EFFECT OF LOGO ON
ACHIEVEMENT IN MATHEMATICS, ATTITUDE TOWARDS MATHEMATICS
AND ACADEMIC SELF-CONCEPT OF NATIVE STUDENTS

by

David Arthur Smith

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ABSTRACT

The objective of the study was to determine whether instruction and practice in Logo, a computer language for children, would positively affect achievement in mathematics, achievement in geometry, attitude towards mathematics, or academic self-concept of native students. The study involved two intact classes of grade four students (N=47) in two native communities in northern Manitoba. The groups were pretested on the dependent variables in September of 1984 after which a microcomputer system was set up in each classroom. From October 1984 to May 1985 one group received weekly instruction and practice in Logo while the other group used their computer for other purposes. Posttests were administered in May 1985. Statistical analyses of the data indicated no significant difference between the two groups in achievement in mathematics or attitude towards mathematics. However, the Logo group did significantly better than the control group ($p<.01$) on the geometry posttest as well as showing a significant gain ($p<.02$) in academic self-concept compared to the control group. The geometry result supports the argument that the visual nature of Logo is compatible with a visual learning style thought to be predominant in native students.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Educational historians of the future will likely describe the 1980's as the decade when the "computer revolution" swept through educational institutions, exerting a profound influence on the educational system. Ten years ago, computer use in the schools was limited primarily to the high school computer science program but the recent development of inexpensive, powerful, and versatile microcomputers has resulted in computers being purchased in quantity and utilized for a wide variety of educational purposes.

Although most educators agree that the computer is a powerful educational medium through which a wide variety of educational goals can be achieved, considerable disagreement exists regarding how the computer should be used with children and what is achieved by any particular use. The teaching of computer programming languages has generated considerable debate in this regard. Increased problem solving ability, enhanced understanding of mathematics, development of logical thought processes, and improved academic self-concept have been cited as some of the educational benefits of learning a programming language but there is a dearth of empirical evidence to support these claims.

A computer language called Logo (from the Greek word "logos" meaning thought or word) has been at the centre of much of this debate. Developed in the late 1960's by Seymour Papert and members of the Artificial Intelligence Laboratory of the Massachusetts Institute of Technology, Logo is unique in being the "first (computer) language designed especially for education" (Shapiro, 1982, p.96). Logo has been described by Harvey (1982) as,

> ...a language for learning how to think. Its history is rooted strongly in computer-science research, especially in artificial intelligence. But it is also rooted in Jean Piaget's research into how children develop thinking skills (p.163).

Papert and his followers have raised tremendous expectations about Logo's potential as an educational tool. The purpose of this study was to examine certain aspects of this potential.

This chapter is an overview of the study beginning with a description of the Logo language.

Description of Logo Language

Logo is a graphics-oriented language consisting of commands called "primitives" which can be used to "program" a triangular-shaped cursor called a "turtle" to draw designs on the computer's screen. Most of the primitives are familiar, everyday words such as forward, back, left, right, repeat, etc. In telling the turtle how to move, the programmer specifies the distance in turtle steps and the amount of turn in degrees.

In most versions of Logo, there are two "modes" - the "draw mode" and the "edit mode". In the "draw mode", each time a valid command is typed and the <RETURN> or <ENTER> key is pressed the turtle carries out the command. Using only two or three primitives in combination, children can make the turtle draw a figure - a geometric shape or a simple picture - on the screen. As children become more familiar with the language, they can write programs or "procedures" in the "edit mode". This involves writing a series of commands and assigning them an identifying name. Once a simple procedure has been defined by assigning it a name it can be combined with other procedures to create a more complex procedure resulting in a more intricate design or picture on the screen. In effect, when children write procedures, they "teach" the computer how to make a drawing. Once a procedure is written, it can be "run" in the "draw mode". Sometimes when a procedure is run, what appears on the screen may be different from what was expected indicating that there is a "bug" in the procedure which needs to be corrected or "debugged".

The above description of Logo deals with the simpler "turtle graphics" capabilities of the language which were used in this study. Logo has numerous other capabilities which were not needed for the purposes of this study.

Reason for the Study

The author was motivated to conduct this study because he was interested in investigating ways of improving the educational program of native students in northern Manitoba and the Logo language appeared to hold particular promise in this regard. More specifically, two aspects of Logo were of interest, namely, the apparent potential of Logo to increase understanding and enjoyment of mathematics and to improve academic self-concept.

The possible relationships among Logo, mathematics, native students and academic self-concept are described below.

Logo and mathematics. Logo's greatest potential appears to lie in the area of mathematics education. In fact, the development of Logo grew out of Seymour Papert's dissatisfaction with the approach which schools traditionally have used to teach mathematics. Papert (1980) contended that:

> Children begin their lives as eager and competent learners. They have to learn to have trouble with learning in general and mathematics in particuluar.... Our education culture gives mathematics learners scarce resources for making sense of what they are learning. As a result our children are forced to follow the very worst model for learning mathematics. This is the method of rote learning, where material is treated as meaningless; it is a dissociated model (p.47).

Papert envisioned the computer as a means by which mathematics could be made more meaningful and interesting to children. He stated:

> We are learning how to make computers with which children love to communicate. When this communication occurs, children learn mathematics as a living language....The idea of 'talking mathematics' to a computer can be generalized to a view of learning mathematics in 'Mathland'; that is to say, in a context which is to learning mathematics what living in France is to learning French (p.6).

Influenced profoundly by the learning theory of Jean Piaget, Papert saw children as "builders of their own intellectual structures" (p.7). Since all builders need materials with which to build and since mathematical materials are not readily available or easily accessible in our culture, Logo was developed to provide children with a "mathematical microworld" containing some of the necessary materials needed to "build" mathematical understanding. Furthermore, the Logo language seems particularly suited to the learning of geometry in that Logo provides a means of communicating to the computer in order to draw and manipulate geometric shapes.

Is Logo the rich mathematical learning environment that its creators intended it to be? Although numerous claims have been made regarding the cognitive and affective benefits of Logo (for e.g., Billstein, 1983; Harvey, 1982;

Lough, April, 1983; Papert, 1980; Watt, 1982), those claims have been based primarily on learning theory or observational evidence. Very little quantitative research has been conducted to either substantiate or refute those claims. Even some of Logo's strongest supporters have stressed the need to objectively and systematically investigate Logo's potential (Leron, 1985; Lough, 1983; Moursund, 1984).

Logo and native students. Numerous educators have outlined the fact that native students have difficulty in traditional mathematics classes (Bradley, 1984; Cheek, 1984; Cristensen, 1982; Green, 1978). Cheek (1984) stated that "the causes of this difficulty have not been documented. Possible solutions have been suggested. Few hypotheses have been tested empirically" (p.1). Franco (1980) pointed out that research in "the last 2 decades (1960-1980) has largely stayed away from addressing concerns related to the mathematics education of minorities" (p.3).

Research regarding the use of microcomputers to enhance the mathematics education of native students is even more scarce (Bradley, 1976; Hakes, 1981). However, various educators have observed a strong emphasis on visual rather than verbally-based acquisition of information in native societies (Bradley, 1984; Coppus, 1978; Heffron, 1984; Kaulback, 1984). Because Logo is visually oriented, it would appear to have the potential to be a powerful mathematical learning aid for native students. Cheek (1984), in outlining some possible avenues of research in mathematics education for natives, specifically mentioned Logo as a timely topic for investigation.

<u>Logo and academic self-concept.</u> In surveying American research Purkey (1970) concluded that "overall the research evidence clearly shows a persistent and significant relationship between the self-concept and academic achievement" (p.15). Numerous researchers have demonstrated this relationship (for e.g., Alvord & Glass, 1974; Brookover, Thomas, & Paterson, 1964; Caplin, 1966; Simon & Simon, 1975; Staines, 1958). The findings of Singh (1983) are of particular relevence to this study; he found a significant positive relationship between self-concept of ability and academic achievement with Cree children from northern Manitoba.

Burns (1979) stated that, "the relationship between self-concept and academic attainment is reciprocal, not unidirectional" (p.283). Thus, academic success raises or maintains self-concept, and self-concept influences academic performance. Furthermore, there is evidence to suggest that academic self-concept can be influenced by the classroom environment (Brookover, et al. 1965; Burns, 1979; Coopersmith, 1981). Coopersmith (1981) provided the following guidelines for creating a classroom environment conducive to enhancing academic self-concept:

- .Allow children free exploration among several activities
- .Give the learners immediate information about the consequences of their actions
- .Institute self-pacing (the rate of activity and progress is determined by the learner)
- .Allow free use of materials so that children can make their own discoveries of how events are related (p.9).

The above conditions are compatible with Papert's philosophy of how Logo should be learned, that is, in an environment where free exploration (playing turtle), immediate feedback (primarily from the turtle on the screen), discovery learning, and self-pacing predominate. Furthermore, Logo's ease of entry means that any student can have a successful experience with Logo. Studies with physically handicapped children have provided observational evidence that learning Logo can positively influence academic self-concept (Weir, 1979; Muller, 1983).

Purpose

The purpose of this study was to investigate the effects of Logo on the achievement in mathematics, the achievement in geometry, the attitude towards mathematics, and the academic self-concept of grade four students in a native community.

Statement of the Problem

Inasmuch as this study sought to determine whether use of the computer language, Logo, would increase understanding and enjoyment of mathematics and improve academic self-concept, the specific research question became:

Do native students who receive instruction in Logo demonstrate improved achievement in mathematics, improved achievement in geometry, a more postitive attitude towards mathematics, or a more positive academic self-concept, compared to native students who do not receive instruction in Logo?

The research hypotheses, derived from the research question were as follows:

Research Hypotheses

Grade four native students who receive instruction in Logo and an opportunity to do Logo on a regular basis throughout the school year will demonstrate:

1) improved achievement in mathematics,

2) improved achievement in geometry,

3) a more positive attitude towards mathematics,

4) an higher level of academic self-concept

compared to grade four native students who do not receive instruction in Logo.

Research Design

A quasi-experimental non-equivalent control group design was used to test the research hypotheses. Two intact grade four classes were treated as follows:

Experimental group. These subjects received Logo instruction in large group sessions and an average of one half hour per week working in pairs at the computer doing Logo.

Control group. These subjects had approximately equal "hands-on" time on a computer as the experimental group but used computer assisted instruction (CAI) programs instead of Logo.

Pretesting of the groups was done in September of 1984. The treatment period was from late September, 1984 to early May, 1985 and posttests were administered in late MAY, 1985.

Definition of Terms

Logo. An interactive computer language developed by Papert and described in his book Mindstorms (1980).

Computer Assisted Instruction (CAI). Any activity in which a computer program directs a person's learning towards a specific, predetermined objective.

Mathematical achievement. The level of proficiency the student has in the mathematical skills and concepts which are outlined in the K to Grade 6 Manitaba Department of Education Mathematics Curriculum Guide (1978).

Geometry achievement. The level of proficiency the student has in the geometric skills and concepts which are outlined in the K to Grade 6 Manitoba Department of Education Mathematics Curriculum Guide (1978).

Attitude toward mathematics. The feeling an individual has at any given time towards mathematics as an academic subject as well as towards his ability to be successful at mathematics.

Academic self-concept. A person's view of himself in the role of student, i.e. as a learner in a school setting.

Native student. Any student, Indian or Metis, Treaty or Non-treaty that is of Indian descent.

Limitations

Sample size. Cost factors such as travel expenses and computer hardware limited the study to two classes with a total of 47 students. The small number of classes increased the possibility that any perceived changes might be due to causes other than the treatment variable, for example, differences in teacher effectiveness, etc.

Duration of study. The study may not have been of sufficient length to allow for any perceptible changes in attitudes or self-concept.

Choice of subjects. Because intact classes of students had to be used, it was not possible to assign subjects randomly to groups. Furthermore, because of cost, choice of the Logo group was not done randomly but was based on proximity to Winnipeg.

Instrumentation. Because one of the instruments for measuring academic self-concept had to be administered by someone who had "a minimum of five to six weeks' experience with the child on a daily basis in a setting associated with learning" (Coopersmith & Gilberts, 1982, p.IV-4), it was necessary to have the respective classroom teachers rate their own students, raising the possibility of rating variation between teachers.

Treatment. The shortage of computer hardware and the difficulties inherent in incorporating computer activities into the regular school program limited the amount of time the subjects were able to spend on the computer. Thus, the level of treatment may have been too small to have any measurable effect on the dependent variables.

Delimitation

Sample. The subjects in the study were grade four students from two northern and predominantly native communities. Therefore, inferences and conclusions are only generalizable to other similar situations.

Summary of Chapter I

This chapter provided an overview of the study, beginning with a description of the Logo language. A reason for the study was provided and the possible relationships of Logo to mathematics, native students, and academic self-concept were discussed. The specific purpose of the study was given, followed by a statement of the problem and the resulting research hypotheses. The research design was briefly described and important terms were defined. Finally, limitations and delimitations of the study were outlined.

CHAPTER II

REVIEW OF THE LITERATURE

In this chapter, the relevant literature is reviewed in two parts, Part 1 which summarizes the literature on Logo and Part 2 which summarizes the literature regarding native students, mathematics, and computers.

