THE EFFECTS ON ACHIEVEMENT, ATTITUDE, AND CREATIVITY
OF USING LOGO TO TEACH A UNIT
OF GEOMETRY TO ADULTS

by

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THESIS SUBMITTED IN PARTIAL FULFILLMENT
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The Effects on Achievement, Attitude, and Creativity of Using Logo to Teach a Unit in Geometry to Adults

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Abstract

This study investigated the effects of learning geometry using Logo on students' achievement, attitude towards mathematics, and development of creativity. The study was conducted with adult students completing their high school at King Edward Campus of Vancouver Community College. Their curriculum was equivalent to that of Grade 9 of British Columbia Secondary Schools. The study was based on an experimental group of 14 students and a control group of 24 students, neither being randomized. The geometry curriculum for the experimental group was presented in 15 sessions of two hours each. Ten sessions were in the computer laboratory using Terrapin Logo with nine Apple IIe computers.

The geometry achievement posttest scores were subjected to an analysis of covariance, using pretest as covariate.

Students answered the Estes Attitude Scale to assess changes in attitude towards mathematics. A repeated measures anova was carried out on the pretest and posttest scores.

The Torrance Test of Creative Thinking (TTCT) Figural form was used to measure creativity. The parallel forms of the TTCT were subjected to a repeated measures anova.
The results of this study did not indicate any differential effects of using Logo on achievement, attitude, or creativity. However, the students from the experimental group had to learn to operate the computer, the basics of the Logo language, and the geometry content; whereas in the same amount of time the control group could concentrate exclusively on the geometry content. From the students' responses to an evaluation of the use of Logo to teach geometry there appears to be a positive social impact on the classroom atmosphere influenced by the Logo environment.
Dedication

To the memory of my parents Sara and Benjamin Prizant.
It is said that Ptolomy, son of King Ptolomy of Egypt, asked Euclid, his mathematics teacher, if there was no short way to learn geometry and Euclid replied: "Oh Prince, there is no royal road to geometry"

(Thompson, 1962, p. 9)
Acknowledgment

An undertaking such as this thesis owes much to the contributions, large and small, of many individuals. I thank them all. Some, however, deserve mention.

I am especially indebted, and sincerely grateful, for the attention, guidance, and support of my thesis supervisor, Professor Tom O'Shea. It was he, at our early meetings, who sponsored me. It was also Tom who guided me through all my master's program. I leant heavily on both his ear and his mind. I thank him for his faith.

Special acknowledgement is also due to Jean Cockell and Mary Anna Hawthorn, Vancouver Community College, King Edward Campus, for their friendship and interest in this project.

I also thank my students for their participation and understanding.

I would also like to thank my family for their support and help. Many thanks to Sharli Orr for proofreading the thesis.

Finally, I want to thank Peter Bayerthal, my husband, who supported and enabled me to return to university.
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CHAPTER 1

Children need to be aware of the nature and uses of computers in order to be able to cope with the present and future technological society. (O'Shea & Self, 1983, p. 1)

INTRODUCTION

Geometry is an important branch of mathematics. It allows students to represent many mathematical relationships using the world of figures and their multiple combinations. The mastery of geometry involves the combined utilization of arithmetic and algebra, and thus provides an appealing and meaningful approach to the learning and comprehension of mathematical concepts.

Most teachers of mathematics search for interesting ways to teach geometry that will provide their students with a good understanding of the subject and, at the same time, help them to develop new skills. Visual interpretation of geometric concepts and their construction are difficult aspects of geometry. Computers may provide a useful means to enhance students' understanding of geometry.

With the availability of computer languages, such as Logo, we could provide students with the excitement of learning and the attainment of greater mathematical comprehension. Logo is a programming language developed
for children and based extensively on Piagetian Theory. Logo supports a heuristic style of learning in which a student is encouraged to seek solutions for himself.

As a geometry tool, Logo appeals because interesting things can be done after a brief introduction to the language. Students can command the computer to draw different geometrical designs and receive immediate feedback. They can watch the turtle, the triangular cursor, draw and know immediately if they have given the correct command. Logo is powerful because it quickly enables the student to concentrate on the actual problem instead of worrying about the constraints of the language.

An important aspect of computer use is that students can experiment without the embarrassment of showing their mistakes to their teacher or peers. Each successive step reinforces confidence, and students start building, block by block, not only skills of geometry, but also their own programs on microworld.

**Background**

In 1984, I taught geometry to a group of Grade 12 students. As a new approach, I introduced Logo in teaching one of the geometry units. Six of the 11 students had had no previous computer experience. Five had some idea of programming in BASIC computer language, but only one
student had knowledge of Logo.

The geometry unit included a total of 20 hours of computer time. After being introduced to the fundamental Logo commands, the students were encouraged to investigate different geometrical figures. They chose their own geometrical projects on which they worked both individually and in groups. Finally each student demonstrated his/her project to the rest of the class.

The results were surprising and beyond my expectations. Not only were the geometrical designs in the final projects well chosen and imaginative, the designs also showed an overall understanding of geometry. The students used Logo's algebraic primitives effectively to create these designs.

For the duration of the geometry unit, I observed that the interaction among students was very productive. By looking at, questioning, and commenting on the designs of other class members, students gained insights which were pertinent to their own projects. This contributed to a positive atmosphere and enhanced each student's comprehension of the subject. I also felt that because the program was a hands-on project, as opposed to a lecture-based course, the experiment enriched my relationship with the students.
The Problem

Based on my experience prior to this study, Logo appeared to be a useful tool for teaching geometry. This study investigated the learning of geometry involving the use of computers and Logo. It was anticipated that students who learned Geometry using Logo, when compared with students who received instruction without Logo, would show increased geometry achievement, greater creativity, and a more positive attitude towards mathematics. Three research null hypotheses were investigated as follows.

Hypothesis 1.
There will be no difference in geometry achievement between students who learned geometry using Logo and those who learned geometry using a traditional lecture approach.

Hypothesis 2.
There will be no difference of attitude towards mathematics between students who learned geometry using Logo and those who learned geometry using a traditional lecture approach.

Hypothesis 3.
There will be no difference in creativity between students who learned geometry using Logo and those who learned geometry using a traditional lecture approach.

The students chosen for the study were from Vancouver Community College, King Edward Campus. Two intact classes participated in the research, one designated as the
control class and the other as experimental class. The
classes had a similar curriculum. The control group had
the more traditional book and hand-out material, while the
experimental group worked with computers and Logo.

To evaluate the above three hypotheses, pretests and
posttests were given to both classes. In addition,
students in the experimental class were asked to evaluate
their learning experiences.

**Limitations and Delimitations**

There were several limitations in this study: the
lack of random sampling, two different teachers, time
constraints, non-standardized geometry achievement tests,
student withdrawal, and absenteeism. It was not possible
to have random sampling because the classes at the college
where the study took place were formed according to the
number of students enrolled each semester. The available
classes were not large enough to split into two random
groups. Therefore the decision was made to have the May-
June semester provide the control class, and the July-
August class became the experimental group.

Due to administrative requirements two different
teachers were involved in the study. A variation in
teaching style could have affected the results.

The time allotted for the geometry unit was a
problem. Generally the unit is taught for 15 days in both classes; however we were only able to use the computer lab to implement Logo in the experimental class for ten days. During the ten days, students in the experimental class had to learn both Logo and the required geometry curricula. Thus the experimental class had to learn more material than the control class in the same amount of time.

The geometry achievement tests used as pretest and posttest were not standardized. However, the pretest was normed in British Columbia.

Student withdrawals and absenteeism precluded collection of complete data from every student.

The study was delimited to learning geometry by adult students at a college. Therefore it might not be possible to generalize the research results to students in secondary schools.

**Significance of the Study**

Maurer states that "the advent of powerful microcomputers is putting computing within reach of every school" (1984, p. 422). Although the impact of new technology has been recognized by educators, parents, and students, the use of computers has not yet been widely investigated. There is little evidence to indicate when, how, and for what purposes computers might best be
utilized in the classroom. We still do not know the long-term effects of learning with computers.

The purpose of this study is to seek ways to increase students' interest in geometry and to enhance learning. In particular, this study investigates the effectiveness of using Logo to teach geometry. Logo is a computer language that provides a safe environment in which the students can learn by trial and error. Students can explore new geometric relationships by themselves. Geometry comes alive with the visualization of the concepts.

Many students do not assimilate the new concepts properly because they lack appropriate experiences or basic knowledge. Logo may provide a satisfactory atmosphere where the student can find independently the necessary schemata to anchor new ideas.

Structure of the Thesis

Chapter 2 contains a review of relevant literature. It consists of three sections: learning mathematics, learning geometry, and Logo.

The methodology is described in Chapter 3, including the treatment, the sample of students, and the instruments used to investigate the hypotheses. The analytic procedure is also described in this chapter.

Chapter 4 describes the instructional events of both
groups, and presents the results of the data analysis.

Chapter 5 includes conclusions, and comments on the relevance of the study. It also contains speculations about the results of the study.
CHAPTER 2

LITERATURE REVIEW

...The focus of all mathematics teaching must soon become teaching students to understand mathematics rather than teaching them to manipulate symbols...(Hirsch & Zweng, 1985, p. 39)

This chapter includes a review of the literature of the following topics: learning mathematics, learning geometry, and Logo.

How Do We Learn Mathematics?

The ability of people of all ages to learn ideas, concepts and languages, has led to much speculation as to how learning occurs. This is especially true in the field of mathematics, where concepts and reasoning are often quite abstract. One of the 20th-Century pioneers in analysing the learning process has been Jean Piaget.

According to Piaget’s (1981) theory of mental growth, the basis of learning is the child’s mental activity in interaction with his or her environment and with other people. Piaget’s theory describes mental activity as a process of adaptation to the environment. This adaptation process consists of two steps:

(a) integration of existing knowledge, or accommodation
and (b) the acquisition of new knowledge, or assimilation. The child's mental activity is organized into structures. The separate mental acts are related to each other and grouped together in clusters called schemas or patterns of behavior.

According to Piaget, we learn when we understand. Understanding means to assimilate a new concept into the appropriate schema or to relate it to something we already know. In mathematics the schema-building process is very important. If the early schemata are not appropriately built, assimilation becomes difficult and at times practically impossible.

Concept is an idea that is associated with a physical form; a word is associated with concept, and the way that word is written and sounds is also related to the same concept. Thus, language is very important in concept formation. It is difficult to separate a concept from its representative word. Piaget maintained that once a concept is formed, we are able to find different manifestations of that concept, and thereafter we are able to find similarities between the different occurrences of that particular concept.

Mathematical concepts, it is generally agreed, are more abstract than those found in our everyday lives. To communicate mathematical concepts we need to expose the child to suitable concrete examples. Once the abstraction
process is done and the child can identify similarities between the examples, then a definition will add precision to the concept.

In the study of mathematics one cannot divorce mathematical concepts from the operations used to form them. For example, if we look at the elements 3 and 7, some of the operations or combinations are 37, 73, 3.7, 7/3, and so on. To understand each symbolic presentation one must understand its individual elements and the meaning of the operations represented by the symbols.

Skemp (1976) distinguished two meanings for intelligence:

One is (A), an innate potential, the capacity for development, a fully innate property that amounts to the possession of a good brain and a good neural metabolism. The second is (B), the functioning of the brain in which development has gone on determining an average level of performance or comprehension by the partly grown or mature person. (p. 22)

Skemp maintains that mathematics is a good example of intelligence B, and cites two reasons: (a) the learning of mathematics permits clear examples of the development of schemas and (b) mathematics is the most powerful tool to relate the physical environment to applications of natural sciences, technology, and commerce.

We are able to learn because we have a potential intelligence which has a logical-mathematical structure. This potential is developed when knowledge is acquired and
the result is a more complex level of intelligence.

Of critical importance, however, is the realization that learning mathematics is a question of linking concepts into increasingly complicated conceptual schemas.

