not Sig.
Test1 Scores	Computer Test Scores	Between	33.98	1	33.98	1.07	NS
		Within	633.57	20	31.68		

$_{.95}F_{1,20=4.35}$ $p>.05$

Table 5

Distribution in percent for Drawing Figures by Group A and Group B

Group	Figures in Percent					
	Correct		Incorrect		Not Drawn	
	Before	After	Before	After	Before	After
A	39	76	43	12	18	12
B	36	58	19	17	45	25

Table 6

Analysis of Covariance for Interview Sheets Scores for Group A and Group B

Covariate	Independent Variable	Source	SS'	v	MS'	F	S=Sig./ NS=Not Sig.
Before Experiment Scores	After Experiment Scores	Between	66.36	1	66.36	7.73	S
		Within	171.59	20	8.53		

$_{.95}F_{1,20=4.35}$ $p<.05$

Table 7

Distribution in percent for Providing Reasons by Group A and Group B

Group	Reason in Percent					
	Correct		Incorrect		Not ~~Drawn~~ GIVEN	
	Before	After	Before	After	Before	After
A	7	33	50	40	43	27
B	6	25	33	39	61	36

Table 8

Analysis of Covariance for Pretest and Post-test Scores for Group A and Group B

Covariate	Independent Variable	Source	SS'	v	MS'	F	S=Sig./ NS=Not Sig.
Pretest Scores	Post-test Scores	Between	12.57	1	12.57	2.24	NS
		Within	112.03	20	5.60		

${}_{.95}F_{1,20}=4.35$ $p>.05$ ${}_{.82}F_{1,20}=2.15$ $p<.18$

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Signature: [signature] 3/27/97	Printed Name/Position/Title: MIAN MUHAMMAD YUSUF Assistant Professor	
Organization/Address: Weber State University 1557 19th Avenue KENOSHA, WI 53140-1522	Telephone: (801) 626-6625	FAX:
	E-Mail Address: myusuf@weber.edu	Date: 3/27/97

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