Part 1 - Logo

Claims Regarding Logo

As stated in Chapter 1, numerous and largely unsubstantiated claims regarding the educational value of Logo have been made. Some of the most prominent claims have been that Logo:

1) can be used as a means of developing computer literacy skills in young children (D'Angelo, 1981);

2) improves logical thinking skills (Lough, March, 1983; Markuson, 1983; Shapiro, 1982);

3) enhances general problem solving skills (Harvey, 1983; Lough, March, 1983; Williams, 1982);

4) encourages a more positive attitude towards making mistakes (Martin and Berner, 1982);

5) enhances creative writing skills (Bearden and Muller, 1983);

6) facilitates the development of peer relationship

skills such as cooperation and communication (Brozan, 1983; Watt, 1982);

7) facilitates the learning of various mathematics concepts (Billstein, 1983; Lough, April, 1983; Papert, 1980);

8) instills a more positive attitude towards mathematics (Papert, cited in Instructor, 1982); and

9) develops a more positive attitude towards oneself as a learner (Harvey, 1982; Markuson, 1983; Papert, 1980).

Criticisms of Claims Regarding Logo

Until recently, objective criticisms of Logo have been rare and all but lost amidst the enthusiastic claims being made by Logo proponents. Steffin (1983) warned that Logo is far from the educational panacea that some of its advocates would have us believe. He suggested that:

> Logo's effectiveness depends largely on the learners' characteristics. Thus, if the learner is highly motivated, curious, and eager to explore meaningful and relevent life events a Logo learning environment will be educationally beneficial (p.88).

Other critics have focussed on the role of the teacher. There is considerable disagreement within the Logo community regarding the amount of structure needed to derive the optimum benefits from Logo as an instructional tool. Howe (1981) has argued for a more teacher-directed approach to Logo than was suggested by Papert (1980) who took the

Piagetian view that students could direct their own learning with little assistance from the teacher. Leron (1985) sought the middle ground in this argument by suggesting a "quasi-Piagetian learning" (p.28) approach to Logo which assumes a more active role for teachers and learning materials, but still leaves considerable freedom and control in the child's hands.

From the above discussion, it is clear that many claims made for Logo are overly simplistic, failing to take into account the complex interaction between the students, teacher, and computer language within the classroom setting, that is, the total learning environment within which Logo is experienced. There is a tendency for Logo enthusiasts to overestimate the power of the Logo computer language to transform that environment while underestimating or ignoring the importance of the other factors.

Some of Logo's most confirmed supporters have expressed concern that Logo is being oversold and that there is a need for research to determine its effectiveness and how it can best be utilized. Moursund (1984), editor of <u>The Computing Teacher</u> and a strong proponent of Logo, stated that "deeply-held beliefs in Logo go largely unsubstantiated" (p.3). Lough (March, 1983) commented that "because Logo has been widely available for only a short time, research studies on its long-term learning effects are still in the infant stage"(p.50). Finally, Leron (1985) a "self-confessed Logophile" (P.26) has urged the Logo community to make its claims more moderate, take a more realistic look at Logo, and begin to tackle the difficulties of effectively using Logo in the classroom.

The question of transfer of learning is central to much of the controversy which surrounds the claims being made for Logo. Do the skills and concepts developed in learning Logo transfer to other cognitive domains such as mathematics and problem solving? Pea and Kurland (1983) in a comprehensive and critical review of the cognitive and educational benefits of teaching children computer programming stated that:

> there is less than compelling evidence for any of the broad claims made about the transfer of programming skills to other domains....the lack of such evidence reflects both the minimal amount of research in this area and its inadequate quality (p.25).

Krasnor and Mitterer (1984) were also critical of both the quality of research as well as the evidence regarding the generalization of Logo learning. Some of their conclusions were:

> 1) To date the literature concerning Logo consists primarily of testimonials, curriculum guides, manuals, and a few studies containing considerable anecdotal evidence (p.135);
>
> 2) Most of the available evidence refers to Logo learning rather than the transfer of Logo learning to other contexts (p.136); and

3) The entire Logo literature merits considerable criticism from an experimental point of view. The general lack of objective measurement makes the currently available work useful only as a first step in evaluating the effects of Logo (p.137).

Leron (1985) also criticized current Logo research on three counts: 1) most research fails to specify the precise method used to teach Logo, 2) the duration of most studies has usually been too short to reasonably expect measurable results, and 3) the evaluation tools used are inappropriate for the processes which are important in Logo learning.

Logo Research Findings

Although Logo has come under criticism because claims for its educational value have far exceeded research evidence, there have been a number of research projects which have attempted to provide evidence of Logo's effectiveness as an educational tool. Some of these projects have been of an exploratory and descriptive nature with conclusions being based primarily on observation rather than quantative measurements. In other projects where objective measurements were taken there was no attempt to compare the results of the Logo group to the results of a control group which had not been exposed to Logo.

A number of descriptive studies have originated out of the Massachusetts Institute of Technology (MIT). One series of projects was conducted by Dr. Sylvia Weir (1979) at The

Cotting School for the physically handicapped in Boston. In these projects, Logo enabled students with cerebral palsy to begin to realize their intellectual potential. By experiencing success in doing Logo, they gained confidence in themselves as learners. This conclusion was reinforced by Muller (1983) who used Logo with both physically handicapped as well as developmentally disabled children. His observations have led him to conclude that Logo is an excellent medium for building self-confidence in children with learning problems.

Two other projects which originated out of MIT were conducted at Lincoln School, Brookline, Massachusetts (Papert, 1977, 1979). The first project involved sixth-grade students learning Logo in a computer lab. In the second project, computers were placed in classrooms from Grades 4 through 8. A student-directed approach was used with the teacher's role being one of facilitation. According to Watt (1982), the projects were "not very successful in obtaining 'objective' data about learning gains made by the students"(p.20). However, Watt (1982), made the following observations: Logo learning environments are suitable for many different kinds of students; some students emerged as Logo "experts" who became tutors for other students; and a collaborative atmosphere developed amongst groups of students. Probably the most important contributions made by the Brookline Projects were that they allowed for the development and field-testing of various

Logo curricular materials as well as providing guidelines for future research.

In 1978, a four year project was initiated at the Lamplighter School in Dallas, Texas involving approximately 400 children ranging from three to nine years of age. There are conflicting reports regarding the outcome of this project. According to Watt (1982), "the research studies that were expected to be part of the project have not materialized"(p.132). However, a more recent report from Lough (March, 1983) not substantiated by empirical evidence stated that:

> Logo helped students: 1) develop logical thinking and problem solving skills; 2) learn to develop and test their own ideas and theories; and 3) become familiar with concepts such as variables, symmetry, angles and geometric forms (p. 50).

New York City has been the site of two major Logo projects - The Computers in the Schools Project and the Bank Street School for Children Project. One of the noted effects of doing Logo was the increased interaction among the students. Furthermore, in the Bank Street Project it was found that when students were doing Logo their conversation was more task-relevant than conversation during a "normal" math class (Brozan, 1983). However, findings regarding Logo's effect on academic achievement were inconclusive. Initial reports from the Computers in the Schools Project, based on observation, were that Logo had a positive effect on students who had not previously been successful in school (Watt, 1982).

In Senegal, West Africa a multidisciplinary team of Senegalese professionals conducted a preliminary study of the effects of using French Logo with pupils aged 7 to 11 (Barry, 1984). Teachers observed that pupils participating in the experiment improved in mathematics as well as displaying more curiosity in the classroom with the most satisfactory results being observed among the girls.

Two major shortcomings of the research projects described above are the absence of an experimental design and the relative scarcity of quantitative evidence to reinforce observational findings. Other studies have attempted to be more rigorous in this regard. Two early studies by Statz (1973) and Chait (1978) generated empirical evidence regarding the development of general problem solving skills. Statz used a pretest, posttest control group design with grade 4 children to investigate whether learning Logo made a difference on four problem solving tasks. The experimental group did significantly better on two of the tasks, namely, word puzzles and permutations, but no better on a Tower of Hanoi task or a horserace problem.

Chait (1978) investigated comparable issues with five grade 7 children who were taught individually. Pretests and posttests were administered but no control group was employed. The test battery included a test of basic arithmetic skills, an alternate uses test, and a set of geoboard problems. The results revealed no significant changes in test scores.

Seidman (1981) explored how learning to program with Logo affected logical reasoning ability. Sixty grade five students were randomly selected, then randomly assigned to an experimental or control group. Both groups were pretested after which the experimental group was given 30 hours of Logo instruction over 15 weeks while the control group received no special instruction. The posttest results revealed that the Logo group performed significantly better on the "inversion fallacy principle" while the control group performed significantly better in reading, a surprising and unexpected result!

Another study which used an experimental design was the Edinburgh Logo Project (Howe, O'Shea, & Plane, 1980). Two primary year 7 (grade 6) classes participated over a two-year period with one class doing Logo structured to supplement the regular mathematics program and the other class receiving the regular mathematics program with no Logo supplement. Objective testing indicated that the Logo group displayed significant improvement in mathematical understanding, attitude towards mathematics, and willingness to talk about mathematics. The project coordinators acknowledged that a number of uncontrolled factors might have contributed to the improvements and that further research was needed.

Pea (1983) investigated whether students ranging in age from 8 to 12 who had extensive opportunity to program in Logo over a school year displayed better planning skills than children who had no Logo experience. A classroom chore-scheduling task was used which allowed children multiple opportunities to come up with the shortest plan they could construct for carrying out a series of chores. It was expected that "better planners would take a more strategic approach to the task, revise or debug their plans more effectively, and engage in more executive and metacognitive decision making as they developed their plans"(Pea, 1983). However, Pea found no differences between the programming and nonprogramming groups and suggested two possible reasons for the results: planning skills may not be developed by engaging in Logo or skills which are developed may not be automatically transferable to non-computer planning tasks.

Brown and Rood (1984) attempted to determine whether learning Logo or BASIC had different effects on intellectually gifted students from Grades 2 to 9. Both groups were pretested, given 8 weeks of instruction in one of the computer languages, then posttested. No significant difference was found between the two groups on any of the tests, namely, problem solving, locus of control, or perceived self-esteem. However, when the results of the groups were combined a significant improvement was found in problem solving ability as measured by <u>The Social Science Piagetian Inventory</u>, providing evidence that learning a computer language contributes to problem solving ability.

A large-scale Logo project involving over 500 grade 4 students in Albemarle County in Virginia was conducted in the 1982-83 school year (Schwartx, Evans, & Caritj, 1984). The evaluation focused on assessing three outcomes: changes in attitudes towards mathematics; changes in motivation; and changes in cognitive ability. A pretest-posttest control group design was employed with eight intact classes constituting the experimental group (N=321) and seven intact classes constituting the control group (N=190). Analysis of the test data led to the conclusion that "experience in learning Logo does apparently have some effect on student attitudes towards learning mathematics, student motivation, and student cognitive abilities"(p.9) and that, "...overall, this project does offer hope that Logo may serve as an effective instructional tool, both in terms of cognitive and affective variables"(p.10).

Summary of Literature on Logo

A review of the literature regarding Logo can be summarized as follows:

1) There have been a large number of unsubstantiated claims made regarding the educational value of Logo.

2) These claims have given rise to unrealistic expectations regarding Logo and have resulted in a call to moderate those claims and to conduct systematic research to evaluate Logo's effectiveness as an educational tool.

3) Research findings thus far have been inconclusive. Some promising findings requiring further investigation are:

a) Logo can have a positive effect on a student's self concept as a learner, particularly if the student has learning disabilities or has had a history of poor academic performance.

b) Logo can assist in the development of logical reasoning and problem solving skills.

c) Students are more apt to talk about mathematics when doing Logo than in a regular mathematics class.

d) Attitudes towards mathematics can be positively influenced by Logo instruction and practice.

e) Learning Logo can result in increased mathematical understanding, particularly in geometry.

Part 2 - Native Students, Mathematics, and Computers

In attempting to summarize what has been written regarding mathematics and native students, two cautions are necessary. Firstly, most of the research in this field has been conducted in the United States; therefore, generalizing the findings to the situation in Canada must be done tentatively. Secondly, it is important to remember that in discussing "native students" one is dealing with a large, diverse group that cannot be defined neatly. In spite of these limitations, the literature seems to suggest that some generalizations about the mathematics education of native students can be made, albeit cautiously.

Mathematics Education of Native Students

The educational problems encountered by native students has been documented by a number of educators. According to Christensen (1982):

> National studies indicate that three-quarters of all Indian children are at least one grade level behind for their age, over one-half of all Indian students drop out of school, and, on average, Indian students fall further and further behind as they progress through school... (p.iii).

With regards to mathematics, A National Institute of Education (NIE) report (1980) stated that:

> Students...often demonstrate potential equalled to

white students in the early grades. As their schooling experiences increase during their elementary and through secondary years many of them fall behind, drop out of mathematics and become negative in their attitude towards the subject" (pp.11-12).