Not only must "mastered" concepts be remembered, they must be integrated into progressively more complex systems of ideas; sometimes they must be reconceptualized when they are extended to new domains. Ideas that are true in restricted domains (e.g., "multiplication is like repeated addition" or "a fraction is part of a whole") are misleading, incorrect, or not useful when they are extended to new domains. Mathematical ideas usually exist at more than one level of sophistication. They do not simply go from "not understood" to "mastered." Therefore, as they develop they must be reconceptualized periodically, and they must be embedded in progressively more complex systems that may significantly alter their original interpretation. (Behr, Lesh, Post, & Silver, 1983, p. 104)

Piaget's insights on learning and how mental structures develop have provided a valuable foundation for inquiry into the teaching and learning of mathematics. Now, with more information available, we know that the learning process is more complex.
Language, as well as thoughtfully chosen materials, plays an important role in the development of geometry thinking. (Crowley, 1987, p. 13)

**How Do We Learn Geometry?**

Geometry arose from practical life, evolving through the years from the world of figures and their relationships to eventually form part of formal mathematical theory. The properties of geometric concepts have been abstracted from the world around us, but they do not belong to geometry until we are able to prove them by formal reasoning. When a square is cut with a diagonal line to yield two triangles, it is visually evident that the two triangles are congruent, but in geometry a logical mathematical proof is necessary to show congruency.

At an early stage of their education, children learn geometry concepts intuitively, that is, through visual perception without reasoning. After the intuitive stage these concepts should be formalized into abstractions which must be proved by reasoning. It may be very clear for the young child that two triangles are congruent, but this perception is only intuition (Jackson, 1967, p. 65). The next step in geometry is the abstract concept of congruency.

The concept of congruency becomes abstract when the child understands that it could be generalized to different
figures such as circles and rectangles. When the child is able to verbalize the congruency theorems, the learning process is complete. The child is now able to use a theoretical approach to prove what was previously only known intuitively. To be able to apply the concept of congruency, according to Piaget, the student’s mental structure must have reached the appropriate stage of maturity.

Over the past decade the Van Hiele model of geometric thought has been prominent in the research about the learning and teaching of geometry.

Assisted by appropriate instructional experiences, the model asserts that the learner moves sequentially from the initial, or basic, level (visualization), where space is simply observed – the properties of figures are not explicitly recognized, ... to the highest level (rigor), which is concerned with formal abstract aspects of deduction. (Crowley, 1987, p. 3)

Van Hiele (Crowley, 1987; Hoffer, 1983) distinguished five levels of understanding:

Level 0: Visualization. The students recognize the geometric shapes and learn geometric vocabulary.

Level 1: Analysis. The students discern the characteristics of shapes such as equal angles or parallel lines. At this level no generalization or definitions are understood.

Level 2: Informal deduction. The students at this level can establish the relationship between properties of figures. For example, a square is a rectangle because it has all the properties of a rectangle.
Level 3: Deduction. At this level a student can construct an original proof in more than one way. The interaction of necessary and sufficient conditions is understood.

Level 4: Rigor. This is the level in which the learner can work in a variety of axiomatic systems and geometry is at the highest level of abstraction.

Van Hiele asserts that progress through the levels is more dependent on the instruction received than on age or maturation. If the student is at one level of understanding and the instruction is at another level, the desired learning is not going to happen.

Because of its visual nature, geometry can be introduced in the curriculum at an early age. When the mental level of the child permits the assimilation of abstraction, then we can introduce the formal verbalization of concepts.

In elementary school, many mathematics teachers involve their students in direct learning experiences and activities to make the process of learning meaningful for them. For example, geoboards are quite useful to learn about areas and perimeters (Kipps, 1970; Liedtke, 1971). The construction of geometric figures with straight edge and compass is a good way to find out the properties of geometric figures (Trafton & LeBlanc, 1973). Later on those properties will be abstracted into the enunciation of the proper theorems.

The final and critical process of learning geometry
They define insight as follows: A person shows insight if the person (a) is able to perform in a possibly unfamiliar situation; (b) performs competently (correctly and adequately) the acts required by the situation; and (c) performs intentionally (deliberately and consciously) a method that resolves the situation. To have insight, students understand what they are doing, why they are doing it, and when to do it. (Hoffer, 1983, p. 205)

In other words, the achievement of insight points to the readiness of the students to acquire meaningful knowledge and to be able to use it in the proper situation to solve different problems.

**Logo**

Logo is a programming language designed for children to learn, to explore, and to play with. Seymour Papert and the staff at MIT developed Logo language from LISP. LISP was developed in order to facilitate computer programs that have their roots in pure mathematics and formal logic. Logo, on the other hand, was designed for easy access by young children; it provides a syntax that resembles English, and a user interface that incorporates turtle graphics.

Logo is more than a programming language; it is a philosophy of education based on Piaget’s theories of learning. Papert (1980) said: "I take from Jean Piaget a
model of children as builders of their own intellectual structures" (p. 7), here Piagetian learning is seen as synonymous with learning without being taught. In Papert's utopian vision of future education, he sees young children, each one with a computer, learning how to program with Logo and exploring new possibilities for learning.

One of the built-in features of Logo is turtle graphics, where a cybernetic turtle, represented by a triangular graphic cursor, moves following the user's commands and leaves a trail drawn on the screen. The Logo primitives commands are FORWARD, LEFT, RIGHT, and BACK. These basic commands need numbers as inputs for magnitude. The commands combined will then draw different shapes. These different designs are the product of the user teaching the turtle how to draw.

The turtle graphics constitute a microworld. Microworlds are the working spaces of the learner's ideas translated into Logo procedures to teach the turtle to draw the designs. "The design of the microworld makes it a 'growing place' for a specific species of powerful ideas or intellectual structures" (Papert, 1980, p. 125).

Although Papert said that Logo is not a panacea, during the last decade it has become a magic formula for many educators looking to solve perennial educational problems.
The relationship between a programmer and his program is much like that of a scientist and his theory, and this comparison has encouraged the opinion that children might benefit from learning to program. The whole sequence of 'teaching the computer' to drive the turtle can serve as a precise, easily grasped metaphor for the child to use in understanding his own thinking and learning. (O'Shea & Self, 1983, p. 18)

Research on Mathematics Learning Using Logo

The potential of Logo to enhance the learning process in mathematics has recently spawned a number of research projects. Some of the major projects are detailed together with the mixed results obtained.

The Edinburgh Project

The Edinburgh Project (Howe, O'Shea, & Plane, 1980) was conducted by the University of Edinburgh, Scotland. It was a two-year project at a private boys' school. The sampling was not random. From the four mathematics classes at the Grade 7 level the classes with the lowest and the second lowest achievement were assigned as the experimental and control groups, respectively. Each group had 11 students. Both groups attended their regular mathematics classes. The experimental students, in subgroups of four, attended the Logo lab at the Artificial Intelligence Department of the University for one hour a week during two school years.
The teaching objectives were: (a) to improve the students' ability to handle particular topics in the mathematics curriculum, (b) to improve their understanding of basic skills and concepts, and (c) to increase their mathematical self-confidence for example, being able to discuss mathematics problems with their teacher.

A set of worksheets was prepared to help the students to overcome their particular difficulties in mathematics. These worksheets were structured in a format similar to the programming worksheets.

The students were given standardized pretests and posttests: (a) Verbal Test, (b) Mathematics Attainment Test, and (c) Basic Mathematics Test. The results showed a significant difference in Mathematics Attainment Test for the control group. The experimental group showed some improvement in the posttest Basic Mathematics. However the teachers attributed this improvement to the worksheets prepared for the experimental group students on specific topics.

At the end of the project the teachers were asked to answer a questionnaire about the students' ability, performance and attitude. Two of the questions were singled out by the researchers: (a) The student will argue sensibly about mathematical issues, and (b) The pupil can explain his own mathematical difficulties clearly. They
found evidence for experimental group superiority on both questions.

The Brookline Project

This study (Watt, 1979) was conducted by the MIT Logo group in collaboration with Brookline, Massachusetts Public Schools. In the first phase of the project, 50 sixth-grade students participated but only the work of 16 students ranging from academically gifted to learning disabled was documented in detail. The results of the project indicate that a Logo learning environment is suitable for gifted as well as average students. Disabled students too were able to enjoy success.

The authors of the project admitted that they were not able to obtain data about learning gains made by the students.

Standardized tests had been rejected as irrelevant to the goals of the project (the ability to use turtle geometry is not measured by sixth-grade math tests). The problem-solving tests and mathematical tests devised and administered by the project staff had inconclusive results. (Watt, 1982, p. 120)
Several studies were conducted during 1981-1983 (Kurland & Pea, 1983; Pea & Kurland, 1984) at Bank Street College of Education, Center for Children and Technology, New York.

**Children's Mental Models of Recursive Logo Programs.**

This study (Kurland & Pea, 1983) deals with the recursive procedure in Logo. The rules for recursive procedure in Logo programming are:

1. The Logo program proceeds line by line. However when a procedure calls another procedure, all the lines of the named procedure are inserted into the executing program at the line where the procedure was called.

2. If a procedure does not call any procedure, execution proceeds line by line until the end of the procedure. END means that the execution of the current procedure has been completed and then will be passed back to the calling procedure.

3. There are exceptions to the line by line execution rule. An important one for recursion is the STOP command. STOP causes the execution to be halted and control to be passed back to the calling procedure. Functionally, then, STOP means to branch immediately to the nearest END statement (Kurland & Pea, 1983, p. 36).

The research was intended to find out how well novice
programmers would be able to understand and use the above rules.

The participants were 7 children from 11 to 12 years of age. They were already in their second year of Logo programming (an average of more than 50 hours of Logo programming) and highly motivated to learn more Logo.

The materials used were short Logo programs constructed with four levels of complexity including REPEAT, STOP, IF and recursive procedures. They were asked to think aloud about how a Logo procedure would work, and then to simulate, using a turtle pen on paper, the program line by line. After that, they were shown the program on the computer. If there were discrepancies they were asked to explain why. The children in general were accurate with the first two levels of complexity. However, those students who had problems had flaws in their mental model of the commands. For example, for them the command STOP or END would be taken quite literally; and they could not understand why the procedure would not stop or end.

The researchers interpreted their results to imply that the programming framework did not allow mapping the meaning of natural language terms to the uses given in the programming languages. They concluded that it is necessary to instruct novice programmers in the correct use and meaning of commands.
Logo Programming and the Development of Planning Skills—Study One

Thirty-two students from a private school in Manhattan participated in this study (Pea & Kurland, 1984). Sixteen of the children were 8 to 9 years old and the others were 11 to 12 years old. The experimental group comprised four boys and four girls of each age group who were learning Logo computer programming. The control group consisted of four boys and four girls of each age group who were not learning Logo. The criteria for selection of students to the experimental group were: "(1) a large amount of time working with Logo during their first two months of computer use (prior to the first experimental session) and (2) teacher-assessed reflectiveness and talkativeness so that rich think-aloud protocols would occur during the task" (Pea & Kurland, 1983, p. 14). Only the second criterion was used to select the control group. The children from the experimental group spent about 30 hours programming in Logo. The control group was the non-programming class.

The study was based on problem-solving, specifically on planning and dissecting a problem with a focus on efficiency. The teachers in charge of the experimental group were trained in Logo before the study and their self-defined role was principally to respond to students' questions (Pea & Kurland, 1984, p. 16). The students were
encouraged to create and develop their own computer programming projects.

The students were tested individually. The result of the study was that the students, after a year of Logo programming, did not show a measurable change in their planning skills.

**Logo Programming and the Development of Planning Skills—Study Two.**

This second study (Pea & Kurland, 1984) was designed to simulate programming in its deep structural features. The intention was to alter the task from Study One to increase the correspondence between the demands of the task and the capabilities of the computer programming language.

The participants were from the same school but this time 64 students were selected. The major difference from Study One was that the teachers decided this time to take a more directive role in guiding their students' explorations with Logo. The experimental and control groups were randomly selected. Control group as in Study One was the non-programming group.

The logic of the analysis for Study Two was different from Study One. The analysis was designed to take a closer look at potential programming-related effects.
Even though the researchers made an effort to give students in the experimental group tasks resembling programming in order to observe the transfer of the skills, the conclusion was that there did not appear to be automatic improvement of planning skills as a consequence of learning Logo programming.
Atlanta-Emory Logo Project

This project (Olive, Lankenau & Scally, 1986) was done through the coordinated efforts of Emory University and the Atlanta Public School System. The purpose of the Emory project was to investigate the effects of a Logo environment on students' understanding of geometric relationships and related cognitive processes.

The Atlanta-Emory Logo Project was organized in four phases. Phase I, which served as a pilot study, started in the Spring of 1984 with one school participating.

Members of one Grade 9 class were randomly assigned to one of two computer classes: a BASIC Language class or a Logo Graphics Programming class. This phase of the study ran for approximately six weeks, and the students met for 1 1/2 hours three times a week. The Phase I curriculum was revised for use in Phase II.

Phase II offered Logo courses during the 1984-1985 school year and two schools participated. The teachers involved in the projects received their training during the summer of 1984. The Logo classes had 15 to 20 Grade 9 students each semester. They were allowed to participate, if their time-tables permitted it. During this phase, project staff and the teachers in charge discussed curriculum, instructional activities, and problems encountered in the implementation of the Logo Graphics programming.
An important feature of this project was the ongoing training and support that the participating teachers received. Besides the training received prior to the project, the teachers developed a close working relationship within and between school and university personnel.

High school mathematics teachers were trained to create a Logo learning environment in order to enhance the students' possibilities in developing cognitive abilities and geometric reasoning.

Logo classes were taught during the two semesters of the 1984-1985 school year. The topics selected for investigation were quadrilaterals and angles.

Phase III began in the Summer of 1985, focusing on curriculum development and documentation for instruction, as well as on evaluation strategies for assessing the Logo project.

Data Collection

The evaluation was focused in two areas: (a) formative evaluation concerned with the development of the program, and (b) summative evaluation to assess the effects of the program. The formative aspect of evaluation was based on information from class, student and teacher interviews, students' dribble files (computer work of each student saved on a disk) (Olive, 1986), and
activities designed to assess students’ understanding at given points in the Logo course. The summative evaluation was carried out with standardized tests of achievement, non-verbal cognitive abilities, and logical thinking.

Two qualitative assessments were developed. Dribble files were analyzed using criteria based on the SOLO (Structure of the Observed Learning Outcomes) taxonomy and Skemp’s model of mathematical understanding, and clinical interviews were designed to assess levels of geometric understanding using the van Hiele model of geometric thought.

It was anticipated that data collection would continue one year after the Logo Experience.

Classroom Implementation.—School 1.

Each class consisted of approximately 20 ninth-grade Algebra I students who were going to take Grade Ten geometry. Enrollment in the Logo class required both that Logo could be accommodated on the student’s schedule, and that parental permission be granted. Students not taking Logo were assigned to the control class.

The class had 14 microcomputers, one printer, a modem, and one graphic plotter. Logo was offered as a one-semester course with daily classes of 50 minutes. Students worked in pairs but also had an opportunity to work alone. They were encouraged to share their work and ideas. The students’
computer experience varied from knowing Turtle Graphics to not having any previous access to a computer.

**Classroom Implementation.- School 2.**

There were 18 students enrolled in the Logo class during the first semester and 14 during the second semester. They had 14 computers, one modem, and one graphic plotter. The students' in-class situation was similar to that in the other school with respect to work habits and computer experience.

At the end of the second semester the students stated:

...that they preferred their role in the Logo class to their role in most other classes. They felt that their opinions were accepted and appreciated by the teacher and other students. They were not afraid to make mistakes in front of their peers. (Olive et al., 1986, p.69)

Students felt free to help each other, and they expressed their ideas more clearly than did students in the control class. It was felt that these factors contributed to improved learning outcomes. (Olive et al., 1986)

Phase IV began in August, 1986 and finished in June, 1987. During this time the testing and data collection were completed.
General Achievement Testing Results

The Logo and comparison groups’ mean scores from various general achievement tests were compared through analyses of covariance using school and semester as covariates and treatment group as the independent factor (Olive et al., 1988, p. 11). No significant differences between group means were obtained for: semester grades, Geometry City Tests, Standardized Achievement Tests, and Test of Logical Thinking.

Cognitive Abilities

The Cognitive Abilities Test, Level G, was administered on three occasions: September, 1985 (pre-Logo), January and May, 1986 (post-Logo for each semester), and May, 1987 (post-Geometry). The four subtests given to all students resulted in nonsignificant differences between Logo and comparison groups in all of the three administrations of the Figure Classification, and Figure Analysis subtests.

For the two subtests, Equation Building, and Figure Analogies, nonsignificant differences were found in the first two administrations. After the geometry course, both subtests yielded significant differences in favour of the Logo group. The researchers commented that these results did not show any consistent pattern that could be attributed to the Logo experience. Most of the geometry
classes had a traditional method were the teacher introduced the topic with exercises from a text book followed by students work on assigned exercises from the text. The Logo classes, on the other hand, had a different context for learning. Therefore, that what was learned in one context should have little impact on what was learned in a different context (Olive et al., 1988, p. 23).

**Associations Among Students’ Interactions with Logo and Mathematical Thinking**

Clinical interviews were conducted with students from Logo and comparison groups each semester. The design of the clinical interview was based on the van Hiele model of levels of geometric thought. The topic was angles and their characteristics. The interviews were analyzed in terms of indicators of levels of thinking achieved. The interviews took place on three occasions: pre-Logo, post-Logo, and at the end of Grade 10 with those students who went on to geometry. Five of the six Logo students appeared to have reached the descriptive level, whereas only three students of the comparison group appeared to have progressed beyond the visual level.

Students’ dribble files were compared with individual students’ mathematics grades, as well as with their responses to clinical interviews, to seek the relationships
between those measures. Different hypotheses were investigated. The conclusions and recommendations were based on the links established among the three theoretical models used to analyze the data. The report confirms that students at relational understanding levels (SOLO Taxonomy) (Olive et al., 1988, p. 31) on Logo programming and geometric concepts would succeed in mathematics courses.

The authors claim that there is some evidence that a Logo environment can help students to use a visual approach to effectively solve geometry problems. However, that visual ability may prevent some students' movement from a descriptive level of thinking and working to a higher level.

The report concludes that, some students who were successful with the programming tasks did not appear to grasp the geometric concepts, thus programming success was not a sufficient condition to do better in mathematics. This results suggests that, for some students, a non-programming use of Logo may be more beneficial in that it provides the opportunity to explore and build mathematical concepts.

The use of Logo microworlds, specifically designed for the exploration of particular mathematical concepts, integrated into the regular mathematics classes, is the major recommendation from this project. (Olive et al., 1988, pp. 47-48)
**The Clements Studies**

Clements and his colleagues have reported positive and interesting outcomes concerning the benefits of computer programming compared to computer-assisted instruction (CAI) on specific cognitive abilities, metacognitive skills, creativity, and achievement.

In a number of studies (Clements, 1985; Clements & Gullo, 1984; Clements & Nastasi, 1985), it was found that students using Logo or computer assisted instruction interacted well with one another. The authors note that those using Logo showed more positive social-emotional effects than the others. Logo learners were more inclined to solve their problems, help one another, work on their own, enjoy their discoveries, and talk about their problem-solving strategies.

Using the Torrance Tests of Creative Thinking (TTCT), which is very simple to administer to young children, Clements and Gullo (1984) found significant differences on fluency and originality. The subjects for the study were 18 first-grade children randomly assigned to either a group that received CAI, or a group that learned computer programming with Logo.

Another study (Clements, 1985) had 72 first-grade children randomly assigned into (a) Logo computer programming, (b) computer-assisted instruction, and (c) a
control group. There were significant differences on the TTCT dimensions of originality and elaboration. Clements speculated that the Logo group's high scores on originality may have resulted from the tendency of the Logo students to combine a entire pages of shapes into single drawings.

**Conclusion**

Over the past 10 years Logo has caused controversies about its different features, its potential, and its learning outcomes. It is interesting to examine the research findings, though they are currently limited to elementary students. Significant differences in geometric achievement were found after the Logo treatment; these results suggest some transfer effects in children, in (a) the ability to follow directions and (b) the ability to formulate directions (Gallini, 1986; Rieber, 1983). Also, Logo appears to enhance the development of metacognitive skills in small children.

Another important issue is the effective use of cooperative learning (See Capper & Copple, 1985 for readings on cooperative learning) in the classroom. Logo enables students to interact, and to benefit from working in pairs (Clements, 1984).

The research findings are quite limited. Little has been established, for example, about the psychological consequences of exposing children at an early age to
computer programming. Just as an electric train may not be a suitable toy for a 6-year-old child, computers may not be the best learning tool for them either.

It is clear from the literature that more specific research is still needed on the long-term effects of Logo not only on the students but on the teacher. The role of the teacher in the Logo environment is different from that of the traditional lecturer (Olive et al., 1988). The Logo teacher is more of a consultant than a lecturer or instructor.

Controversies between teachers have ignited Logo investigations. The opponents suggest that exposure to Logo may not produce the desired motivation and positive attitudes towards learning. On the other hand, the proponents claim that learning via Logo promotes a favorable interaction in the classroom.
CHAPTER 3

METHODOLOGY

This chapter describes the purpose, sample, procedure, treatments, instruments, and data analysis used for this study.

Purpose

The main purpose of this study was to determine whether teaching geometry using Logo would increase students' mathematical achievement. Also of interest was whether Logo would have a positive influence on both improving students' attitudes towards mathematics and on developing their creativity.

Sample

This study was conducted with students enrolled in Mathematics 051 at Vancouver Community College (VCC), King Edward Campus (KEC). The curriculum is equivalent to Grade 9 Mathematics in British Columbia public schools, and contains a unit on geometry. This course, Math 051, is offered for adults over 19 years of age whose main interest is to upgrade their education in order to complete high school. In general these classes at VCC, KEC, have a withdrawal rate of between 15 and 20%. There is also a
high rate of absenteeism, due mainly to the economic and social problems of the students. In spite of this, the students are strongly motivated to learn.

Procedure

For the study we designated the two available classes, respectively, as the control class and the experimental class. One of the regular VCC teachers was in charge of the control class, I was in charge of the experimental class, and I also tested both classes. The control group was taught during May and June of 1967. It had an enrollment of 33 students, but because of student withdrawal and absenteeism we were able to obtain complete data for only 24 students. The experimental group was taught during July and August of 1967. It had an enrollment of 21 students, and we were able to obtain complete data for 14 students. The students were asked to sign a consent form with the information about the study (See Appendix A). Their participation was voluntary.

The schedule for the Mathematics 051 course consisted of 36 days of two-hour classes. For both groups the geometry curriculum was taught for 15 days. The control group was taught using a traditional lecture method. The experimental group had its schedule divided into 10 days at the computer lab and five days in a regular classroom.
Treatment

The control group received traditional lecture-style instruction in geometry, and the experimental group was taught geometry using computers and Logo. Both groups completed a number of pretests and posttests. The tests were selected to enable the assessment of achievement in geometry, attitudes towards mathematics, and creativity.

Both classes started the geometry unit with three sets of pretests. The first set, the Geometry and Measurement Grade 7/8 Achievement Tests, constituted a general achievement test in geometry; the second, the Estes Attitude Scale, was used to judge students' attitudes towards mathematics; and the third, the Torrance Test of Creative Thinking, was utilized to evaluate creativity. Following the testing session, a slide collection of geometrical designs from Islamic Art was shown. The students were given two sheets printed with different geometrical patterns and asked, as homework, to create designs based on the Islamic Art slides.

The geometry curriculum for both classes consisted of the following units: (a) Lines, segments, angles, and parallel lines; (b) Triangles, areas and perimeters; (c) Circles, circumferences and areas; and (d) Regular polygons, inscribed and circumscribed in a circle. (See Appendix B)
Instruction in the control class was based on handouts and lectures. The teacher explained the section and gave handouts with homework based on that day's instruction.