Cheek (1984) in reviewing what has been written about this situation pointed out that native students have difficulty in traditional mathematics classes and that their lack of success in mathematics prevents many of them from pursuing careers in mathematically oriented occupations. According to Green (1978), "for American Indian students, math anxiety and math avoidance are the most serious obstacles to general education and to the choice of scientific careers" (p.1).

The previous comments are directed specifically at the situation in the United States. No sources were found which give a comprehensive overview of the Canadian situation. However, the author's experience with native students in Frontier School Division has led to the conclusion that these students face a similar dilemma to that of their American counterparts. For example, any formal mathematics testing which has been done in the past five years (i.e. Canadian Test of Basic Skills, Stanford Diagnostic Mathematics Test, and the Provincial Mathematics Assessment) has indicated that many students are below grade level and continue to lose ground as they progress through school.

Although the existence of the problem has been documented and agreed upon, there is no similar consensus regarding the underlying causes. Christensen (1982) suggested that the problem is the "product of the complex interaction of socialization, educational exposure, and attitudes" (p.iii). Green (1978) suggested that "...the problem of ... lack of achievement in mathematics is one of emotional or psychological origin" (p.2).

A National Institute of Education (NIE) report (1980) focused on three major areas of influence in the mathematical education of minority children, namely: 1) learning style, personality and self-concept influences; 2) linguistic effects; and 3) school influences. They also listed a number of other influential factors such as: parents, community, socioeconomic status, administrators, structure of the family, values of the culture, and influences of peers.

The learning style factor was of particular interest in the present study. Kaulback (1984), in reviewing the research regarding styles of learning among native children stated that "Some researchers view [the] mismatch between learning style and instructional methods as a prime cause of school failure among native children" (p.27). He pointed out that extensive use of the Illinois Test of Psycholinguistic Abilities (ITPA) with a number of different native groups throughout North America (e.g. Navajo, Pueblo, Papago, Sioux, and Inuit) had yielded surprisingly consistent results. While he emphasized that interpretation of these results needs to be done with caution, he stated that:

> All of the studies point to the fact that both Indian and Inuit children are most successful at processing visual information and have the most difficulty performing well on tasks saturated with verbal content (p.30).

According to Heffron (1984), this generality about the predominant learning style of native children has been cited by many others in the literature and has implications for the way in which mathematics can be most effectively taught to native students. Simpson (in NIE Report, 1980) suggested the "inclusion of multi-dimensional, student-selected materials, which emphasize the visual manipulation of mathematics concepts"(p.16). Moses (in NIE Report, 1980), stressed that "more emphasis on geometric perception would provide opportunities for students to stretch their spacial capacities"(p.20). Cheek (1984) argued for an activity-based approach in which concrete and visual experiences would make mathematical concepts more understandable.

Native Students and Computers

Heffron (1984) suggested that "some accepted values and learning style tendencies apparent in native children...are very adaptive to computer education"(p.17). She specified such qualities as: 1) a visual learning style; 2) the need for privacy when faced with a new learning situation; 3) the emphasis on cooperation, sharing, and individual responsibility for decision making; and 4) a "friendly", nonjudgemental atmosphere, as being compatible with a computer environment.

There have been a few Computer Assisted Instruction (CAI) projects in which the computer was used as a mathematics tutor for native students. Using CAI with Pueblo students, Suppes, Fletcher, and Zanotti (1975) found substantial increases in mathematics placement. Brooks (1977) noted the same results with natives in Morley, Alberta. Hakes (1981) developed and used a computer-based learning unit in mathematics and science for grade 5 Pueblo students. She noted an improvement in classroom atmosphere, teacher-student relationships, attitudes, instruction, individual behavior, and learning.

Computer programming has been suggested as another way of using computers to enhance the mathematics education of native students (Coppus, 1978; Cheek, 1984; Heffron, 1984), and Logo has been specifically mentioned in this regard. For example, Heffron (1984) stated that:

> Logo is especially adaptive to the native child. In addition to the child's spatial-mechanical mode of learning, Logo would build upon the child's natural learning tendencies to learn by exploration and discovery. Using the child's knowledge of his/her body movements, the native child would learn formal

geometric principles with Logo. Using Logo to do geometry would help a native child understand the process of learning and develop his/her heuristic strategies within a visually interactive mode (p.21).

Only one research project which dealt with the use of Logo with native students was found in the literature. In that project, Bradley (1976) used loom-woven beadwork and Logo to develop a culture-based mathematics curriculum for Indian students. Students developed their beadwork designs using Logo and "by writing computer programs to draw shapes, designs, or animated pictures, the students learn mathematics" (Bradley, 1984, p.101). Her conclusions were based on observational findings but no empirical evidence was gathered. Heffron (1984) mentioned the possibility of a Logo study being conducted with native students in Ontario, but as yet no information has been published.

Finally, Cheek (1984) in summing up the need for research in mathematics education for native students, stated that:

> We need to see...whether Native American students learn to understand mathematics over a period of 2 or 3 years through a Logo environment. The availability of the Logo computer language on several microcomputers and the tendency of some reservation schools to have stable populations over long time periods help make it a timely program for investigation (p.7).

Summary of Literature: Native Students, Math and Computers

A review of the literature regarding native students, mathematics and computers can be summarized as follows:

1) Native students have had a long history of difficulty with mathematics in school which has handicapped their academic development and severely limited their career choices.

2) Numerous reasons for the difficulties have been postulated ranging from psychological to socioeconomic to cultural.

3) Incompatibility of instructional methods with learning styles has been cited as a major contributor to the problem. Instructional methods have been verbally oriented whereas native learning style is visually oriented.

4) The use of the computer has been suggested as one promising way of adapting mathematics instruction to the style of the learner.

5) Logo has characteristics which could provide native students with a mathematical learning environment conducive to a visual learning style.

6) Research projects to investigate the potential of the computer to enhance mathematics education for native students are virtually non-existent and urgently needed.

Summary of Chapter II

In this chapter, the relevant literature was reviewed under two general headings - literature related to Logo and literature related to native students, mathematics, and computers. The possiblility of using Logo to improve mathematics instruction for native students was raised in light of the apparent compatibility of Logo with the predominantly visual learning style of native students.

CHAPTER III

METHOD

The purpose of this study was to investigate the effects of instruction and practice in Logo on achievement in mathematics, achievement in geometry, attitude toward mathematics, and academic self-concept.

This chapter provides a detailed description of how the study was conducted. The information is organized under the headings Subjects, Instruments, Design, Procedure, and Data Analysis.

Subjects

Subjects were Grade 4 students enrolled at schools in two native communities in northern Manitoba.

The experimental (Logo) group (N=26) was an intact class from a Kindergarten to Grade 12 school located on an Indian reserve about 200 kilometers northeast of Winnipeg. Most of the students are of Saultaux Indian ancestry and can be classified as either Status Indians or Metis.

The control (CAI) group (N=21) was an intact class from a Kindergarten to Grade 8 school located in a native community about 500 kilometers north of Winnipeg. Most of the students are of Cree Indian ancestry and can be classified as either Status Indians or Metis.

Instruments

Mathematics achievement was operationally defined as a score on the Frontier School Division Mathematics Survey - Level IV (Kozak, Petrencik, & Smith, 1985). Geometry achievement was operationally defined as a score on the 10 geometry-related items on the above instrument. Attitude towards mathematics was operationally defined as a score on the Estes Attitude Scales - Elementary Form (Estes, Estes, Richards, & Roettger, 1981). Lastly, academic self-concept was operationally defined as a score on two related instruments - the school/academic subscale of the Coopersmith Self-Esteem Inventory (SEI) - School Form (Coopersmith, 1981) and the Behavioral Academic Self-Esteem (BASE, Coopersmith & Gilberts, 1982). These instruments are described below.

Frontier School Division Mathematics Survey - Level IV. Developed by the mathematics consultants of Frontier School Division this instrument is one of a series of grade level tests being used to measure proficiency in mathematics skills and concepts of students in the division. The Level IV survey (see Appendix), consists of 103 multiple-choice, computer-scorable items developed using the core objectives of grade 4 mathematics as outlined in the Manitoba K-6 Mathematics Curriculum Guide (1978). The Mathematics Assessment Program (1981) tests developed by the Department of Education for grades 3 and 6 were used as a model for the format and content of the Frontier surveys. Ten of the items on the Level IV survey are geometry questions.

For the pretest (September, 1984), a condensed fifty-seven item version of the survey was used. This instrument has the same format and is based on the same core objectives as the posttest instrument but there are less items for any given objective on the pretest version.

Estes Attitude Scales - Elementary Form. This instrument consists of three 14-statement Likert-type scales, one to measure the attitudes of elementary school children toward each of three school subjects: mathematics, reading, and science. The scales are intended for use with children from the end of second grade through sixth grade. No reading is required of children because the statements are read to them by an administrator. Item content is easily understood by most elementary students. Each scale may be administered separately, or the entire battery may be given at one sitting of about twenty minutes duration. For the purposes of this study, only the Mathematics Attitude Scale was used. Two sample statements from that scale are: "It is easy to get tired of math." (item #3) and "Math is interesting." (item #11)

The Estes Scales have been normed on 1 815 students. Internal consistency reliability coefficients are .80 or greater. Evidence of criterion-related, construct, and factorial validity have been established (Estes, et al., 1981).

Coopersmith Self-Esteem Inventory (SEI) - School Form. This form is designed for use with students aged eight through fifteen and consists of fifty-eight items: fifty self-esteem items and eight items that constitute the Lie Scale, which is a measure of a student's defensiveness or test wiseness. For each statement, students are to indicate whether the statement is "like me" or "unlike me" by checking the appropriate box. The statements may be read aloud by the administrator if reading ability is deemed to be a problem.

The self-esteem items yield a total score and, if desired, separate scores for four subscales: General Self (26 items), Social Self/Peers (8 items), Home/Parents (8 items), and School/Academic (8 items). The subscales allow for variances in perceptions of self-esteem in different areas of experience. For the purposes of this study the School/Academic subscale was of primary interest. Two sample statements from the School/Academic subscale are: "I often get discouraged at school." (item #23) and "I'm proud of my schoolwork." (item #33).

"Since its development, the SEI has been administered to tens of thousands of children and adults....All socioeconomic ranges and many ethnic and cultural groups are represented.... Well over 100 studies have been conducted" (Coopersmith, 1981, p.12). Internal consistency reliability coefficients for grades 4 to 8 are .87 or better. Construct concurrent, predictive, and factorial validity have been established (Coopersmith, 1981).

A condensed version of the School Form called the School Short Form was used for the pretest. This form consists of the first 25 items on the School Form and does not include the Lie Scale nor does it elicit subscale scores. Total score correlation between the School Short Form and the School Form is .86 (N=121; Coopersmith, 1967).

Behavioral Academic Self-Esteem (BASE). Designed to be used in conjunction with the Coopersmith Self-Esteem Inventory, BASE is an observational rating scale that assists in the assessment of academic self-esteem of childen from preschool through Grade 8. It can be completed by anyone who has access to sustained direct observation of the child. BASE consists of 16 items on a Likert scale and assesses student behaviour on 5 factors: student initiative, social attention, success/failure, social attraction, and self-confidence.

Estimates of internal consistency were based on correlations of individual items with the total score. All correlations were significant at the .001 level and ranged from a low of .37 to a high of .76 with a mean z transformation of the correlation coefficients of .61. When different teachers rated the same children, the interrater reliability was estimated as moderately strong with a correlation of .71 in a sample of 216 students. With regards to predictive validity, BASE ratings were found to be moderately strong predictors of academic achievement scores for students from grades 2 to 6. For example, a correlation coefficient of .46 was found between BASE and grade 4 mathematics achievement as measured by the <u>Comprehensive Test of Basic Skills</u>. Construct validity has also been established (Coopersmith & Gilberts, 1982).

Design

A quasi-experimental non-equivalent control group design with intact classes was used. Using the format developed by Campbell & Stanley (cited in Gay, 1981), the design can be depicted as follows:

O X1 O

O X2 O

Where: O = tests, pretests or posttests

X1 = instruction and practice in Logo

X2 = use of computer for computer assisted instruction (CAI)

As the diagram indicates, both groups were pretested on the dependent variables after which the treatment conditions were set up with the experimental group using the computer for learning about and doing Logo and the control group using the computer with various CAI programs. The control group was given equal access to a computer to control for the possibility that access to a computer rather than experience with Logo could cause the hypothesized changes in the dependent variables. After the treatment period (Oct./84 to April/85), both groups were posttested on the dependent variables.

Procedure

Details regarding the procedure are given below under the headings: time/task line, selection of subjects, teacher training, computer hardware, support materials, treatment of subjects, and data collection.

Time/Task Line. The following time/task line outlines specific steps taken during the study:

May/June, 1984	Select subjects Select test instruments Contact school personnel
August, 1984	Begin training Logo teacher (1 day) Acquire computer hardware and support materials
September, 1984	Pretest subjects Set up computer hardware in classrooms Assist Logo and CAI teachers in getting started with treatment
October, 1984	Visit with Logo group to monitor progress Continue training Logo teacher
November, 1984	Visit with CAI group to monitor progress Provide assistance to CAI teacher
January, 1985	Visit with Logo group to monitor progress Continue training Logo teacher
April, 1985	Visit with Logo group to monitor progress Continue training Logo teacher
May, 1985	Posttest subjects
June, 1985	Analyze data and write report

Selection of subjects. The school for the experimental group was chosen because of its proximity to Winnipeg, making it the most economical and convenient location for the author to make regular visits to monitor progress and provide assistance to the teacher. The other major factor influencing the choice of the school was the willingness of the grade 4 teacher to take part in the study.