The experimental class started each of their first 10 sessions in the computer lab. We had access to nine Apple IIe computers, and we used Terrapin Logo. We had the use of a computer hookup to a large TV screen for class demonstrations. Every student was given a disk with previously saved Logo procedures on it; the students were expected to expand upon the supplied material and to produce more elaborated Logo procedures (e.g. circles, polygons). The students received handouts which outlined the: (a) content of the computer lab sessions, (b) Logo commands, (c) project specifications, and (d) procedure explanations. (See Appendix C)

The final five sessions for the experimental group were held in a classroom; the instruction consisted of lectures and handouts.
Instruments

Pretests

The three pretests given to both classes were:

1. The Geometry 7/8 achievement test.
2. The Estes Attitude Scale.
3. Torrance Tests of Creative Thinking, Figural Form A.
   (See Appendix D)

Geometry 7/8 Test

The test used was the Geometry and Measurement Grade 7/8 test from the 1980 British Columbia Mathematics Achievement Tests. These tests are keyed to objectives for Grade 7 in the 1980 edition of the provincial curriculum guide for mathematics.

Before they were selected to be included on these tests, all the test items were pilot-tested during the 1978-79 school year on over 6,500 Grade 7 students from all regions of British Columbia. The information thus obtained was used to select the 40 items for this test and to provide the interpretive information in this (teacher) manual. (Geometry & Measurement, 1980)

The test is divided into 3 parts:

Part A, Angles and Segments, with 11 multiple-choice items;
Part B, Geometric Figures, with 12 multiple-choice items; and
Part C, Units of Measure, with 17 multiple-choice items.

The students were given 45 minutes to answer the 40 questions.
Estes Attitude Scale

This test was given to measure the students' attitudes toward mathematics. The test has fifteen statements, and each one was rated on a scale from one to five. An example typical of the statements is "Being able to add, subtract, multiply, and divide is all the math the average person needs". The possible answers are: I strongly agree (5), I agree (4), I cannot decide (3), I disagree (2), and I strongly disagree (1).

Torrance Tests of Creative Thinking: Figural Form A.

The Torrance tests consist of three activities. In each one the student is encouraged to think of an original picture by constructing, or adding lines, to shapes or incomplete figures. The students are asked to give a title that best represents each picture. The students are given ten minutes to complete each activity after the instructions have been read. Activity 1, is a picture construction using a given shape. Activity 2, has ten incomplete figures to be completed by adding lines. Activity 3, has 30 pairs of straight lines that should be the main part of a figure to be completed.

The dimensions of creativity that each student is assessed on are: fluency, flexibility, originality, and elaboration.

The tests were submitted to the Scholastic Testing
Service for scoring. Each student report contained a score divided into three sections: (a) a profile of creative thinking scores, (b) general interpretive guide, and (c) part-score information.

The student's raw scores for each dimension were converted into standard scores. Standard scores are reported on a scale with a mean of 100 and a standard deviation of 20. The students' standard scores for each of the four dimensions were used to do a comparison between the control and experimental groups.

Parallel test reliabilities between Form A and Form B for each dimension are: fluency $r = .71$; flexibility $r = .73$; originality $r = .85$; elaboration $r = .83$. (Norms—Technical Manual, 1974)
The three posttests given to both classes were:

1. The Geometric Achievement Test,
2. The Estes Attitude Scale, and
3. Torrance Test of Creative Thinking, Figural Form B.

(See Appendix D)

**Geometric Achievement Test**

The geometry test (See Appendix D) contained a combination of items taken from Ministry of Education British Columbia, Classroom Achievement Tests Grade 9/10, Geometry and Measurement (1981), and items taken from prior exams used for the Mathematics 051 course with a total of 50 marks.

The test contained four parts:

Part A, Areas, parallel lines and circumferences. Nine multiple-choice items from the Geometry and Measurement Classroom Achievement Test 9/10 (18 marks);

Part B, Construction of angles, bisection, and inscribed regular polygons in a circumference. Four open-ended items (12 marks);

Part C, Angle measurement problems. Four open-ended items (8 marks); and

Part D, Problems involving areas and differences of areas in circles and squares. Four open-ended items. (12 marks)

The students were given one hour to answer the questions.
The construction of the test, and the criteria used for the scoring of the tests for both groups, was based on agreement between both participating teachers. There was agreement on the distribution of the marks and the criteria for scoring each item. Each number item was marked by the same teacher for both classes. I marked the even numbers and the other teacher the odd numbers. This procedure ensured that every question would have the same evaluation criteria.

Estes Attitude Scale

The same Estes Attitude Scale items were used on the posttest as were used on the pretest.

Torrance Test of Creative Thinking Figural Form B

The Torrance Test Form B is a parallel test to Form A, and is designed to be used as a posttest.
Logo Evaluation

The experimental students were asked to answer a two-part questionnaire related to their impressions of the Logo learning experiences.

Part A investigated the development of new skills due to the influence of Logo, the students' appreciation of this method of learning, and the use of time spent in learning Logo as part of the course; the students were also asked to provide comments about any aspect of the course.

Part B surveyed students' previous computer experience, knowledge of Logo, and use of Logo as a tool to learn geometry and algebra, as well as students' exposure to computers in other subject areas. (See Appendix D)

Analytic Procedures

To analyze the data I used the statistical package SPSS on the MTS operating system.

Geometry Achievement

The students' pretest scores were used to compare the prior geometric knowledge of students in the experimental and control classes. An independent t-test was performed to detect differences.
The students’ pretest and posttest scores from the experimental group were used in a t-test to assess the gain in geometric knowledge.

The students’ pretest and posttest scores from the control group were used in a t-test to assess the gain of geometric knowledge.

The posttest scores of the experimental and control classes were then subjected to an analysis of covariance using the pretest scores as covariate in order to compare geometric achievement after treatment.

**Estes Attitude Scale**

The results of pretest and posttest Estes Attitude Scales from the experimental and control classes were subjected to a repeated-measures analysis of variance to determine students’ changes of attitude towards mathematics after the geometry unit.

**Torrance Test**

The students’ raw scores from the TTCT for each of the four dimensions were converted into standard scores. The average of these standard scores was used to do a repeated-measure analysis of variance to determine if the control and experimental class differed in their creativity after the geometry unit.
CHAPTER 4

RESULTS

Students' Activities in the Experimental Group

The purpose of this section is to inform readers of the research results and the way that we progressed day by day. It also gives useful information based on the control teacher and my observations in order to improve future experiments and results.

The students used 12 Apple IIe computers and had the use of a computer hookup to a large TV color screen for demonstrations. The class handouts, Logo curriculum, Logo outline, and worksheets were prepared by myself. (See Appendix C) The activities were taken from Logo Discoveries (Moore, 1984) (See Appendix E). We had 10 Logo Terrapin programs that the students used to load the computer and each student had his/her own disk with procedures already saved for them. In addition, their disk was used to save their projects during the class.
Session 1

Description. This session was mainly dedicated to showing the students how to load the computer with the Logo program and to explain the different Logo commands in order for them to be able to work on their own. The students had reading material and books available as a source of ideas. They received handouts indicating their daily activities.

Comments. 1. For some students this was the first time they had to work with a computer. Consequently they had to learn how to use the keyboard and encountered some difficulties in operating it.

2. The students were encouraged to work in pairs. In general they did so.

3. They followed the specifications and some were able to produce interesting designs by just moving the turtle on the screen.

4. The specifications did not have a list of error commands and some of the students had a hard time trying to understand their errors, and how to eliminate them.
Session 2

Description. Every class started with a demonstration by the instructor. The demonstration was based on the drawing of a house. I asked the students to help with ideas about problem-solving. I allowed their mistakes to happen and encouraged the students to look for the solution. I explained the uses of the procedures that were saved in their work disks.

The students started drawing their designs. They were at liberty to draw anything they chose. They were able to look at the resource books or discuss the details between themselves or with the instructor. The idea was for them to learn the Logo commands according to their needs.

Comments. 1. In general, students were able to follow the instructions. Some students asked for procedures that were not in the handout.

2. They were happy to be able to try new instruction methods and their motivation was high. Some of them remarked, "this is great, it is hard, but I like it!"

3. They started to communicate better with one another and this led to cooperation among peers.

4. Some students preferred to follow the instructions instead of trying new possibilities.

5. The students found the worksheet very helpful.
Session 3

Description. The students that were able to finish their design from the previous session were asked to demonstrate their work to the class. The students were encouraged to lay out in advance their design instead of working directly on the computer. They learned how to "SAVE" and to "READ" from a disk. Some of the students were able to start working on Project # 1.

Comments. 1. The TV screen was very useful for the daily demonstration.

2. The students' attitude was enthusiastic and positive.

3. Often students neglected to write up their procedures. It was important for them to do that, in order to be able to follow the procedure's logic and to improve those procedures.

4. We noticed something very important - when students were absent they lost two hours of computer-time. How could the students recover this lost time when they were only able to use the computers during class?
Session 4

Description. At this point it was necessary to have a question-time session. We used it to solve the difficulties that some students encountered while doing their projects. In general the solutions came from other students who had had the same problems and found a way around them. The questions in general were related to Project #2. A very useful procedure for Project #2 was coordinates on a plane. (See Appendix C)

Comments. 1. The students who worked in pairs were already working on the second project and learning how to print their designs.

2. The students discussed their projects. There was camaraderie in the classroom.

3. Only two students were not able to finish their quilt projects.
Session 5

Description. Today I noticed a big change. The students walked into the computer lab and began to work immediately without waiting for instructions.

Comments. 1. Some of the students were able to work on their own and this gave me time to help those who had previously missed a class or needed some extra help.

2. At this point, every student had a clear concept of angles, distances and coordinate-axis. The procedure for learning the coordinate-axis was well understood by the class.

3. Today the students started to save their projects and problems arose with understanding the Logo file system.

4. Two students commented: "sometimes it is frustrating, but you really learn".
Session 6 and 7

Description. At the beginning of the session 6, the students received an activity sheet to complete. They were not allowed to use the computer; instead they had to write the necessary commands to get the figure (See Appendix E). The demonstration was based on how to use the printer and in general one student helped the other.

Comments. 1. Three students wanted to learn more Logo on their own.
2. Again the absenteeism problem was difficult to solve. There should be a way to give the students a chance to recover lost computer-time.
3. One student who was very talented was able to copy a difficult design from the material available in the classroom. However he was not interested to follow the class curriculum.
**Session 8**

**Description.** This session was dedicated to learn about angles in a triangle, square, and hexagon. The worksheet was based on designs using triangle designs (See Appendix C). The purpose of the worksheet was to learn about variables and how to use them in Logo commands.

**Comments.** 1. An unusual situation developed when one student was able to deal with angles and dimensions but not able to work effectively with the computer.

2. We had five pairs of students who were able to produce excellent results. Probably as a result of their group work, and good interaction they were able to achieve that level. Their final projects revealed that they had gone beyond the curriculum requirements.

**Session 9 and 10**

**Description.** Session 10 students answered a Logo Test (See Appendix F). The students worked on Polygons and Stars, and Parallelograms (See Appendix C). Both sessions were used to complete and print their work. The students who finished were able to try the challenge class work. Towards the end of the class interesting discussions developed between the students about the best way to do Logo designs.
Individual Observations

One student started to develop algebraical formulas which enabled him to take the following approach to his project:

TO TRIANGLE: SIZE
REPEAT 3[FD: SIZE RT 120]
REPEAT 3[FD: SIZE + 10 RT 120]
REPEAT 3[FD: SIZE + 20 RT 120]
END

He used the increment to the variable size instead of changing the size for every line as every other student did. He was able to work with variables by trial and error and as a result he got a clear understanding of commands not explained in class.

Another student worked by himself on a three-dimensional project and developed procedures to be able to clear the screen and to read the procedures he was using with only one command. He finished the required in-class work two days before the rest of the class.

A very successful pair was able to combine the computer ability of one with the other's creativity to produce excellent work. By the end of the computer days the latter felt quite comfortable with computers.
Classroom Activities for the Experimental Group

The five following sessions were dedicated to finishing the geometry curriculum in the classroom. The instruction method was lecture and handouts related to in-class work.

Session 1

The session was dedicated to constructions using a compass, a straight-edge, and a protractor: (a) bisecting angles and segments, (b) classification of angles, and (c) parallel lines cut by a transversal and angles' relationships.

Session 2

The session was dedicated to triangles: (a) triangle construction and classification according to their sides and angles measurement, (b) locate incentre and orthocentre, and (c) areas and perimeter problems.

Session 3

Circles and part of a circle: (a) circumference and area of a circle, and (b) inscribe and circumscribe triangles in a circle.
Session 4
Regular polygons inscribed in a circumference:
(a) construction of triangles, quadrilaterals, pentagon, and hexagon, (b) area and perimeter of a regular polygon.

Session 5
Problems: (a) calculations of ring areas by differences of areas between two circles, (b) determine the measurement of angles in a figure.


Test Results

Geometry Tests

The following hypothesis was investigated: there will be no difference in geometric achievement between experimental and control group previous to the treatment.

The pretest scores from the experimental and control groups were used to run a t-test \( p = .05 \). The results showed a significant difference between the experimental and control classes in geometric achievement. The null hypothesis can be rejected. The experimental class and control class started with a different geometric achievement level. (See Table 1)

Table 1

Geometry Pretest Scores Analysis

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<td>30.29</td>
<td>5.9</td>
<td></td>
<td>2.14</td>
<td>.04</td>
</tr>
<tr>
<td>n=24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hypothesis 1

Hypothesis 1 stated that there will be no difference in geometry achievement between students who learned geometry using Logo and those students who learned geometry using a traditional lecture approach. The results of the analysis of covariance showed no significant difference. The null hypothesis cannot be rejected. (See Table 2).

Table 2

Geometry Pretest Posttest Analysis of Covariance

<table>
<thead>
<tr>
<th>MAX SCORES</th>
<th>MEAN</th>
<th>STD DEV</th>
<th>F-RATIO</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE 40</td>
<td>25.92</td>
<td>6.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POST 50</td>
<td>32.00</td>
<td>11.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRE 40</td>
<td>30.29</td>
<td>5.9</td>
<td>.992</td>
<td>.326</td>
</tr>
<tr>
<td>POST 50</td>
<td>38.89</td>
<td>8.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXPERIMENTAL n=14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTROL n=24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hypothesis 2

Hypothesis 2 stated that there will be no difference in attitude between students who learned geometry using Logo and those students who learned geometry using a traditional lecture approach. The results of the repeated measures analysis of variance showed no significant difference. The null hypothesis cannot be rejected. Means and standard deviation are reported in Table 3 and the results of the analysis of variance are contained in Table 4.

Table 3
Estes Attitude Scale Scores

<table>
<thead>
<tr>
<th></th>
<th>MAX SCORES</th>
<th>MEAN</th>
<th>STD DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXPERIMENTAL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n=14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRE</td>
<td>75</td>
<td>31.97</td>
<td>4.6</td>
</tr>
<tr>
<td>POST</td>
<td>75</td>
<td>32.08</td>
<td>5.7</td>
</tr>
<tr>
<td><strong>CONTROL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n=24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRE</td>
<td>75</td>
<td>34.09</td>
<td>6.4</td>
</tr>
<tr>
<td>POST</td>
<td>75</td>
<td>33.67</td>
<td>6.8</td>
</tr>
</tbody>
</table>
**Table 4**

**Analysis of Variance on Estes Attitude Test Scores**

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARES</th>
<th>DEGREES OF FREEDOM</th>
<th>MEAN SQUARES</th>
<th>F RATIO</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUPS</td>
<td>54.051</td>
<td>1</td>
<td>54.051</td>
<td>0.785</td>
<td>0.382</td>
</tr>
<tr>
<td>WITHIN</td>
<td>2133.938</td>
<td>31</td>
<td>68.837</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td>0.298</td>
<td>1</td>
<td>0.298</td>
<td>0.042</td>
<td>0.840</td>
</tr>
<tr>
<td>GROUP/TIME</td>
<td>1.313</td>
<td>1</td>
<td>1.313</td>
<td>0.183</td>
<td>0.672</td>
</tr>
<tr>
<td>WITHIN</td>
<td>222.375</td>
<td>31</td>
<td>7.173</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hypothesis 3

Hypothesis 3 stated that there will be no difference in creativity between students who learned geometry using Logo and those students who learned geometry using a traditional lecture approach. The results of the repeated-measures analysis of variance showed no significant difference. Furthermore, no significant difference was found on the subtests. \( (p = .05) \). The null hypothesis cannot be rejected. Means and standard deviation are reported in Table 5, and the results of the analysis of variance are contained in Table 6.

Table 5

Torrance Test of Creative Thinking Scores

<table>
<thead>
<tr>
<th></th>
<th>MAX SCORES</th>
<th>MEAN</th>
<th>STD DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPERIMENTAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n = 14 )</td>
<td>PRE 180</td>
<td>78.21</td>
<td>18.2</td>
</tr>
<tr>
<td></td>
<td>POST 180</td>
<td>82.21</td>
<td>11.9</td>
</tr>
<tr>
<td>CONTROL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n = 24 )</td>
<td>PRE 180</td>
<td>82.96</td>
<td>17.3</td>
</tr>
<tr>
<td></td>
<td>POST 180</td>
<td>89.38</td>
<td>24.5</td>
</tr>
</tbody>
</table>
Table 6

Analysis of Variance on Torrance Test of Creative Thinking Scores

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SUM OF SQUARES</th>
<th>DEGREES OF FREEDOM</th>
<th>MEAN SQUARES</th>
<th>F RATIO</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUPS</td>
<td>626.546</td>
<td>1</td>
<td>626.546</td>
<td>1.024</td>
<td>0.318</td>
</tr>
<tr>
<td>WITHIN</td>
<td>22018.438</td>
<td>36</td>
<td>611.623</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td>479.684</td>
<td>1</td>
<td>479.684</td>
<td>3.515</td>
<td>0.069</td>
</tr>
<tr>
<td>GROUP/TIME</td>
<td>25.836</td>
<td>1</td>
<td>25.836</td>
<td>0.189</td>
<td>0.666</td>
</tr>
<tr>
<td>WITHIN</td>
<td>4912.938</td>
<td>36</td>
<td>136.470</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Logo Evaluation Results

Part A

The students could select from the following choices: disagree, somewhat disagree, maybe, somewhat agree, and agree. They were assigned 1 to 5 points respectively.

1. Do you agree that you developed new skills with this learning experience?
2. You would like to be taught other geometry or algebra courses using this learning method.
3. The time spent in learning Logo was a positive addition to the course.
4. Please write any comments you might have related to this course.

Table 7

Logo Evaluation Students Responses Distribution Part A

<table>
<thead>
<tr>
<th>Question #</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Maybe</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>4.4</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>3.9</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>4.6</td>
</tr>
</tbody>
</table>
Comments

The following comments were written by the students in response to Question # 4.

* "I would like to see more structure with regards to assignments. e.g. specific assignments (in class or at home) with follow-up explanations for each problem."

* "This course is interesting, helpful, fun, etc."

* "I believe that any tools available to speed or ease learning should be used - the computer is such a tool. My experience with the computer was 'practical' and 'hands on' learning. I do not think that it complements traditional Algebra where the 'ends do not justify the means approach' is taught. Learning with Logo was interesting and proved to me that there are many ways to find a solution. In short I feel that Logo and conventional Algebra teaching are conflicting (sic) together."

* "Make it a separate course for people who would rather take the basic geometry within the regular math class."

* "Learning with Logo excited me a great deal. It adds a pride of success to each assigned exercise. It would be somewhat boring to do what we did on the computer with a pencil and paper. With the pride of drawing a shape with the computer, a deeper understanding and interest of
the shapes came also."

* "Logo and computer helped me to understand more about computers and to give exact commands because even a small error can cause a problem. I enjoyed working with computers in this course."

* "When I first started on computers I expected frustration and hard work. Working on the computer was fun although I am uneasy concerning how useful it was, since it didn’t seem to engage my thinking as well as traditional teaching methods. Is it possible for learning to be so easy? I don’t know!.

* "I have found that using Logo has helped me a great deal in learning geometry."

* "I really enjoyed working with Logo. I learned a lot and enjoyed working with my partner."

* "The proper understanding of how the computer works or functions would make it easier to work with. Other than that I found it very interesting."

* "Computers, to me, were a bigger monster than grey hair, wrinkles, and a life without cakes, but a very special lady, made this adventure not tolerable, but interesting and exciting. Another major miracle!"

* "It was a more interesting way of learning math. Usually I hate math but I'm actually beginning to enjoy it."

Of the 14 students, 2 did not write comments.
Part B

The students could select from the following choices: a lot, some, very little, and none. We assigned the following points, 4 points, 3 points, 2 points, and 1 point respectively.

1. How much computer hands-on experience did you have before enrolling in this class?
2. If you said "a lot" or "some" in question 1: Do you think that computer knowledge helped you to learn Logo, and to what extent?
3. Did you know any Logo before?
4. Do you think that Logo computer language helped you to learn geometry?
5. Do you feel that learning Logo has been worthwhile?
6. For your Logo design, did you make use of your algebra knowledge?
7. For your Logo design, did you make use of your geometry concepts?
8. Would you like to continue working with computers?

Please give one or two reasons why you would like to continue working with computers and explain what kind of work you would like to do.
### Table 8

**Logo Evaluation Part B: Students Responses**

<table>
<thead>
<tr>
<th>QUESTION #</th>
<th>Responses n=14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a lot (4)</td>
</tr>
<tr>
<td>1. computer experience</td>
<td>0</td>
</tr>
<tr>
<td>2. computer helps Logo</td>
<td>1</td>
</tr>
<tr>
<td>3. previous Logo experience</td>
<td>0</td>
</tr>
<tr>
<td>4. Logo helped geometry</td>
<td>4</td>
</tr>
<tr>
<td>5. Logo was worthwhile</td>
<td>7</td>
</tr>
<tr>
<td>6. algebra helped Logo</td>
<td>1</td>
</tr>
<tr>
<td>7. previous geometry helped Logo</td>
<td>5</td>
</tr>
<tr>
<td>8. computers work in the future</td>
<td>5</td>
</tr>
</tbody>
</table>

**Comments**

Question # 8 requested reasons for wanting to continue working with computers and the areas that they would like to explore. Three of the students would like to learn more about computers for practical reasons such as word processing at home and work. Another three students...
would like to use the Logo graphics to do designs in sport medicine and three-dimensional structures. Another wondered if it were possible to learn Physics or Chemistry with Logo. Finally one student said "If Logo can help me to understand Algebra better I think I could finally understand it"

Four students did not answer.
CHAPTER 5

CONCLUSIONS

This study investigated the effects of learning geometry using Logo on students' achievement, attitude towards mathematics, and development of creativity. The results of this study did not support any of the research hypotheses.

Hypothesis 1 stated that students who received Logo instruction would demonstrate higher levels of geometry achievement than those students who received a traditional lecture approach. The results of the analysis indicated that there was no significant difference.

The nonsignificant difference in geometric achievement could have resulted from the inequitable time constraint imposed on the experimental class. The geometry unit was taught for two hours every day for three weeks. The students in the experimental group were expected to learn how to operate the computer, the basics of the Logo language, and the geometry content; in the same amount of time the control group could concentrate exclusively on the geometry content. The fact that the experimental group did as well as the control group might be deemed to be of significance. However other studies on this subject have been inconclusive in showing that time would
significantly alter students’ achievement (Pea, 1983; Watt, 1982).

Another factor that may have contributed to the nonsignificant difference in achievement in this study is the lack of structure in the Logo instructional environment. Papert (1980) claimed there is no need for a curriculum and students should learn Logo through discovery learning. In the present study students took many different directions, there was insufficient time for students to fully explore their ideas. Because of the time constraint, the exercises were structured towards the required curriculum; the students were able to produce the suggested geometrical figures but could not, by themselves, generalize on the geometrical concepts they were learning.