The control group was chosen because of its similarity to the experimental group in mathematics achievement as measured by the grade 3 Provincial Mathematics Assessment Program test administered in May of 1984 about four months prior to the commencement of this study. The willingness of the teacher to take part in the study and the fact that the class size was similar to the experimental group also influenced the selection.

Teacher training. Training of the Logo teacher was to have taken place during a one-week Logo course being offered by the Faculty of Education, University of Manitoba in the summer of 1984. However, this course was cancelled due to lack of enrollment, making it necessary for the author to provide the teacher training. An initial one-day training session was conducted in August of 1984 and consisted of the following components: orientation to the philosophy of Logo; hands-on experience with Logo to provide familiarity with the language; overview of Logo support materials and suggestions regarding their use; and discussion regarding implementing Logo in the classroom. Follow-up training sessions dealing with further aspects of the Logo language and instructional ideas were conducted on-site during the 4 visits to the school (September, October, January, April). The author also worked directly with the children during those visits in order to demonstrate useful teaching techniques.

Training of the CAI teacher was conducted in September, 1984 and consisted of the following components: hands-on experience with the computer programs; discussion about how the programs could be used; and specific suggestions regarding the logistics of implementing a CAI programme in the classroom. Further discussions were held during the November visit.

It is obvious from the above description that the Logo teacher received considerably more training than the CAI teacher. This was necessary and unavoidable given the relative difficulty of implementing Logo in the classroom as opposed to implementing CAI. At the completion of the study, both teachers were asked the question: "Do you feel you were adequately prepared to use a computer with your students?" The Logo teacher's response was "No!...a 2-day workshop for beginners in the summer would have been ideal." In contrast, the CAI teacher's response was: "I feel I was adequately prepared to use a computer with my students." Thus, although the CAI teacher received less training, he felt more adequately prepared to use the computer than the

Logo teacher.

Every effort was made to ensure that students in the CAI class were given approximately equal hands-on time with the computer as students in the Logo group. Both teachers were asked to schedule each student for a minimum of one-half hour per week and to attempt to give all students roughly equal access to the computer.

Computer hardware. The Logo group used a Franklin Ace 1000, an Apple-compatible computer with a composite color monitor and a disk drive. The color capabilities of Logo were rarely used during the study. In the late stages of the study (April), an Epson MX-80 FT dot matrix printer was added to the system and used to print some of the students' procedures and pictures.

The CAI group used an Apple II Plus computer with a green monochrome screen monitor and a disk drive.

For both groups, the computer equipment was set up in the classroom where it remained for the duration of the study.

Support materials. The Logo group used M.I.T. Logo for the Apple II (Krell Software Corporation, 1981). Among the printed materials used by the teacher as an aid to planning Logo lessons and activities, were: Logo in the Classroom (Torgerson, 1984); Apple Logo for Teachers (Babbie, 1984); The Turtle's Sourcebook (Bearden, Martin, & Muller, 1983); and Learning With Logo (Watt, 1983).

The CAI group used the following programs: Alien

Addition, Alligator Mix, Demolition Division, Dragon Mix, Meteor Multiplication, and Minus Mission (Developmental Learning Materials, 1984); Elementary Volumes 1 to 4, 8, 9, 12 and Mathematics Volume 1 and 3 (Minnesota Educational Computing Consortium); and Apple Dissemination Disks #1 to #8, #44, #45 (Softswap Microcomputer Center).

Treatment of subjects. Both classes received a regular grade 4 mathematics program based on the same textual series, Starting Points in Mathematics by Ginn and Company (1982). In addition to that core program, the Logo group received a half-hour class lesson in Logo about twice a month and an opportunity to do Logo at the computer for about one half hour each week. The CAI students also averaged about one half hour per week working at the computer. Both CAI and Logo students generally worked at the computer in pairs.

Both teachers reported that the amount of computer time varied from week to week and from student to student for various reasons. Such factors as special school events, teacher or student absenteeism, individual differences, and scheduling logistics mitigated against maintaining a high degree of consistency.

Data collection. As indicated in the time/task line, all subjects were pretested in September of 1984. The Frontier School Division Mathematics Survey (57-item version), Estes Attitude Scales, and Coopersmith Self-Esteem Inventories - School Short Form were administered by the author. The Behavioral Academic Self-Esteem instrument was completed by the respective classroom teachers because of their familiarity with the students.

Posttesting was conducted in May with the Estes Attitude Scales, and Coopersmith Self-Esteem Inventories - School Form being administered by the author. The Frontier School Division Mathematics Survey (103-item version) and Behavioral Academic Self-Esteem were administered by the respective classroom teachers.

Data Analysis

As indicated in the Procedures section, the CAI group was chosen based on its "equivalence" to the experimental group in mathematics achievement as measured by the grade 3 Provincial Mathematics Assessment Program test which was administered to both groups in May of 1984. A two-independent sample t-test performed on the test data confirmed that there was no statistically significant difference in mathematical achievement between the Logo and CAI groups ($t=1.36$, $df=43$, $p>.05$).

By September 1984, the makeup of the CAI group had changed considerably. Five students were transferred to another grade 4 class in the school and seven students were transferred in from another class. During this time, the makeup of the Logo group had not changed. Because of the unforeseen changes in the CAI group, the "equivalence" of the two groups on the mathematics achievement variable became suspect. This was confirmed by an analysis of the pretest data. A two-independent sample t-test revealed that the groups were significantly different on the mathematics achievement pretest, Frontier School Division Mathematics Survey ($t=5.79$, $df=45$, $p<.05$). In addition, the two groups differed significantly ($t=24.06$, $df=46$, $p<.01$) on one of the pretest measures of self-esteem, namely Behavioral Academic Self-Esteem. However, there were no significant differences between the groups on the Mathematics Attitude Subscale of the Estes Attitude Scales ($t=3.24$, $df=46$, $p>.05$) or on the School Short Form of the Coopersmith Self-Esteem Inventories ($t=0.33$, $df=45$, $p>.05$).

According to Cook & Campbell (1979), when significant differences between the experimental and control groups occur on pretest measures, a simple analysis of variance (ANOVA) on the posttest data is inappropriate and alternative methods must be considered. Three possible methods of analysis are: analysis of covariance (ANCOVA), post-hoc blocking, and analysis of variance with gain scores. Each method is briefly described below.

Analysis of Covariance. The ANCOVA with a single covariate extends the elementary ANOVA by including the pretest measure as a term in the linear model. Using the pretest (covariate) in this way provides an adjustment for initial differences between the groups. The adjustment usually alters the expected value of the treatment-effect estimate as compared to the ANOVA. In essence, the ANCOVA uses the pretest scores to predict the posttest scores. The estimate of the treatment effect is the difference between the predicted posttest scores of individuals in the two groups who have been "matched" on pretest scores. A statistically significant difference suggests that one group would have significantly outperformed the other on the posttest if the groups had started with the same pretest scores.

The main reason for using the ANCOVA rather than the ANOVA is to remove bias due to selection differences. However, the effectiveness of this technique to provide an unbiased estimate of the treatment effect is limited by various factors. For example, "random measurement error in the pretest...can bias the estimate of the regression slope and thus bias the estimate of the treatment effect" (Cook & Campbell, 1978, p.160). Also, according to Keppel (1973), "covariance requires a number of specialized statistical assumptions, the most stringent of which is the assumption of homogeneous within-group regression"(p.514).

Post-hoc Blocking. This technique involves arranging subjects in blocks on the basis of pretest performance after the groups have been formed. Thus, individuals in the experimental and control groups are separately ranked and placed into groups that have similar pretest scores. For example, a "high" ability block and a "low" ablility block could be formed. If there were two treatment levels this would result in a "Treatment X Block" design with four cells. In this case, the blocking technique would transform a single-factor experiment into a two-factor design, factor A being the treatment and factor B being the ability levels. because the subjects are assigned to a block based on their actual pretest score rather than randomly, the resultant blocks usually have unequal numbers of subjects, resulting in a nonorthogonal factorial design.

Cook & Campbell (1979) point out that there are advantages to using the block design over using the ANCOVA in that, "... blocking does not require the researcher to specify the general shape of the regression of posttest on pretest scores, since...the block and interaction effects can adapt to any shape"(p.178).

On the other hand, a disadvantage of blocking versus other methods of analysis is that assigning subjects to blocks may result in omitting some individuals from the analysis because their pretest scores do not reasonably fit into any of the blocks. This would result in a different estimate of the treatment effect than if all subjects were included in the analysis.

<u>Gain Score Analysis.</u> An analysis of variance using gain scores examines the change in performance from the pretest to the posttest. The model for the analysis is identical to the elementary ANOVA except that the gain score (posttest minus pretest) is the dependent variable rather than just the posttest alone. An important criterion to

minimize bias is that the pretest and posttest be operationally identical. Even if this criterion is met, Cook & Campbell (1978) advise caution in using gain score analysis citing threats to validity such as: "selection-maturation interactions, instrumentation (floor and ceiling effects), and problems of regression" (p.184).

After considering the alternatives in light of the pretest data analysis and Cook & Campbell's suggestions, the following decisions were made regarding analysis of the posttest data:

1) Mathematics attitudes and academic self-concept (Coopersmith): Because there was no significant difference in the pretest results, a single factor (Treatment) analysis of variance would be performed on the posttest data.

2) Mathematics achievement and geometry achievement: Because there was a significant difference in the mathematics pretest scores, the posttest scores would be analysed by two Treatment X Block Factorial ANOVA using the mathematics pretest scores as the blocking variable.

3) Academic self-concept (BASE): Two methods of analysis were considered for these data. Firstly, because there was a significant difference in the pretest scores, a Treatment X Block ANOVA could be performed on the posttest data. However, a closer examination of the pretest scores revealed that in order to form two homogeneous blocks, eight scores from the Logo group would have to be deleted.

Further, these scores represented the lowest eight scores in this group. As a way of retaining all the data, gain score analysis was considered as an alternative method. However, because the use of this method is questionable due to various threats to validity it was felt that exclusive use of gain score analysis would not be justifiable. Therefore, it was decided to use both analyses (blocking and gain score) on the BASE posttest data.

Finally, it was decided to avoid the use of ANCOVA to analyse any of the posttest data because of the various statistical restrictions inherent in that model.

Summary of Chapter III

This chapter provided detailed information regarding how the study was conducted, organized under the headings: subjects, instruments, design, procedure, and data analysis.

CHAPTER IV

RESULTS

The purpose of this investigation was to determine what effect instruction and practice in Logo would have on grade 4 students' mathematics achievement, geometry achievement, attitude towards mathematics, and academic self-concept. As outlined in the data analysis section of Chapter III, the choice of analysis of the posttest data was based on the nature of the pretest data. Excluding the tests of the blocking variables, these analyses resulted in nine tests of significance. To control the experimentwise probability of a Type I error at .18, each of these nine statistical tests was evaluated at a .02 level of significance.

The statistical analyses were done on the mainframe computer at the University of Manitoba using the Statistical Analysis System (SAS) program by SAS Institute Inc. For all factorial analyses, F tests were based on partial sums of squares resulting from the following order of factors: Block, Treatment, Treatment X Block (see <u>SAS User's Guide: Statistics</u>, pp. 165-166).

<u>Results Relevant to Research Hypothesis 1</u>

<u>Research Hypothesis 1.</u> Students who receive instruction and practice in Logo will demonstrate improved achievement in mathematics compared to students who use the

computer for CAI.

This hypothesis was tested using a two-factor (Treatment X Block) ANOVA. The results of this analysis are presented in Table 1. Means, standard deviations, and cell sizes associated with the four treatment-block combinations are given in Table 2. As seen from Table 1, there was no significant difference between the Logo and CAI groups on mean posttest mathematics achievement nor was there a significant Treatment by Block interaction. Thus, the data did not support the research hypothesis.

<u>Results Relevant to Research Hypothesis 2</u>

<u>Research Hypothesis 2.</u> Students who receive instruction and practice in Logo will demonstrate improved achievement in geometry compared to students who use the computer for CAI.

This hypothesis was also tested using a Treatment X Block ANOVA. The results of this analysis are presented in Table 3. Means, standard deviations, and cell sizes associated with the four treatment-block combinations are given in Table 4. As seen from Table 3, there was a significant difference between the Logo and CAI groups on mean posttest geometry achievement, thus supporting the research hypothesis. Further, as evidenced by the nonsignificant Treatment by Block interaction, the result applied to both high and low ability groupings.

As seen from Table 4, the overall mean of the Logo

Table 1

Mathematics Achievement - Treatment X Block Factorial Analysis

SOURCE	SS	DF	MS	F VALUE	PR>F
Treatment	250.07	1	250.07	2.71	0.1074
Block	4865.43	1	4865.43	52.79	0.0001
Treatment X Block	36.24	1	36.24	0.39	0.5342
Error	3686.82	40	92.17		

Note. Subjects were assigned to blocks based on their score on the mathematics pretest. The low block included subjects with pretest scores between 0 and 30. The high block included subjects with pretest scores between 31 and 61.

Table 2

Mathematics Achievement-Means and Standard Deviations(S.D)

			TREATMENT	
			LOGO	CAI
BLOCK	LOW	Mean	35.25	32.13
		S.D.	10.83	5.97
		N	16	8
	HIGH	Mean	59.43	52.46
		S.D.	8.52	10.17
		N	7	13
	Overall Mean		42.61	44.71

Table 3

Geometry Achievement - Treatment X Block Factorial Analysis

SOURCE	SS	DF	MS	F VALUE	PR>F
Treatment	4291.32	1	4291.32	14.85	0.0004
Block	3448.99	1	3448.99	11.94	0.0013
Treatment X Block	594.18	1	594.18	2.06	0.1593
Error	11555.84	40	288.90		

Note. Subjects were assigned to blocks based on their score on the mathematics pretest. The low block included subjects with pretest scores between 0 and 30. The high block included subjects with pretest scores between 31 and 61.

Table 4

Geometry Achievement - Means and Standard Deviations (S.D)

			TREATMENT	
			LOGO	CAI
BLOCK	LOW	Mean	40.63	27.50
		S.D.	16.52	15.81
		N	16	8
	HIGH	Mean	67.14	38.46
		S.D.	21.38	15.73
		N	7	13
		Overall Mean	48.70	34.29

group was approximately 14 points higher than that of the CAI group on geometry achievement. In the high ability grouping, this mean difference was approximately 28 points, while in the low ability grouping it was approximately 13 points.

Results Relevant to Hypothesis 3

Research Hypothesis 3. Students who receive instruction and practice in Logo will demonstrate a more positive attitude towards mathematics compared to students who use the computer for CAI.

This hypothesis was tested using an ANOVA. The results of the analysis are presented in Table 5. Means and standard deviations are given in Table 6. As seen from Table 5, there was no significant difference between the Logo and CAI groups on mean posttest mathematics attitudes. Thus, the data did not support the research hypothesis.

Results Relevant to Research Hypothesis 4

Research Hypothesis 4. Students who receive instruction and practice in Logo will demonstrate a higher level of academic self-concept compared to students who use the computer for CAI.

Two instruments were used to measure academic self-concept - the Coopersmith Self-Esteem Inventories (SEI) and the Behavioral Academic Self-Esteem (BASE).

An ANOVA was done on the posttest data of the

Table 5

Mathematics Attitudes - Analysis of Variance

SOURCE	SS	DF	MS	F VALUE	PR>F
Treatment	22.01	1	22.01	1.08	0.3043
Error	896.10	44	20.37		

Table 6

Mathematics Attitudes-Means and Standard Deviations (S.D.)

	Logo	CAI
Mean	16.96	15.57
S.D.	4.50	4.52
N	25	21

SEI instrument. The results of the analysis are presented in Table 7. Means and standard deviations are given in Table 8. As seen from Table 7, there was no significant difference between the Logo and CAI groups on mean posttest academic self-concept. Thus, the data did not support the research hypothesis.

The BASE data were tested using a Treatment * Block ANOVA. The results of the analysis are presented in Table 9. Means, standard deviations, and cell sizes associated with the four treatment-block combinations are given in Table 10. As seen in Table 9, there was no signicant difference between the Logo and CAI groups on mean posttest academic self-concept nor was there a significant Treatment by Block interaction. Thus, the data did not support the research hypothesis.

An analysis of variance on gain scores was also used to test the BASE data. Pretest scores were subtracted from posttest scores to arrive at a gain score for each subject and an ANOVA was conducted on those gain scores. Results of the analysis are presented in Table 11. Means and standard deviations are given in Table 12. As seen in Table 11, there was a significant difference between the Logo and CAI groups on mean gain in academic self-concept. As shown in Table 12, the mean gain of the Logo group was approximately 3 points higher than the mean gain of the CAI group on the BASE instrument.

Table 7

Academic Self-Concept (Coopersmith) - Analysis of Variance

SOURCE	SS	DF	MS	F VALUE	PR>F
Treatment	269.04	1	269.04	0.47	0.4977
Error	22396.86	39	574.28		

Table 8

Academic Self-Concept (Coopersmith) - Means and Standard Deviations (S.D.)

	Logo	CAI
Mean	56.78	61.94
S.D.	22.93	25.24
N	23	18

Table 9

Academic Self-Concept (BASE) - Treatment X Block Factorial Analysis

SOURCE	SS	DF	MS	F VALUE	PR>F
Treatment	13.32	1	13.32	0.55	0.4648
Block	365.11	1	365.11	14.98	0.0005
Treatment X Block	86.40	1	86.40	3.54	0.0681
Error	853.24	35	24.38		

Note. Subjects were assigned to blocks based on their score on the BASE pretest. The low block included subjects with pretest scores between 40 and 55. The high block included subjects with pretest scores between 56 and 80. Eight students in the Logo group scored below 40 in the pretest and their data were not used in the analysis.

Table 10

Academic Self-Concept (BASE) - Means and Standard Deviations (S.D.)

			TREATMENT	
			Logo	CAI
BLOCK	LOW	Mean	50.17	54.80
		S.D.	6.69	6.80
		N	12	5
	HIGH	Mean	60.33	58.31
		S.D.	3.01	2.96
		N	6	16
	Overall Mean		53.56	57.48

Table 11

Academic Self-Concept (BASE) - Analysis of Variance of Gain Scores

SOURCE	SS	DF	MS	F VALUE	PR>F
Treatment	104.68	1	104.68	5.84	0.0198
Error	807.28	45	17.94		

Table 12

Academic Self-Concept (BASE) - Gain Score Means and Standard Deviations (S.D.)

	Logo	CAI
Mean	3.19	0.19
S.D.	.91	.05
N	26	21

The results of the gain score analysis provide only indirect support for Hypothesis 4. The analysis indicates a greater gain in academic self-concept whereas the hypothesis predicts a higher level of academic self-concept as a result of using Logo. However, use of the gain score analysis allowed for the inclusion of all the BASE data and indicates that the Logo group made significant gains in academic self-concept compared to the CAI group.

Summary of Chapter IV

This chapter presented an analysis of the data for each of the research hypotheses. The statistical analyses conducted did not support hypotheses 1 (mathematics achievement) and 3 (mathematics attitude), but did support hypothesis 2 (geometry achievement). Two of the analyses for hypothesis 4 (academic self-concept) did not support the hypothesis while a third analysis using gain scores provided indirect support for this hypothesis.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Overview of the Study

The objective of this study was to determine whether instruction and practice in Logo, a computer language for children, would positively affect achievement in mathematics, achievement in geometry, attitude towards mathematics, or academic self-concept of native students. A review of the literature indicated that the Logo language could be used to establish a learning environment in which children's understanding and enjoyment of mathematics would be enhanced. The literature also provided tentative evidence that, particularly with low achievers, a successful learning experience with Logo would contribute to the development of a more positive academic self-concept. Furthermore, for various reasons, native students have had a history of poor performance in school mathematics. Because of the compatibility of Logo with the predominantly visual learning style of native students it was felt that Logo could be a valuable teaching/learning aid in the mathematics education of these students.

The study involved two intact classes of grade four native students (N=47) from two communities in northern Manitoba. The groups were pretested on the dependent variables in September of 1984 after which a microcomputer system was set up in each classroom. From October 1984 to May 1985 one group received weekly instruction and practice in Logo while the other group used their computer with CAI programs. Students from both groups generally worked at the computer in pairs and averaged about a half-hour per week of "hands-on" time. Exclusive of the treatments, each group received the same basic mathematics program, that is, Starting Points in Mathematics 4 (Ginn & Co., 1982). All subjects were posttested in May, 1985.

Discussion of the Findings

The following is a summary of the findings and conclusions related to each of the research hypotheses.

Research Hypothesis 1. Students who receive instruction and practice in Logo will demonstrate improved achievement in mathematics compared to students who use the computer for CAI.

The data did not support this research hypothesis in that there was no significant difference between the Logo and CAI groups on mean posttest mathematics achievement. Possible explanations for this result might be:

1) Logo is not an effective means of improving mathematical achievement.

2) The magnitude of the treatment, i.e. a half hour per week for eight months was insufficient to have any measureable effect.

3) The instrument used to measure mathematics

achievement was not sensitive to some of the mathematical skills which might have been developed by learning Logo...e.g. estimation, problem solving,...

4) CAI programs are just as effective as Logo in improving mathematics achievement.

<u>Research Hypothesis 2.</u> Students who receive instruction and practice in Logo will demonstrate improved achievement in geometry compared to students who use the computer for CAI.

The data supported this research hypothesis. There was a significant difference ($p<.01$) between the Logo and CAI groups on mean posttest geometry achievement. Possible explanations for this result might be:

1) Logo is effective in increasing the understanding of geometric concepts. Because Logo involves working with distances, angles, and geometric shapes, it follows that it should improve achievement in geometry by giving children a visual and interactive experience with that subject.

2) The teacher of the Logo group might have been more effective in teaching geometry than the CAI teacher.

<u>Research Hypothesis 3.</u> Students who receive instruction and practice in Logo will demonstrate a more positive attitude towards mathematics compared to students who use the computer for CAI.

The data did not support this research hypothesis in that there was no significant difference between the Logo and CAI groups on mean posttest mathematics attitudes.

Possible explanations for this finding might be:

1) Logo is not effective in altering students' attitude towards mathematics.

2) Students did not make a connection between Logo and mathematics. That is, Logo and school mathematics were seen as mutually exclusive entities and the attitude instrument simply measured their feeling towards school mathematics.

3) The exposure to Logo may not have been of sufficient magnitude to have a measurable effect on attitude. An attitude, once developed, is not easily changed and the students had already had four years of school mathematics in which to develop and entrench their attitude.

4) The students' attitude towards mathematics was not unduly negative at the outset of the study and was therefore not easy to influence in a positive direction. The normative information provided in the Estes Attitude Scales Manual indicates that the pretest mean of the Logo group translates into a T-score of 42 and the pretest mean of the CAI group translates into a T-score of 44. The manual states that, "raw scores that convert into T-scores ranging between 40 and 60 represent fairly typical attitudes toward basic school subjects" (p.17). Thus, the mathematics attitudes of both groups were in the lower part of the normal range at the time of the pretest.

Research Hypothesis 4. Students who receive instruction and practice in Logo will demonstrate a higher level of academic self-concept compared to students who use the computer for CAI.

The data did not directly support this research hypothesis in that there was no significant difference between the Logo and CAI groups on mean posttest academic self-concept as measured by either of the self-concept instruments. Possible explanations for this finding might be:

1) Logo is not an effective means of influencing academic self-concept.

2) The exposure to Logo may not have been of sufficient magnitude to have a measurable effect on academic self-concept. As in the case of attitudes, academic self-concept develops over a number of years and is not easily or quickly influenced.

3) The students' academic self-concept was not unduly low at the outset of the study and was therefore not easy to influence in a positive direction. The normative data provided in the two administrative manuals (see <u>SEI Manual</u>, p.17 and <u>BASE Manual</u>, p.IX-1) indicates that the mean pretest academic self-concept of both groups fell within the normal range.

A gain score analysis on the data from the <u>Behavioral Academic Self-Esteem</u> instrument did provide indirect support for this research hypothesis. That is, there was a significant difference ($p<.02$) in the improvement in academic self-concept from pretest to posttest in the Logo group compared to the CAI group. This result must be interpreted cautiously however, since the rating of the students was done by the respective classroom teachers and depended on a subjective interpretation of the rating guidelines provided. It is highly probable that the teachers differed in their interpretation of the guidelines. It is also possible that each teacher's interpretation of the guidelines changed from pretest to posttest. At best, the result of this analysis could be considered promising but tentative.

Conclusions

Subject to the limitations stated, this study indicates that geometry achievement can be positively influenced by instruction and practice in Logo. This is an important finding in that geometry in the elementary mathematics program tends to receive little attention as compared to arithmetic. Thus, Logo could be a valuable teaching aid which would enable teachers to improve this part of the mathematics program.

The study failed to establish that working with Logo can positively influence mathematics achievement, mathematics attitudes, and academic self-concept. Some possible reasons for this failure were speculated.

Some tentative conclusions can be drawn from the findings of this study:

1) The positive result in geometry achievement supports the visual learning argument, underscoring the importance of

identifying appropriate learning modes and developing instructional strategies which take advantage of the learners' predominant learning style.

2) The absence of significant results in mathematics achievement, mathematics attitudes, and academic self-concept emphasises the need for caution in making ambitious claims for Logo.

3) Despite the fact that, with the exception of geometry achievement, the findings of this study were inconclusive, the literature still suggests possible links between Logo and mathematics achievement, mathematics attitudes, and academic self-concept. Further research is needed to establish whether those links are imagined or real.

Programmatic Recommendations

Based on the findings of this study, the following recommendations are made:

1) The use of Logo to aid in the teaching of elementary school geometry should be encouraged.