The Edinburgh Logo Project was highly structured in many aspects, with assigned worksheets and Logo activities focussed specifically on the mathematics curriculum. The students’ progress was carefully monitored. However, "...the results of the project on student achievement were not very dramatic." (Watt, 1982, p. 118)

Hypothesis 2 stated that the students in the experimental group would change their attitudes towards mathematics after their experience with Logo. The analysis showed no significant difference. The students’ comments in their evaluation of their learning experience
were in general positive. Most found the novelty of the use of the computer interesting and challenging. It is my impression from their comments that the students found the experience beneficial; however, they did not relate learning geometry using Logo to a change in their attitudes towards mathematics.

Hypothesis 3 stated that students in the experimental group would develop increased creativity after the treatment. The Torrance Tests of Creative Thinking Figural Test was used. It evaluates four dimensions: fluency--how many original ideas the student had; flexibility--how varied these ideas were one from the other; originality--how original the ideas were when compared to a normative group; and elaboration--how many details were added to the main idea. Even though the test is recommended for adults, my informal observation was that the students did not take the completion of figures seriously. Students' indifference to the TTCT may have been a factor in producing nonsignificant difference in the creativity measures.

The results of this study suggest that the strong claims by Papert (Mindstorm, 1980) for learning geometry by programming with Logo need serious reexamination. The use of Logo to teach geometry, using a relatively unstructured format, seems to be an insufficient means to
increase achievement, change attitudes or develop creativity.

Speculations

Social Impact of Logo

An important issue that has come to the attention of a number of other investigators is the social impact of Logo (Clements, 1984; Gallini, 1986; Horner & Maddux, 1985). Although it is possible that there will never be consistent proof of Logo's influence on mathematics achievement, perhaps Logo will be instrumental in giving students the chance to assume responsibility for their own success. In other words Logo may have the potential to positively affect students' academic performance.

The experimental group's enthusiasm was remarkable. The impact of Logo graphics was strong enough to stimulate peer interaction and cooperative learning. Informal observations by the researcher indicated that some of the students had never considered the possibility of working with a computer because they did not think they would have been able to understand the computer's operation. Thus, in this particular study, to be able to learn about computers using an interesting language like Logo, benefited the students by increasing their self-confidence.

Logo permitted the students to explore geometry in a
safer environment than the traditional class setting. They were able to take risks, learning by trial and error. The situation was homogeneous in the sense that only one student had some notion of Logo and the rest none. That created a good social/emotional atmosphere in the classroom, which gave the students greater enthusiasm and self-esteem. Furthermore it enhanced peer interaction. Finally, the students' introduction to computers and Logo gave them the confidence to try other uses of computers in the future.

The change in attitude towards computers after a Logo experience may radically influence the social interaction of Logo learners. Weir and Emanuel, in a study with autistic children reported: "the resulting dramatic improvement in sense of personal worth and the consequences for intellectual activity has led the school to implement its own computer centre using a recently implemented microcomputer Logo system" (cited in O'Shea & Self, 1983, p. 236).

*Mathematics in Year 2000* 

Although the experimental group did not perform better than the control group it is important to note that they did not do worse. Furthermore they had the
opportunity to learn how to use a computer as well as learning geometry. In this age of technology the introduction of computers in the classroom is inevitable.

In his predictions for the mathematics curriculum in the year 2000, Maurer (1984), noted that geometry in some of the schools has been reduced to a one-semester course and is tending to disappear. The reason it has not is because curricula designers cannot agree on what else to offer.

The computer as a tool and Logo as a language provide a natural world of shapes and surfaces and the means of displaying, rotating and dissecting them on a computer screen. Logo is a language which promotes the acquisition of computer literacy and at the same time the investigation of geometric concepts. The use of computer and Logo also enables the students to learn, practice and develop some important skills which they seldom would use otherwise.

The role of geometry in school mathematics is of increasing importance. Interesting problems could be solved with a better visual perception. For example by graphing equalities, inequalities, and transformations, geometry acquires a new dimension.

To draw a triangle with turtle graphics requires the knowledge of side length, the interior angle measures, and the angle measures exterior to the figure. Thus, the use
of Logo opposed to paper and pencil construction, opens a
new approach with a thoughtful challenge. (Finney, 1970).

The predictions for year 2000 (Maurer, 1984) are that
classical geometry will tend to disappear but the role of
visual mathematics will increase. The foundations of the
most striking developments of modern physics have a
geometrical background. The Newtonian theory of mechanics
and the non-conservation of parity for elementary
particles are based on Euclidean space. The ability to
visualize geometrically is no doubt part of the
scientist's mental equipment (Duff et al., 1967).

Visual and intuitive work are indispensable at
every level of mathematics and science, both as
an aid to clarification of particular problems
and as a source of inspiration, of new "ideas".
(Duff et al., 1967, p. 6).
APPENDIX A

Consent Form
Information and Consent Form for Logo and Geometry Research

Dear Student:

I am about to begin a research project with class 051. The purpose of this letter is to ask for your consent to participate in this project. This project has been carefully reviewed and approved by Jean Cockell, Mathematics Department Head and Dr. Lawrence Fast, Principal of King Edward Campus. It also has been examined and approved by Dr. Tom O'Shea, Faculty of Education, Simon Fraser University.

From time to time we do research to improve the teaching of mathematics. On this opportunity we are going to introduce a new approach to the geometry unit using different methods to enhance the understanding and learning of the subject. You will be asked to complete evaluation forms regarding the presentation and the perception that you have of the new methods used, as well as the influence that this new methods had on the class's learning. The evaluation and information collected from the class are going to be confidential and will not influence in any way your marks or performance appraisals at any point. If you would like to have more information please do not hesitate to ask me about it. The final results of this project are going to be made available to you on request.

Your participation will be very much appreciated and is voluntary. You can withdraw from this research project at any time. Thank you very much for your co-operation, which will make possible to improve for you and others the learning of mathematics at King Edward Campus.

Sincerely,

Myriam Bayerthal

I agree to participate in the project described above.

Name. ________________________________ (please print)  (signature)
APPENDIX B

Geometry Curriculum
GEOMETRY CURRICULUM

LINES AND ANGLES
1. Construct congruent line segments, and bisect a segment.
2. Construct congruent angles and bisect an angle.
3. Classify angles according to their measures: acute, right, obtuse, straight, reflex, one revolution.
4. Name and state the properties of special pairs of angles: adjacent, vertical, complementary, supplementary.
5. Construct perpendicular and parallel lines.
6. Identify special pairs of equal angles formed by two parallel lines cut by a transversal such as: alternate interior, alternate exterior, corresponding. Determine the measure of the angles and their properties: supplementary, congruency, equality.

TRIANGLES
1. Part of a triangle: sides, vertices, angles.
2. Classify triangles according to their: a) sides- scalene, isosceles, equilateral; b) angles- acute, right, obtuse.
3. Problems related to area, perimeter, and measure of interior and exterior angles of a triangle.
4. Similarity of triangles, corresponding sides and angles. Problems related to angles' measures and sides' measures.
CIRCLES
1. Intuitive definition of circle: circle is the limit of a regular polygon with infinite sides.
2. Identify the parts of a circle: centre, radius, chord, arc, diameter, semicircle.
3. Calculate the circumference and the area of a circle.

POLYGONS
1. Identify special types of polygons depending on the number of their sides: triangles, quadrilaterals, pentagons, hexagons, octagons, decagons, regular and irregular.
2. Calculate perimeter and area of polygons.
3. Inscribed and circumscribed polygons in a circle: equilateral triangle, square, pentagon, hexagon; create designs using a variety of these constructions.
APPENDIX C

Logo Outline

Logo Worksheets
GEOMETRY 051 OUTLINE
INTRODUCING "LOGO" LANGUAGE

I. Reading Materials


II. Reference Books

2. Logo for the Apple II. Harold Abelson.

III. Outline

SESSION 1

1. Learn operation of computer
   - start up
   - load the program
   - start the DRAW mode
2. The students will be able to experience hands-on computer graphics.
3. Learn the commands:

- RIGHT RT - LEFT LT
- FORWARD FD - BACK BK
- PENUP PU - PENDOWN PD
- HIDETURTLE HT - SHOWTURTLE ST

4. The students will move the TURTLE on the screen using the above commands and they will draw different figures, using lines angles and gain the feeling that they are in control.

SESSION 2

1. The students will be able to start drawing their designs:
   a) By using and complementing the manual’s procedures.
   b) By creating their own procedures.

2. They will apply their designs to the learning of new commands and the creation of more complex designs. e.g. CIRCLE, POLYSPI, REPEAT, [...] , etc.

3. What is a procedure? e.g.: TO HOUSE, TO SQUARE.

SESSION 3

1. EDIT mode, ED, TO MYWORK, leaving EDIT mode by pressing <CTRL> C
2. Students write their own designs as a procedure:
   a) simple procedures
   b) super-procedures.
3. Definition of a procedure.
   Example: SQUARE defined.
4. SAVE "MYWORK on a disk.
5. READ "MYWORK from a disk.

SESSION 4

PART B: TURTLE GEOMETRY - The Combination and Understanding of Geometrical Figures.
1. Draw squares of different sizes.
2. Draw the diagonal of a square.
   Hint: Use command SQRT =square root of...
3. Draw circles of different sizes.
4. How would you draw an arc of a circle?
   a) left arc circle
   b) right arc circle
5. Create different designs using circles, squares, and arcs. Examples:
   - a square inside a circle
   - flowers inside a square.
6. PROJECT # 1: create a design inside a square.
   side 80.
SESSION 5

1. PROJECT # 2: building a quilt.
   A. Groups of five students will combine their
designs to form a quilt with the squares.
   B. Using cartesian coordinates: SETXY command

SESSION 6

POLYSPI Microworld

1. PROJECT # 3: design a procedure using circles
   and regular polygons.

SESSION 7

Analyzing inscribed and circumscribed circles in a
polygon.
1. Circumference and area of a circle.
2. Regular and irregular polygons. Measurement
   of interior and exterior angles, sides and
   perimeter.

SESSION 8

PROJECT # 3 due.
1. Evaluation, presentation of designs
   explaining the characteristics and the
   procedures to produce them.
SESSION 1

CONTENT: INTRODUCTION TO LOGO

1. Demonstration of LOGO commands.
2. Demonstration of LOGO procedures.
3. Hands-on computer exercises using LOGO.
4. Saving and printing your work.

NOTE: Make sure your "CAPS LOCK" is down.

LOGO COMMANDS

<table>
<thead>
<tr>
<th>COMMAND</th>
<th>ABBR.</th>
<th>e.g.</th>
<th>COMMAND</th>
<th>ABBR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRAW</td>
<td></td>
<td></td>
<td>PENUP</td>
<td>PU</td>
</tr>
<tr>
<td>HOME</td>
<td></td>
<td></td>
<td>PENDOWN</td>
<td>PD</td>
</tr>
<tr>
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<td>FD</td>
<td>FD 60</td>
<td>CLEARSCREEN</td>
<td>CS</td>
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<tr>
<td>LEFT</td>
<td>LT</td>
<td>LT 30</td>
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<td>HT</td>
</tr>
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<td>RT</td>
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</tr>
<tr>
<td>BACK</td>
<td>BK</td>
<td>BK 30</td>
<td>GOODBYE</td>
<td></td>
</tr>
</tbody>
</table>

READ

READ "CIRCLES"

SAVE

SAVE "CIRCLES"

READPICT

READPICT "TRUCK"

SAVEPICT

SAVEPICT "TRUCK"

CTRL or CONTROL key e.g. :CTRL-T means that you press the CONTROL key and the letter T at the same time.

CTRL - T : gives a full text screen
- S : gives mixed text/graphics
- F : gives full graphics screen
- W : stops program execution
- D : delete the character

HARDCOPY

This utility allows you to obtain a print-out of your work.