2) Logo learning activities should be developed which relate directly to the elementary mathematics curriculum, particularly the geometry units at the various grade levels.

3) The elementary mathematics curriculum should be examined and possibly modified in light of Logo's potential to increase mathematical understanding in certain areas. For example, using Logo, it may be feasible to introduce

certain geometric concepts at an earlier age than was previously possible.

4) Teachers should be provided with hardware support, software support and professional development support so that they can effectively exploit Logo's potential in the classroom. Professional development is particularly crucial and should include such components as: orientation to the philosophy of Logo, familiarity with the Logo language, and practical ideas for implementing Logo in the classroom.

5) Consideration should be given to increasing the incidence of the visual presentation of mathematical concepts, particularly with native students.

Research Recommendations

This study raised a number of questions which merit closer investigation. It is recommended that studies be undertaken in which:

1) the same dependent variables are examined, but a larger sample and, if possible, a randomized design are used.

2) a longer time period of two or three years duration is used.

3) a more intensive Logo experience is provided. For example, three or four computers could be set up in a classroom and students could be given the opportunity to do Logo each day for several weeks or months.

4) various grade levels are included to determine

whether and in what way Logo's effectiveness differs at different grade levels.

5) the effects of Logo instruction on native students is compared to the effects of Logo on non-native students.

6) the effects of implementing Logo on classroom dynamics are examined. Such variables as teacher planning time, lesson delivery, timetabling, student interaction, distraction level, amount of time devoted to core curricula, time on task, etc. could be compared prior to and after Logo is implemented.

7) the relative merits and drawbacks of teaching Logo using different degrees of structure are examined. For example, one group could be subjected to a structured approach as advocated by Howe (1980), another group to a "quasi-Piagetian" approach (Leron, 1985), and a third group to a Piagetian approach (Papert, 1980).

8) half the class uses the computer for Logo while the other half uses it for CAI. Except for the treatment, other environmental factors would be identical for both groups, that is, teacher, classroom, school, academic program, etc.

9) Logo activities, designed to reinforce specific learning objectives from the elementary geometry curriculum, are used.

The above recommended studies could be undertaken individually or in various combinations.

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APPENDIX

Frontier School Division Math Survey, Level 4

FRONTIER SCHOOL DIVISION

1985 MATHEMATICS' SURVEY

LEVEL IV

Part A

(1) Count FORWARD by 5's......, 17, ___, ___, ___,......

(A) 18, 19, 20, ...
(B) 22, 27, 32, ...
(C) 20, 23, 26, ...
(D) 27, 37, 47, ...
(E) 25, 35, 45, ...

(2) Count BACKWARD by 6's ....., 39, ___, ___, ___, ...

(A) 45, 51, 57, ...
(B) 34, 29, 24, ...
(C) 33, 27, 20, ...
(D) 33, 26, 20, ...
(E) 33, 27, 21, ...

(3) Which multiplying table has the answers.., 48, 56, 64,..

(A) the 8 times' table
(B) the 4 times' table
(C) the 9 times' table
(D) the 6 times' table
(E) the 7 times' table

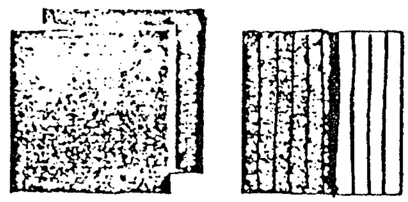
(4) Which numeral shows "four thousand sixty-one" ?

(A) 4061
(B) 46 100
(C) 40 061
(D) 461
(E) 4 000 61

(5) Which numeral shows "nine AND three tenths" ?

(A) 9 300
(B) 0.93
(C) 9.003
(D) 9.3
(E) 9.03

(6) Which whole numeral is shown by ......



(A) 26

(B) 206

(C) 62

(D) 260

(E) 620

FOR THE NEXT THREE QUESTIONS
FIND THE NEXT CORRECT NUMERAL IN EACH

(7) 4, 8, 12, 16, ______.......

(A) 20
(B) 24
(C) 28
(D) 32
(E) 36

(8) 9, 12, 15, 18, _____.......

(A) 20
(B) 21
(C) 22
(D) 23
(E) 24

(9) 1, 4, 16, 64, ______........

(A) 128
(B) 200
(C) 225
(D) 256
(E) 321

(10) The sum of $\begin{array}{r} 4\,6\,4\,8 \\ +\ \underline{2\,3\,7\,0} \end{array}$ is .....

(A) 7028

(B) 7018

(C) 7928

(D) 6018

(E) 7928

(11) The sum of

$$\begin{array}{r} 1089 \\ 2056 \\ \underline{3428} \end{array}$$

is .....

(A) 6572
(B) 6563
(C) 6574
(D) 6473
(E) 6573

(12) The sum of 25 + 26 + 37 is .....

(A) 78
(B) 88
(C) 87
(D) 252 637
(E) 178

(13) The difference for

$$\begin{array}{r} 91 \\ -\underline{47} \end{array}$$

is .....

(A) 138
(B) 43
(C) 54
(D) 46
(E) 44

(14) The difference for

$$\begin{array}{r} \$3027 \\ -\underline{923} \end{array}$$

is .....

(A) $2104
(B) $3104
(C) $3950
(D) $2103
(E) $6104

(15) The difference for 7426 - 3872 is .....

(A) 3544
(B) 3554
(C) 4554
(D) 4456
(E) 11 298

(16) The product of $\begin{array}{r} 34 \\ \times\ \underline{2} \end{array}$ is .....

(A) 36
(B) 32
(C) 68
(D) 66
(E) 78

(17) The product of $\begin{array}{r} 816 \\ \times\ \underline{5} \end{array}$ is

(A) 4080
(B) 480
(C) 921
(D) 4050
(E) 4070

(18) The product of $\begin{array}{r} \$9.76 \\ \times\ \underline{8} \end{array}$ is

(A) \$78.14
(B) \$72.14
(C) \$67.04
(D) \$72.08
(E) \$78.08

(19) The product of \$6.46 x 35 is .....

(A) \$226.10
(B) \$227.10
(C) \$236.10
(D) \$326.10
(E) \$226.01

(20) The quotient of $7\overline{)42}$ is .....

(A) 6
(B) 6 remainder 2
(C) 5
(D) 7
(E) 7 remainder 2

(21) The quotient of $3 \overline{) 23}$ is .....

(A) 7
(B) 7 remainder 1
(C) 7 remainder 2
(D) 8
(E) 8 remainder 2

(22) The quotient of $894 divided by 6 is .....

(A) $115.66
(B) $149
(C) $148
(D) $137.75
(E) $129.50

(23) 6 x ___?___ = 54

(A) 10
(B) 9
(C) 8
(D) 7
(E) 6

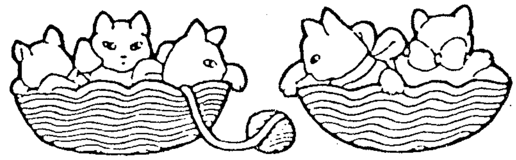
(24) 12 + 18 = 18 + ___?___

(A) 18
(B) 16
(C) 0
(D) 14
(E) 12

(25) 86 + 71 = 150 + ___?___

(A) 71
(B) 86
(E) 1
(D) 9
(E) 7

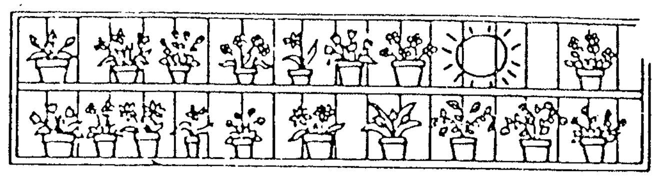
(26) 3 kittens are in one basket.
2 kittens are in another.



To find how many kittens in all, we need to .....

(A) add 3 + 2.
(B) subtract 3 - 2.
(C) multiply 3 x 2.
(D) divide 3 by 2
(E) add 3 + 2 + 2.

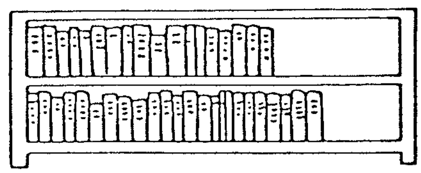
(27) 143 flowers are on one shelf.
256 flowers are on another.



To find how many flowers altogether, we need to .....

(A) add 256 + 143.
(B) subtract 256 - 143.
(C) multiply 256 x 143.
(D) multiply 143 x 256
(E) divide 256 by 143

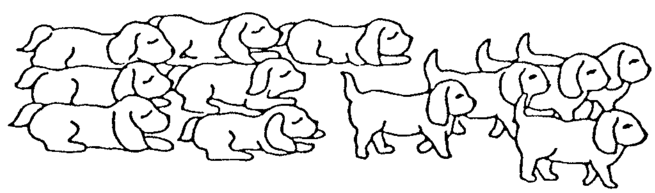
(28) 18 books are on one shelf.
24 books are on another.



To find how many books altogether, we need to .....

(A) add 18 + 24.
(B) subtract 24 - 18.
(C) subtract 18 - 24.
(D) multiply 18 x 24.
(E) divide 24 by 18.

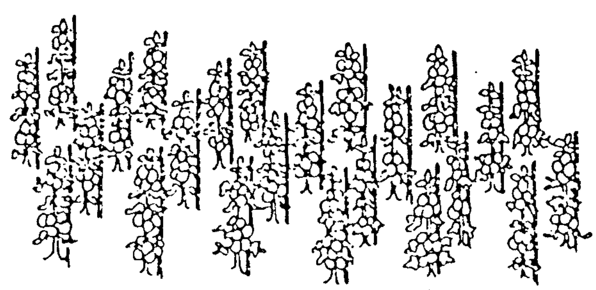
(29) There are 12 puppies.
5 puppies walk away.



To find how many are left, we need to .....

(A) add 12 + 5.
(B) subtract 12 - 5.
(C) multiply 12 x 5.
(D) multiply 5 x 12.
(E) divide 12 by 5.

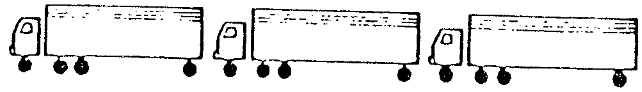
(30) Ellen planted 6 rows of tomato plants.
There are 4 plants in each row.



To find how many plants in all, we need to ......

(A) add 6 + 4.
(B) subtract 6 - 4.
(C) multiply 6 x 4.
(D) multiply 4 $\div$ 6.
(E) divide 6 by 4.

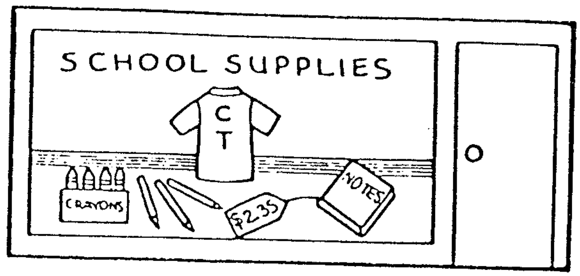
(31) There are 3 trucks.
Each truck has 8 wheels.



To find how many wheels there are altogether, : we need to .....

(A) add 8 + 3.
(B) subtract 8 - 3.
(C) subtract 3 - 8.
(D) multiply 8 x 3.
(E) divide 8 by 3.

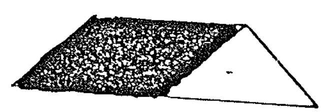
(32) Jo buys 3 note books.
Each book costs $2.35.



To find the cost of all the books, we need to .....

(A) add 3 + $2.35
(B) subtract 3 - $2.35
(C) subtract $2.35 - 3
(D) multiply $2.35 x 3
(E) divide $2.35 by 3

(33) Which fraction shows how much is DARK ?

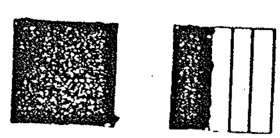


(A) $\frac{3}{2}$ (D) $\frac{1}{2}$

(B) $\frac{2}{3}$ (E) $\frac{3}{1}$

(C) $\frac{1}{3}$

(34) Which fraction shows how much is DARK ?

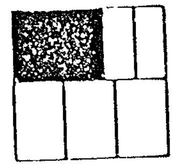


(A) $\frac{3}{10}$ (D) $\frac{2}{3}$

(B) $1\frac{2}{5}$ (E) $1\frac{2}{3}$

(B) $1\frac{3}{5}$

(35) Which fraction shows how much is DARK ?



(A) $\frac{3}{10}$ (D) $\frac{3}{8}$

(B) $\frac{1}{6}$ (E) $\frac{5}{8}$

(C) $\frac{3}{11}$

(36) The sum of $\frac{3}{10} + \frac{4}{10}$ is .....

(A) $\frac{7}{20}$ (D) $\frac{34}{100}$

(B) $\frac{7}{10}$ (E) $\frac{34}{20}$

(C) $\frac{7}{100}$

(37) The difference of $\frac{18}{5} - \frac{11}{5}$ is .....