1. READ "SCREEN DUMP from utilities disk.
2. Print OUTDEV 1.
3. Follow screen instructions.
4. End of print-out, print OUTDEV 0.
UTILITIES DISK

INSTRUCTIONS: To use the procedures in the "Utilities Disk", enter READ "(NAME OF PROCEDURE)", e.g.: READ "CIRCLES"

PROCEDURES

1. CCIRCLES, will draw a circle around the turtle's position. You have to indicate the radius.
   command: CCIRCLE 40 (the radius is 40 turtle steps)

2. CIRCLES, will draw right circle (RCIRCLE) or left circle (LCIRCLE), and right arc (RARC) or left arc (LARC). You have to indicate the radius.
   command: RCIRCLE 40 (the radius is 40 turtle steps)
   LCIRCLE 40
   RARC 40
   LARC 40

3. SHAPES, will draw: rectangle, polygon, circle, or star. You have to indicate dimensions, such as: length, width, angle sizes, side lengths or circle radius. Each procedure's dimensions are related to the procedure itself.
   command: RECTANGLE 75 60 (length 75, width 60)
   POLYGON 5 50 72 (sides 5, length 50, angle 72)
   CIRCLE 60 (radius 60)
   STAR 5 60 144 (sides 5, length 60, angle 144)

4. PICTURE, will draw a scene.
   command: PICTURE

5. SYMMETRY, will draw: window, pretty, or pattern.
   command: WINDOW
   PRETTY
   PATTERN

RECOMMENDATIONS: Work with different procedures and try to combine them in order to do your own picture or scene. You can get some ideas by READ "TRUCK. Type TRUCK. This truck is a combination of a box, small box, and wheels. Type EDIT ALL and you will see the procedures used in making the truck.
**Exploration of Angle with The Turtle**

1. **Number of degrees in angle A** 
2. **Number of degrees in angle B** 
3. **Number of degrees in angle C**

1. **Number of degrees in angle A**
2. **Number of degrees in angle B**
3. **Number of degrees in angle C**
4. **Number of degrees in angle D**
5. **Number of degrees in angle D + E + F + G**

1. **Number of degrees in angle A**
2. **Number of degrees in angle B**
3. **Sum of interior angles**
4. **Sum of exterior angles**
5. **Complementary angles are**
6. **Supplementary angles are**

**Polygon is:**

**Regular polygon is:**

In LOGO is a theorem called "The Total Turtle Trip" or TTT, suppose your turtle takes a trip around the screen and ends up facing in the same direction as when it started. Add up the degrees it turns during the trip. Write your conclusions.
1. Draw the following angles:
   (use the line provided)

right angle $= 90^\circ = \angle ABC$
(label the angle using the letters A, B, C)

complementary angles $= \angle ABC + \angle CBD = 90^\circ$
(label the angles using the letters A, B, C, D)

straight angle $= 180^\circ = \angle$
(label the angle)

supplementary angles $= \angle ABC + \angle CBD = 180^\circ$
(label the angles using the letters A, B, C, D)

What are: adjacent angles?
vertical angles? Draw them and name the angles using the letters E, F, G, H, I, etc..
DESIGNS WITH TRIANGLES

INSTRUCTIONS:
1. Write a procedure for a triangle using a side's variable.
2. Using that procedure with different inputs, write a superprocedure to draw each of the four designs below.
3. Save your work and print your procedures and design.
POLYGONS AND STARS

POLYGONS: Let's use the REPEAT command and compare the different procedures.

example: TO SQUARE
REPEAT 4[FD 50 RT 90]
END

TO HEXAGON
REPEAT 6[FD 50 RT 60]
END

TO PENTAGON
REPEAT 5[FD 50 RT 72]
END

Complete the Table below and find the relationship between the size of the angle and the number of turns of the turtle. Write others procedures for OCTAGON, DECAGON, HEPTAGON (7 sides).

<table>
<thead>
<tr>
<th>ANGLE</th>
<th>TURNS</th>
<th># OF REPEATS</th>
<th>PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRIANGLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQUARE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PENTAGON</td>
<td>90</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>HEXAGON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DECAgon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCTAGON</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. STARS: Write the following procedures, compare your results with the polygon's procedures. What do you conclude?

TO STAR.5
REPEAT 5[FD 50 RT 144]
END

TO STAR.6
REPEAT 6[FD 50 RT 120]
END

TO STAR.7
REPEAT 7[FD 50 RT ((360/ 7)*3)]
END

TO STAR :M :N
REPEAT :N[FD 50 RT (:M * 360/ :N)]
END

Observe the different designs STAR.5, STAR.6, and STAR.7. Write your conclusions. Try the procedure TO STAR :N :M replacing the variables :N, :M by 1 and 2; 2 and 4; 3 and 4; 5 and 6; 4 and 8; 4 and 9. Which one of this pair of number give a star? What can you conclude? (Complete the table below).

<table>
<thead>
<tr>
<th>NUMBER OF SIDES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1   2   3   4   5   6   7   8   9   10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MULTIPLIER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1   2   3   4</td>
</tr>
<tr>
<td>N   Y   Y   Y</td>
</tr>
</tbody>
</table>
PARALLELOGRAM

Write the procedure and experiment with many inputs for the variables L, W, and A. For each new result determine the measure of the numbered angles. Write your conclusions.

TO PARA :L :W :A
REPEAT 2[ FD :L RT :A FD :W RT (180 - :A)]
END

BONUS PROCEDURE: Experiment and make a box. Make it with variables for a cube or a rectangular box.
TO AXES
REPEAT 2[LINE 100 RT 90 LINE 150 RT 90]
END

TO LINE :LENGTH
FD :LENGTH
BK :LENGTH
END
APPENDIX D

Geometry Achievement Test 7/8
Geometry Achievement Test 051
Estes Attitude Scale
Logo Evaluation
Instructions
1. Do NOT open the test booklet until you are told to do so.
2. Be sure that you have a ruler, a pencil, and an eraser.
3. Do NOT use a compass, a protractor, or a calculator.
4. There are four answer choices for each question. Make a $\Box$ in the box which corresponds to your answer for each question.
5. Mark only one box per question.
6. If you have no idea of the correct answer, leave the question blank.
PART A — ANGLES AND SEGMENTS

(1) The measure of this angle is:

![Angle Diagram]

- a. $130^\circ$ ................. □
- b. $50^\circ$ .................. □
- c. $100^\circ$ .................. □
- d. $180^\circ$ .................. □

(2) Given the following segments and their lengths:

- $AB$ 6 cm
- $EF$ 6 m
- $GH$ 6 cm
- $JK$ 6 km

Which two segments are congruent?

- a. $AB$ and $EF$ ................. □
- b. $EF$ and $GH$ .................. □
- c. $GH$ and $AB$ .................. □
- d. $AB$ and $JK$ .................. □
If $PQ$ bisects $RS$, which line segments must be equal as a result?

- $PT$ and $TQ$
- $RT$ and $TS$
- $PT$ and $RT$
- $TS$ and $TM$

Which angle is congruent to angle $ABC$?

- a.
- b.
- c.
- d.
(5) What is the measure of this angle?

- AC bisects angle A and angle C. One pair of equal angles is:

  - a. 150° ........................................
  - b. 30° ........................................
  - c. 60° ........................................
  - d. 120° ........................................

(6) AC bisects angle A and angle C. One pair of equal angles is:

  - a. 1 and 4 .................................
  - b. 1 and 2 .................................
  - c. 3 and 1 .................................
  - d. 3 and 4 .................................

7) What is the measure of angle ABD?

  - a. 120° ........................................
  - b. 90° ........................................
  - c. 300° ........................................
  - d. 60° ........................................
If angles A and B both measure 50°, then they are:

a. congruent ................. ☐  
b. complementary ............. ☐  
c. supplementary ............ ☐  
d. adjacent .................. ☐

Which two of the segments shown below are congruent?

- I
- II
- III
- IV
- V

a. III and V .................. ☐  
b. II and IV .................. ☐  
c. I and V .................... ☐  
d. I and III .................. ☐
The following diagram shows four different paths from A to B. Using your ruler, which of the following is the length of the shortest path?

![Diagram of paths from A to B]

- a. 7 cm
- b. 5 cm
- c. 6.5 cm
- d. 8.5 cm

Given $m\angle A = 20^\circ$, $m\angle B = 60^\circ$, $m\angle C = 20^\circ$, $m\angle D = 70^\circ$, $m\angle E = 90^\circ$. Which pair of angles is congruent?

- a. $\angle A$ and $\angle B$
- b. $\angle A$ and $\angle C$
- c. $\angle B$ and $\angle D$
- d. $\angle C$ and $\angle D$

Angles and Segments: ___ out of 11

PART B — GEOMETRIC FIGURES

Which one of these does NOT have any parallel sides?

- a. a parallelogram
- b. a triangle
- c. a square
- d. a rectangle
Lines that are in the same plane and do not intersect are called:

a. parallel lines ..............
b. perpendicular lines .......
c. skew lines ................
d. intersecting lines ........

All rectangles are:

a. triangles ..................
b. rhombi ....................
c. squares ...................
d. parallelograms ...........

In which figure is a diameter of the circle shown?

a. .................................................. 

b. .................................................. 

c. .................................................. 

d. .................................................. 

(16) Given the circle with centre O and diameter AB, which of the following is a chord?

[Diagram of a circle with chords MN, AO, OB, and MN]

a. MO 

b. AO 

c. OB 

d. MN 

(17) Mike was flying his motorized model airplane in the school yard which measured 100 metres by 200 metres. He stood in the middle of the yard and held a 20 metre wire that was attached to the plane. Which figure best describes the flight pattern of Mike's airplane?

a. a rectangle 

b. a square 

c. a triangle 

d. a circle 

(18) Indicate which name best describes the figure below:

[Diagram of a parallelogram]

a. parallelogram 

b. rectangle 

c. square 

d. quadrilateral
(19) A 4-sided polygon which always has all sides and angles equal in measure is called:

   a. a parallelogram .................................. □
   b. a rectangle ........................................ □
   c. a square ............................................ □
   d. a trapezoid ........................................ □

(20) The segments in this diagram are:

   a. parallel ............................................. □
   b. horizontal ......................................... □
   c. vertical ............................................. □
   d. perpendicular ...................................... □

(21) The hands of a clock form an angle closest to 90° at:

   a. 12 o'clock .......................................... □
   b. 3 o'clock ........................................... □
   c. 5 o'clock ........................................... □
   d. 8 o'clock ........................................... □

(22) Name a diameter of the circle with centre C.

   a. AC .................................................. □
   b. BC .................................................. □
   c. AD .................................................. □
   d. AB .................................................. □
(23) If C is the centre, name a radius of the circle.

\[
\begin{array}{c}
A \\
\hline
C \\
\hline
B \\
\hline
D
\end{array}
\]

Geometric Figures: ___ out of 12

PART C — UNITS OF MEASURE

(24) The most appropriate metric unit for measuring a person's height is the:

a. kg
b. mL
c. cm
d. cm²

(25) Area is measured in units of:

a. volume
b. linear measure
c. cubic measure
d. square measure
26) When measuring the size of an angle which of the following units would you use?
   a. inches ........................................
   b. degrees ........................................
   c. centimetres ...................................
   d. metres .........................................

27) Which unit would be used to measure how much an apple juice can holds?
   a. ml .................................................
   b. kg ................................................
   c. cm$^2$ ............................................
   d. mg ................................................

28) Which unit would you use to measure the volume of air in a room?
   a. m$^3$ ..............................................
   b. m$^2$ ............................................... 
   c. m .................................................. 
   d. kg ................................................ 

29) How many pieces the same size as A are needed to cover B?

   a. 4 .................................................
   b. 5 .................................................
   c. 6 .................................................
   d. 7 .................................................
(30) Which of these units would you use to measure how much wallpaper would be needed to cover a wall?

a. cm³ ........................................... □
b. m² ........................................... □
c. kl ........................................... □
d. mg ........................................... □

(31) How many degrees are there in a right angle?

a. 90° ........................................... □
b. 450° ........................................... □
c. 180° ........................................... □
d. 360° ........................................... □

(32) How many metres are there in 0.65 kilometres?

a. 65 ........................................... □
b. 650 ........................................... □
c. 6.5 ........................................... □
d. 0.65 ........................................... □

(33) Solve: \( 1500 \text{ g} = \underline{\text{}} \text{kg} \)

a. 150 ........................................... □
b. 15 ........................................... □
c. 1.5 ........................................... □
d. 0.15 ........................................... □

(34) Which symbol produces a true statement?

\[ 5000 \text{ mm} \underline{\text{ }} 5 \text{ m} \]

a. < ........................................... □
b. > ........................................... □
c. = ........................................... □
d. ≠ ........................................... □
Boxes of candy each having a volume of 40 cubic centimetres, were packed into large cartons with a capacity of 20 480 cubic centimetres. How many candy boxes could be put into each carton?