(A) $\frac{29}{10}$ (D) $\frac{6}{5}$

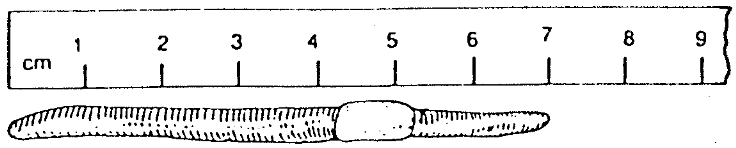
(B) $\frac{6}{0}$ (E) $\frac{7}{5}$

(C) $\frac{7}{0}$

(38) $\frac{3}{4}$ of 16 cookies are .....

(A) 4 cookies. (E) 14 cookies.
(B) 8 cookies. (E) 16 cookies.
(C) 12 cookies.

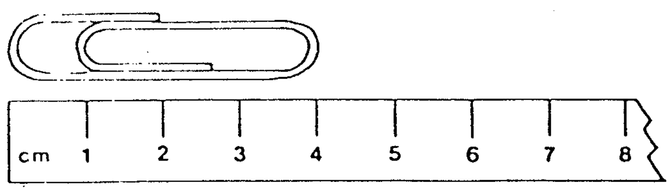
(39)



The length of this picture of an earthworm is about...

(A) 5 centimetres.
(B) 6 centimetres.
(C) 7 centimetres.
(D) 8 centimetres.
(E) 9 centimetres.

(40)



The length of this picture of a paper clip is about...

(A) 3 centimetres.
(B) 4 centimetres.
(C) 5 centimetres.
(D) 6 centimetres.
(E) 7 centimetres.

(41) The MASS of your body might be ......

(A) 35 kilograms.
(B) 10 kilograms.
(C) 100 kilograms.
(D) 100 grams.
(E) 1000 grams.

(42) The meat in one hamburger might be about .....

(A) 2 kilograms.
(B) 1 kilogram.
(C) 2 grams.
(D) 10 grams.
(E) 150 grams.

(43) Jerry has two $1.00 bills, three quarters, and one dime.
Altogether, he has .....

(A) $1.35
(B) $1.85
(C) $2.85
(D) $2.75
(E) $2.35

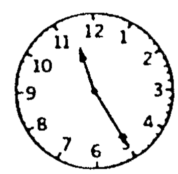
(44) Martha has a $5.00 bill, three $1.00 bills, one quarter, two dimes and three nickels.

In all, she has .....

(A) $6.40
(B) $6.50
(C) $8.40
(D) $8.60
(E) $8.75

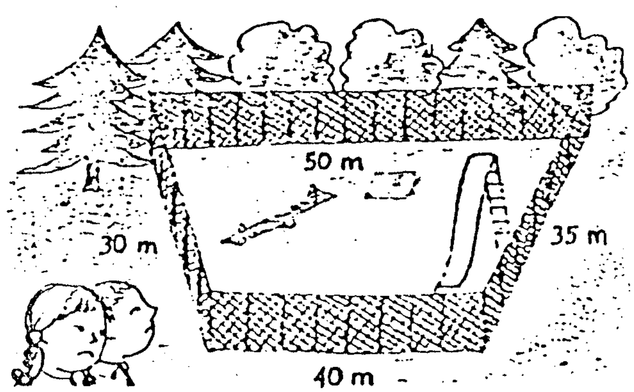
(45) Which time is shown on this clock ?

(A) 25 minutes past 11 o'clock.
(B) 55 minutes past 5 o'clock.
(C) 5 minutes past 11 o'clock.
(D) 11 minutes past 5 o'clock.
(E) 25 minutes past 12 o'clock.



(46) The PERIMETER of this field is ...

(A) 40 metres.
(B) 50 metres.
(C) 155 metres.
(D) 155 square metres.
(E) 2000 square metres.



(47) The AREA covered by this lake is about...

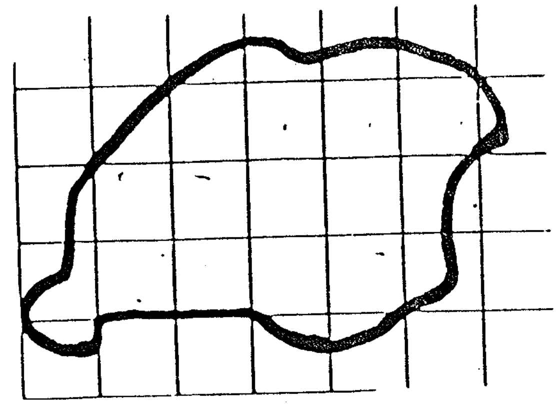
(A) 8 square units.

(B) 10 square units.

(C) 12 square units.

(D) 14 square units.

(E) 16 square units.



(48) The number of cubes in this shape is .....

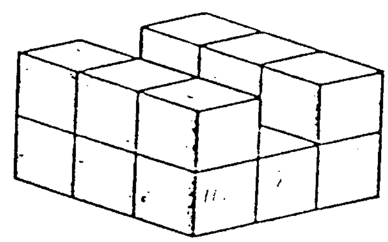
(A) 11.

(B) 15.

(C) 16.

(D) 18.

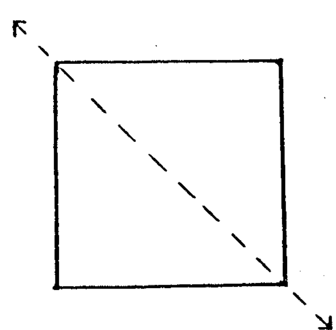
(E) 19.



(49) Here is a square showing 1 MIRROR LINE (line of symmetry).

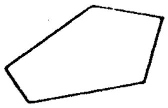
Altogether, a square has .....

(A) 1 mirror line.
(B) 2 mirror lines.
(C) 3 mirror lines.
(D) 4 mirror lines.
(E) 5 mirror lines.

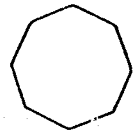


(50) Which polygon is a PENTAGON ?

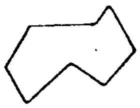
(A)



(D)

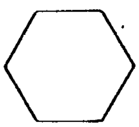


(B)

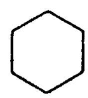


(E)

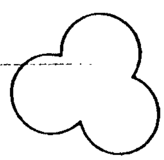
(C)



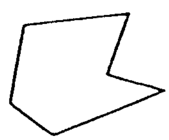
(51) Which polygon is SIMILAR to .....



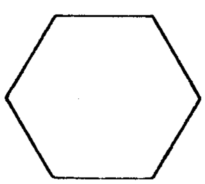
(A)



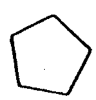
(D)



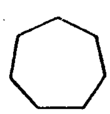
(B)



(E)

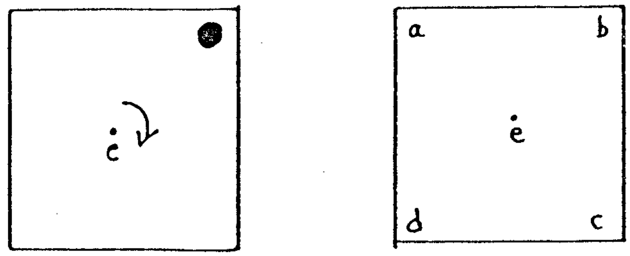


(C)



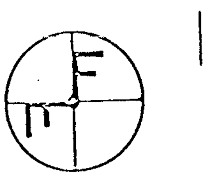
(52) Where will the black dot be after a $\frac{3}{4}$ turn ?

(A) at a
(B) at b
(C) at c
(D) at d
(E) at e



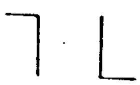
(53) Which picture shows a FLIP ?

(A)



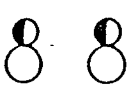
(D)

(B)



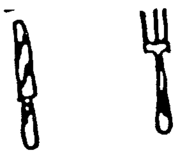
(E)

(C)

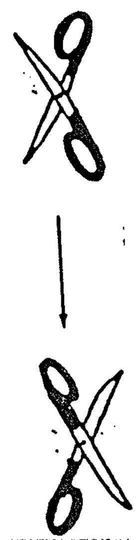


(54) Which picture shows a SLIDE ?

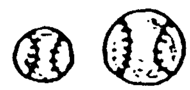
(A)



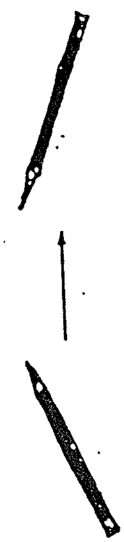
(B)



(C)



(D)



(E)

FRONTIER SCHOOL DIVISION

1985 LEVEL IV MATHEMATICS' SURVEY

Part B

(55) The LARGEST numeral of
39 078 39 780 39 087 39 870 39 807 is .....

(A) 39 078
(B) 39 780
(C) 39 087
(D) 39 870
(E) 39 807

(56) The SMALLEST numeral of
11 101 11 110 11 011 10 111 11 111 is .....

(A) 11 101
(B) 11 110
(C) 11 011
(D) 10 111
(E) 11 111

(57) Which ONE sentence is true ?

(A) $987 > 987$
(B) $1625 < 1641$
(C) 4007 = four hundred seven
(D) $40\ 000 < 4\ 000$
(E) $864 = 800 + 600 + 400$

(58) Which is the quickest way to add $18 + 7 + 2 + 23$?

(A) $18 + 7 + 2 + 23$
(B) $18 + 23 + 7 + 2$
(C) $18 + 2 + 7 + 23$
(D) $7 + 2 + 18 + 23$
(E) $7 + 18 + 2 + 23$

(59) Which ONE sentence is NOT TRUE ?

(A) $16 + 4 = 4 + 16$
(B) $16 - 4 = 4 - 16$
(C) $16 \times 4 = 4 \times 16$
(D) $132 + 156 = 156 + 132$
(E) $925 \times 405 = 405 \times 925$

(60) Which ONE sentence is <u>true</u> ?

(A) $13 \times 5 = (10 \times 5) + (3 \times 5)$

(B) $13 \times 5 = (10 \times 4) + (3 \times 1)$

(C) $75 + 22 = 90 + 70$

(D) $75 + 22 = 9 + 7$

(E) $73 - 71 = 71 - 73$

(61) The sum of

$$\begin{array}{r} 458 \\ 1609 \\ \underline{722} \end{array}$$

is .....

(A) 1789.
(B) 2689.
(C) 2779.
(D) 2789.
(E) 2788.

(62) The sum of

$$\begin{array}{r} \$4127 \\ \$2964 \\ \$\underline{2198} \end{array}$$

is .....

(A) \$9289.
(B) \$8289.
(C) \$9198.
(D) \$9279.
(E) \$9287.

(63) The sum of \$8876 + \$629 is .....

(A) \$15 166.
(B) \$ 9 506.
(C) \$ 9 505.
(D) \$9 405
(E) \$9 496

(64) The difference for

$$\begin{array}{r} 2001 \\ -\underline{732} \end{array}$$

is .....

(A) 1269.
(B) 1259.
(C) 1168.
(D) 1169.
(E) 1268.

(65) The difference for $\begin{array}{r} \$7\ 0\ 0\ 0 \\ -\ \underline{1\ 9\ 5\ 0} \end{array}$ is .....

(A) \$6140.
(B) \$5050.
(C) \$6150.
(D) \$8950.
(E) \$5150.

(66) The product of $\begin{array}{r} 6\ 5 \\ \times\ \underline{\ \ 7} \end{array}$ is .....

(A) 355.
(B) 455.
(C) 356.
(D) 456.
(E) 445.

(67) The product of $\begin{array}{r} \$1\ 7\ 8 \\ \times\ \underline{\ \ \ \ 8} \end{array}$ is .....

(A) \$1424
(B) \$1323
(C) \$1324
(D) \$ 864
(E) \$1404

(68) The product of $\begin{array}{r} \$6\ 4\ 6 \\ \times\ \underline{\ \ 3\ 5} \end{array}$ is .....

(A) \$22 610
(B) \$12 610
(C) \$21 610
(D) \$22 590
(E) \$12 509

(69) The quotient of $4\ \overline{)\ 1\ 6\ 0}$ is .....

(A) 4
(B) 40
(C) 5
(D) 50
(E) 6

(70) The quotient of $3\ \overline{)\ 9\ 6\ 0}$ is .....

(A) 32
(B) 230
(C) 32 remainder 1
(D) 23
(E) 320

(71) The quotient of $8\overline{)\$2\ 7\ 2}$ is .....

(A) $340
(B) $ 34
(C) $ 34.50
(D) $43
(E) $43.50

(72) Five-tenths of a cake is written as .....

(A) 0.5 of a cake.
(B) 5.0 of a cake.
(C) 5.10 of a cake.
(D) 0.05 of a cake.
(E) 5.00 of a cake.

(73) Thirteen-hundredths of all the trees is written as ...

(A) 13.100 of the trees.
(B) 1.3 of the trees.
(C) 13.00 of the trees.
(D) 0.13 of the trees.
(E) 1.30 of the trees.

(74) The sum of 10 cents and 17 cents is .....

(A) $27.00
(B) $10.17
(C) $ 0.27
(D) $2.70
(E) $0.027

(75) One whole numeral which would make _?_ > 5 is ....

(A) 6
(B) 5
(C) 4
(D) 3
(E) 2

(76) One whole numeral which would make _?_ < 12 is .....

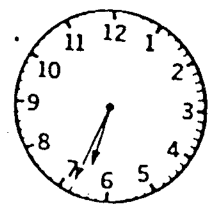
(A) 12
(B) 15
(C) 16
(D) 11
(E) 13

(77) To make ___?___ < 4,
we could use the whole numerals .....

(A) 0, 1, 2, 3 and 4.
(B) 0, 1, 2 and 3.
(C) 1, 2 and 3.
(D) only 0, 1 and 2.
(E) only 1 and 2.

(78) Which time is shown on this clock ?

(A) 7 minutes past 6 o'clock.
(B) 34 minutes past 7 o'clock.
(C) 26 minutes past 7 o'clock.
(D) 26 minutes past 6 o'clock.
(E) 34 minutes past 6 o'clock.



(79) Which temperature is shown ?

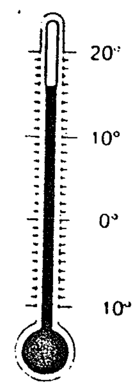
(A) 14° Celsius.

(B) 15° Celsius.

(C) 16° Celsius.

(D) 17° Celsius.

(E) 18° Celsius.



(80) What happens at this temperature ?

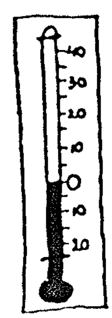
(A) Fish start jumping to catch flies.

(B) Water in the lake starts to freeze.

(C) Water in a kettle starts to boil.

(D) Old men can go outside in a T-shirt.

(E) Ski-doos fall through the ice.



(81) 18 millimetres across my thumb is equivalent to .....

(A) 18 centimetres.
(B) 18 metres.
(C) 1.8 metres.
(D) 1.8 centimetres.
(E) 0.18 centimetres.

(82) 2 litres of milk is equivalent to .....

(A) 1000 millilitres.
(B) 2000 millilitres.
(C) 4000 millilitres.
(D) 20 millilitres.
(E) 2 millilitres.

(83) 1200 grams of potatoes is equivalent to .....

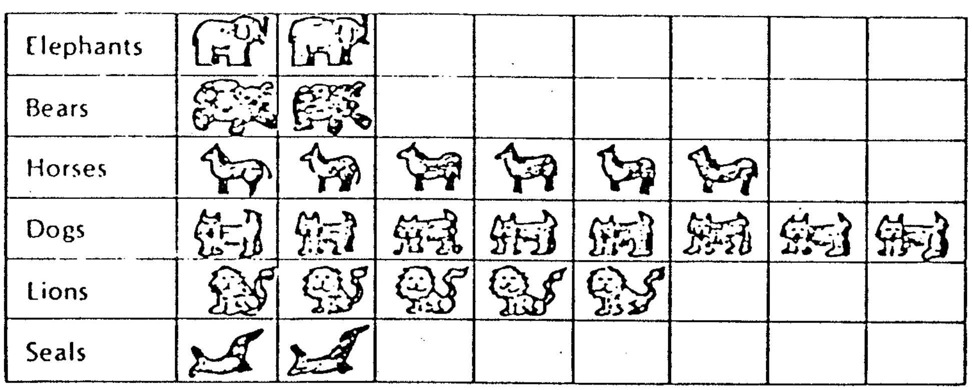
(A) 1.2 kilograms.
(B) 0.12 kilograms.
(C) 1.02 kilograms.
(D) 120 kilograms.
(E) 12 kilograms.

(84) The average of 1 raven, 3 ravens and 5 ravens is .....

(A) 1 raven.
(B) 4 ravens.
(C) 5 ravens.
(D) 2 ravens.
(E) 3 ravens.

(85)

Animals in the Circus

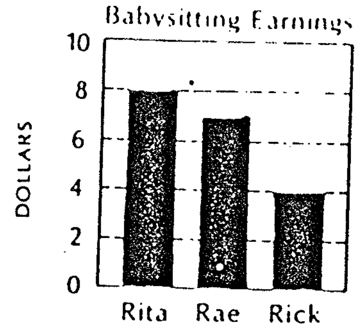


Each picture represents one animal.

How many more lions are there than bears ?

(A) 1 more lion.
(B) 3 more lions.
(C) 5 more lions.
(D) 7 more lions.
(E) 9 more lions.

(86)



How much money did Rae make ?

(A) $4.00
(B) $7.00
(C) $8.00
(D) $3.50
(E) $2.00

(87) 15 + _?_ = 45

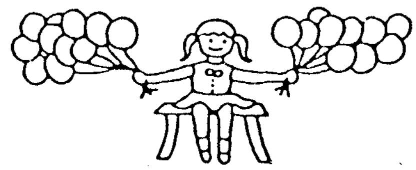
(A) 60
(B) 25
(C) 30
(D) 20
(E) 1545

(88) 64 - _?_ = 8

(A) 72
(B) 62
(C) 8
(D) 56
(E) 58

(89) _?_ x 5 = 75

(A) 15
(B) 25
(C) 65
(D) 20
(E) 6



(90) Pat has 35 balloons.
She gives 14 balloons away.

To find out how many balloons are left, we need to .....

(A) add 35 + 14.

(B) subtract 35 - 14.

(C) multiply 14 x 35.

(D) multiply 35 x 14.

(E) divide 35 by 14.

(91) 32 birds are in a tree.
18 of them fly away.

To find how many birds are still in the tree, we need to .....

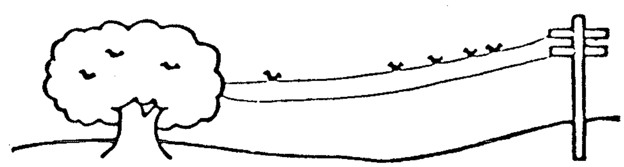
(A) add 18 + 32

(B) add 32 + 18

(C) subtract 32 - 18.

(D) multiply 32 x 18.

(E) divide 32 by 18.



(92) 123 birds are on a wire.
87 birds are in a tree.

To find how many birds in all, we need to .....

(A) add 123 + 87.

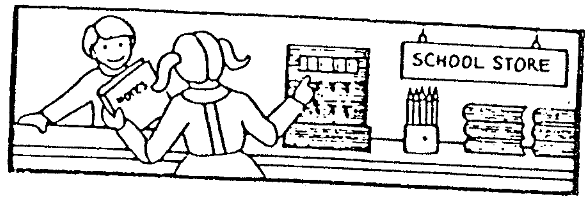
(B) subtract 123 - 87.

(C) subtract 87 - 123.

(D) multiply 123 by 87.

(E) divide 123 by 87.

(93) Our school had 2364 books. 1678 were used up.



To find how many books are left, we need to .....

(A) add 2364 + 1678.

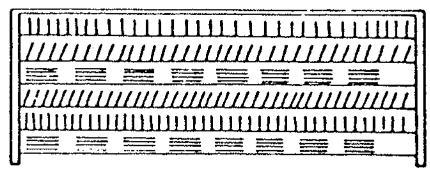
(B) add 1678 + 2364.

(C) subtract 2364 - 1678.

(D) multiply 2364 x 1678

(E) multiply 1678 x 2364

(94) Chris has 240 records. He keeps them on 6 shelves. There are an equal number of records on each shelf.



To find how many records are on each shelf, we need to ..

(A) add 240 + 6.

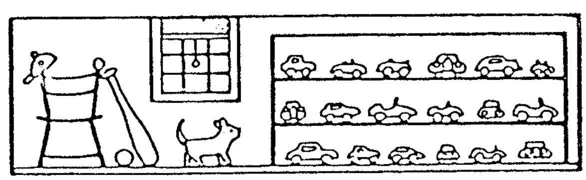
(B) subtract 240 - 6.

(C) multiply 6 x 240.

(D) multiply 240 by 6.

(E) divide 240 by 6.

(95) Pierre has 60 model cars. He keeps them on 3 shelves. There are an equal number of cars on each shelf.



To find how many cars are on one shelf, we need to .....

(A) add

(B) subtract 60 - 3

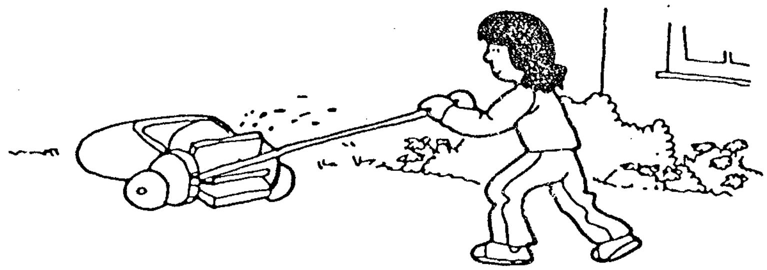
(C) multiply 60 x 3.

(D) add 60 + 3.

(E) divide 60 by 3.

(96) Paul cut 4 lawns on Tuesday,
3 lawns on Wednesday,
and 2 lawns on Thursday.
Dave cut 3 lawns EACH of those three days.

To find how many lawns the two boys cut together, we need to .....



(A) add 4 + 3 + 2.

(B) add 3 + 3 + 3.

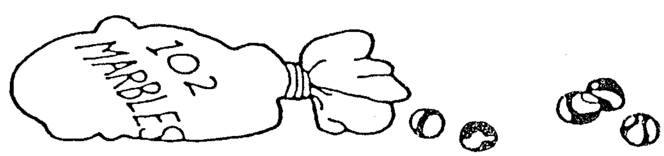
(C) add 4 + 3 + 2 + 3 + 3 + 3.

(D) add 4 + 3 + 2 + 3 + 3.

(E) add 4 + 3.

(97) Lee-Anne divided 102 marbles with her 5 friends and herself.

To find out how many marbles each would get, we ......



(A) add 102 + 5.

(B) add 102 + 5 + 1

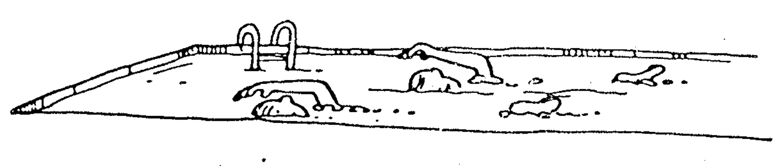
(C) divide 102 by 5.

(D) divide 102 by 6.

(E) multiply 102 by 5.

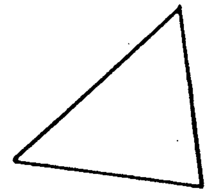
(98) Jerry swam 2 lengths of the pool.
Doris swam 5 more lengths than Jerry.

To find how many lengths Doris swan we need to .....



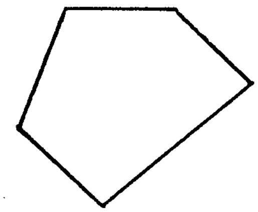
(A) add 5 + 2.
(B) subtract 5 - 2.
(C) multiply 5 x 2.
(D) subtract 2 - 5.
(E) multiply 2 x 5.

(99) A shape with three sides is called a .....



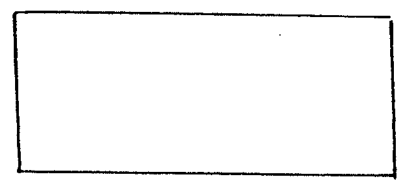
(A) square
(B) circle
(C) triangle
(D) quadrilateral
(E) cube

(100) A shape with five sides is called a .....



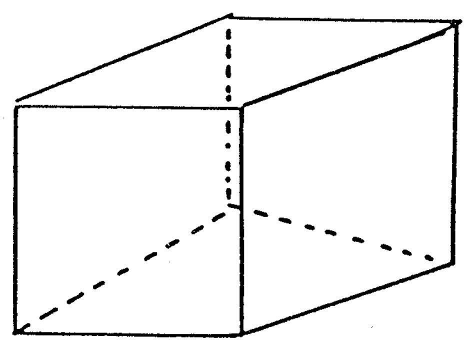
(A) square
(B) triangle
(C) octagon
(D) rectangle
(E) pentagon

(101) A shape with exactly four inside angles is called a ..



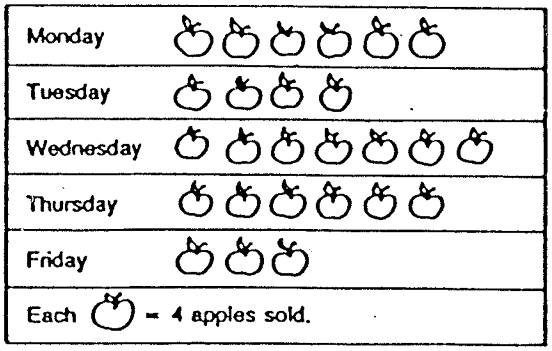
(A) triangle
(B) rectangle
(C) circle
(D) pentagon
(E) octagon

(102) How many sides has a lump of sugar like the one in the picture.



(A) 4 sides
(B) 6 sides
(C) 8 sides
(D) 10 sides
(E) 12 sides

(103)



How many apples were sold on Thursday ?

(A) 6 apples.
(B) 5 apples
(C) 7 apples
(D) 12 apples
(E) 24 apples