6) Solve: \(2 \text{ m} + 3 \text{ cm} = \quad \text{m}\)

37) 60 times 6.6 cm is:

Loggers must use a mixture of oil and gas to keep their chain saws running in good condition. If 0.5 litres of oil must be added to 1 litre of gas, how much oil would be needed in 0.5 litres of gas?
(39) Solve: \(5 \text{ m}^3 = \underline{\phantom{0000000000}} \text{cm}^3\)

a. 5 000 000
b. 1 000 000
c. 5
d. 1

(40) The thickness of a book, excluding the covers, is 32.3 millimetres. If each page has a thickness of 0.19 millimetres, how many pages are there in the book?

a. 210
b. 170
c. 163
d. 189

Units of Measure: ___ out of 17

TEST TOTAL: ___ out of 40
GEOMETRY 051 TEST

NAME: ................................
(please print your name)

SCORE

<table>
<thead>
<tr>
<th>PART</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>PART A</td>
<td>18</td>
</tr>
<tr>
<td>PART B</td>
<td>12</td>
</tr>
<tr>
<td>PART C</td>
<td>8</td>
</tr>
<tr>
<td>PART D</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>50</td>
</tr>
</tbody>
</table>
PART A
A. There are four answer choices for each question. Write the letter of your answer in the line provided. 2 marks each.

***** Give only one answer for each question. *****

ANSWER

1. If the length of a rectangle is 24 cm and its width is 10 cm, its perimeter measures:

A) 34 cm  
B) 68 cm  
C) 120 cm  
D) 240 cm

1.  

2. The area of triangle XYZ is:

A) 28  
B) 56  
C) 70  
D) 80

2.  

10
Z
14
8
X
Y
3. The area of this figure is:

The area of the figure is 10 cm x 6 cm = 60 cm². The options provided do not match the correct area of 60 cm².

4. Lines $k$ and $m$ are parallel. This means that the value of $x$ is:

Given that $k$ and $m$ are parallel, the value of $x$ is determined by the angles formed. Since the figure is not labeled with specific angles, we cannot determine the exact value of $x$ without additional information. However, if we assume that $x$ is the angle between $k$ and some reference line, we need more information to solve for $x$.

Answer: The answer is not provided in the image.
5. If lines \(k\) and \(m\) are parallel, then the value of \(x\) is:

- A) 15
- B) 75
- C) 105
- D) 115

6. If \(\angle 1\) and \(\angle 4\) are acute congruent, it follows that:

- A) lines \(n\) and \(m\) are parallel
- B) line \(k\) is perpendicular to lines \(n\) and \(m\)
- C) \(\angle 1 = \angle 3\)
- D) \(\angle 1\) and \(\angle 3\) are complementary angles.
7. Three sides of the triangle are congruent. The measure of $\angle 1$ is:

A) $30^\circ$
B) $60^\circ$
C) $120^\circ$
D) $150^\circ$

8. The centre of the circle is at $O$. The curved line from $A$ to $B$ is called:

A) a semicircle
B) an arc
C) a chord
D) a diameter
9. The center of the circle is at O. What is the measure of $\angle ACB$?

A) 45°
B) 180°
C) 90°
D) 60°

9. _____
PART B

B. Constructions. All constructions are to be done with a compass and straight edge only. Show all construction lines. 3 marks each.

1. Construct $\angle EDF$ equal to $\angle ABC$.

```
    A
   / \
  /   /
/     /
B -- C
```

2. Construct a 60° angle.
3. Divide line segment AB into 4 equal parts. Use only a compass and a straight edge. Name the equal parts.

4. Do ONE of the following constructions: Show all the construction lines.

   a) Inscribe a square  OR  b) Inscribe a hexagon in a circle.
PART C
C. Answer the following questions, showing all the necessary steps that lead you to the answer. 2 marks each.

1) If triangle RST is isosceles, angle S = 50°, and RS = ST, find the measure of angle R.

2) Given the diagram below, find: \[ \angle BAC = \]
\[ \angle PBA = \]
3) If \( \angle AOB = \angle COD \), and \( \angle AOB = a^\circ \), how many degrees are there in \( \angle BOC \)?

4) Find \( \angle ABE \) and \( \angle A \).
PART D

D. Solve the following problems, showing all the necessary steps that lead you to the answer. 3 marks each.

1) Calculate the area of the shape.

2) Calculate the area of the shaded region in the figure. The inner boundary is a circle, and the outer boundary is a square.
3) A circular sheet of metal has an area of 154 m². Calculate its diameter.

4) Two concentric circles (having the same centre) have diameters of 35 m and 56 m. What is the difference in the lengths of each circumference?
DIRECTIONS: These scales measure how you feel about courses taught in school. On the first and second sheet are statements about mathematics. Read each statement and decide how you feel about it. Rate each statement on a scale of 1 to 5, as follows:

5 will mean "I strongly agree"
4 will mean "I agree"
3 will mean "I cannot decide"
2 will mean "I disagree"
1 will mean "I strongly disagree"

Please be as honest as possible in rating each statement. Your ratings will not affect your grade in any course. Show your answer by circling the number of your choice.

1. People who like math are often weird.
   5 4 3 2 1

2. Working math problems is fun, like solving a puzzle.
   5 4 3 2 1

3. It is easy to get tired of math.
   5 4 3 2 1

4. Working math problems is a waste of time.
   5 4 3 2 1

5. Studying math in college would be a good idea.
   5 4 3 2 1

6. Being able to add, subtract, multiply, and divide is all the math the average person needs.
   5 4 3 2 1
7. It is impossible to understand math.
   5 4 3 2 1

8. Even though there are machines to work math problems, there is still a reason to study math.
   5 4 3 2 1

9. Math is boring.
   5 4 3 2 1

10. Only mathematicians need to study math.
    5 4 3 2 1

11. Knowledge of math will be useful after high school.
    5 4 3 2 1

12. Without math courses, school would be a better place.
    5 4 3 2 1

13. A student would profit from taking math every year.
    5 4 3 2 1

14. Math is easy.
    5 4 3 2 1

15. Math is doing the same thing over and over again.
    5 4 3 2 1
LOGO EVALUATION

PART A

Directions: circle the answer that best represents your agreement to the statement.

1. Do you agree you developed new skills with this learning experience.
   (1) agree (2) somewhat agree (3) maybe (4) somewhat disagree (5) disagree

2. You would like to be taught other geometry or algebra courses using this learning method.
   (1) agree (2) somewhat agree (3) maybe (4) somewhat disagree (5) disagree

3. The time spent in learning Logo was a positive addition to the course.
   (1) agree (2) somewhat agree (3) maybe (4) somewhat disagree (5) disagree

4. Please write any comments you might have related to this course.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
PART B:

Directions: circle the letter that best describes your reaction to each question.

1. How much computer hands-on experience did you have before enrolling in this class?
   a. none   b. very little   c. some   d. a lot

2. If you said "a lot" or "some" in question 1: Do you think that computer knowledge helps you to learn Logo, to what extent?
   a. none   b. very little   c. some   d. a lot

3. Did you know any Logo before?
   a. none   b. very little   c. some   d. a lot

4. Do you think that Logo computer language helped you to learn geometry?
   a. none   b. very little   c. some   d. a lot

5. Do you feel that learning Logo has been worthwhile?
   a. none   b. very little   c. some   d. a lot

6. For your Logo design, did you make use of your algebra knowledge?
   a. none   b. very little   c. some   d. a lot

7. For your Logo design, did you make use of your geometry concepts?
   a. none   b. very little   c. some   d. a lot

8. Would you like to continue working with computers?
   a. none   b. very little   c. some   d. a lot

Please give one or two reasons of how and what kind of work you would like to do.
APPENDIX E

Activities
The first set of *primitive commands* to explore contains:

<table>
<thead>
<tr>
<th>DRAW</th>
<th>FORWARD</th>
<th>BACK</th>
<th>RIGHT</th>
<th>LEFT</th>
</tr>
</thead>
</table>

Help the turtle draw by giving the commands below. Remember to press RETURN after you type each line. In the space next to each list of commands, sketch what the turtle draws.

1. **DRAW**
   - RIGHT 30
   - FORWARD 20
   - LEFT 60
   - BACK 20
   - RIGHT 60
   - FORWARD 20
   - LEFT 60
   - BACK 20
   - LEFT 60
   - FORWARD 40
   **Sketch:**

2. **DRAW**
   - FORWARD 100
   - RIGHT 90
   - FORWARD 100
   - RIGHT 90
   - FORWARD 100
   - RIGHT 90
   **Sketch:**

3. **DRAW**
   - FORWARD 40
   - LEFT 120
   - FORWARD 40
   - LEFT 120
   - FORWARD 40
   - LEFT 120
   **Sketch:**

4. **DRAW**
   - BACK 10
   - RIGHT 90
   - FORWARD 50
   - LEFT 90
   - FORWARD 10
   - LEFT 90
   - FORWARD 50
   - RIGHT 90
   **Sketch:**

5. **DRAW**
   - LEFT 45
   - FORWARD 30
   - BACK 30
   - RIGHT 90
   - FORWARD 30
   - BACK 30
   - LEFT 45
   - BACK 40
   **Sketch:**

6. **DRAW**
   - FORWARD 30
   - RIGHT 135
   - FORWARD 40
   - LEFT 135
   - FORWARD 30
   **Sketch:**

7. **DRAW**
   - FORWARD 30
   - RIGHT 360
   - FORWARD 30
   - LEFT 180
   - FORWARD 60
   **Sketch:**

8. **DRAW**
   - FORWARD 30
   - RIGHT 240
   - FORWARD 30
   - BACK 30
   - RIGHT 120
   - FORWARD 30
   **Sketch:**

For Apple Logo, change DRAW to CLEARSCREEN.
Read each command and sketch what you think the command will tell the turtle to draw. Then check your prediction by giving the command. If your prediction was inaccurate, correct your sketch.

<table>
<thead>
<tr>
<th>Command</th>
<th>Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DRAW REPEAT 3[FD 30 RT 120]</td>
<td></td>
</tr>
<tr>
<td>2. DRAW REPEAT 4[FD 30 RT 90]</td>
<td></td>
</tr>
<tr>
<td>3. DRAW REPEAT 5[FD 30 RT 72]</td>
<td></td>
</tr>
<tr>
<td>4. DRAW REPEAT 6[FD 30 RT 60]</td>
<td></td>
</tr>
<tr>
<td>5. DRAW REPEAT 9[FD 30 RT 40]</td>
<td></td>
</tr>
<tr>
<td>6. DRAW REPEAT 12[FD 30 RT 30]</td>
<td></td>
</tr>
<tr>
<td>7. DRAW REPEAT 18[FD 10 RT 20]</td>
<td></td>
</tr>
<tr>
<td>8. DRAW REPEAT 36[FD 10 RT 10]</td>
<td></td>
</tr>
</tbody>
</table>

For Apple Logo, change DRAW to CS.
APPENDIX F

Logo Test # 1
LOGO TEST # 1

PART A

Each one of these procedures have one or more errors. Make the corrections and draw the corrected sketch.

(10 marks).

1. TO SQUARE
   REPEAT [FD 50 RT 90]
   END

2. TO HEXAGON
   REPEAT 6[FD20 RT 60]
   END

3. TO PENTAGON
   5[FD 30 RT 72]

4. TO TRIANGLE
   REPEAT [3 FD 60 RT 90]
   END

PART B

Write a procedure for the following designs. The Turtle is in the starting position. (15 marks)

1. Window

2. Arrow
PART C

Choose ONE of the following design to write a procedure.

SQUARE TOWER
(use a variable)

WHEEL
References


