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Growth in Geometric Skills Made by Students in Grade Four

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GROWTH IN GEOMETRIC SKILLS MADE BY STUDENTS IN GRADE FOUR

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of the Requirements for the Degree

Master of Education

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by

Gail Crum

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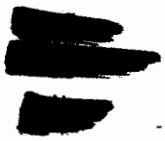

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

Modern mathematics means many things to many people. In most cases it implies change. Much thought and thorough planning is being done to determine the optimum level at which to commence classroom instruction in the various branches of mathematics. Geometry is one of the fields currently under study.

I. THE PROBLEM

Purpose. For the first time in School District Number Seven, Yakima, Washington, a structured geometry course is included in the fourth grade mathematics program.

The purpose of this study was to determine the growth in geometric skills made by the students enrolled in this program. It is a study to help determine which learnings fourth graders grasp, which only a few grasp, and, if there are some, none grasp.

Hypothesis. Pupils studying the fourth grade School Mathematics Study Group geometry course exactly as presented in their text will show growth in the following:

1. Identification of geometric figures

2. Identification of geometric solids

3. Drawing of geometric figures and of geometric solids

4. Linear measurement of geometric figures

5. Relationship of lines and line segments

6. Numeration of vertices, edges and faces of geometric solids.

It is a study to determine the relative growth made in each of the above six areas. Greater growth will be made in some of the six areas than in others.

Materials needed for each student. Each student was issued the course of study, School Mathematics Study Group publication, Mathematics for the Elementary School, Grade 4 (revised edition).

The geometry sections are : Chapter 5, Sets of Points; Chapter 8, Recognition of Common Geometric Figures; and, Chapter 9, Linear Measurement.

Students also used a pencil, an eraser, a compass, a piece of string, unruled paper, and a ruler (with both inch and centimeter scales).

The instructor needed a blackboard, a large chalk compass, flexible wire, ruler, yardstick, and meter stick.

II. PROCEDURE

Sampling. There was no special selection of the children participating in this study. The group consisted of twenty-nine children in one grade-four room. There were fourteen boys and fifteen girls.

The average intelligence quotient of the group was 109.

The average age of the group when instruction started was nine years and ten months.

All students were taught by the same teacher. They were taught as a single group.

Procedure. The S. M. S. G. textbook was followed page by page using the teacher's manual as a guide for suggested procedure. Each geometry period was between thirty minutes and one hour in duration.

Before any instruction began, on October 5, 1963, the group was given the California Mental Maturity Test to determine the I. Q. of the members of the group.

The group was then given a series of tests covering six areas. These were completed on December 21, 1963. Instruction began on January 3, 1964. The average age of the group at this time was nine years and ten months.

On March 23, at which time the instruction was completed, another test covering the same learnings was given the students.

In both tests problems were classified to correspond to the subdivisions of the hypothesis.

Problems in each area were on a one to one relationship so tested learnings would correspond.

Two and one-half months later the first test was again given.

All three tests were corrected and recorded.

The number of correct answers to each problem on all three tests was recorded. Also, an individual record for each child was compiled. From this material an analysis was made and conclusions drawn.

III. DEFINITIONS OF TERMS USED

Geometry... space and space relations at rest.

Identification of geometric figures... the ability to assign a figure its proper name.

Identification of geometric solids... the ability to name correctly forms that have four properties: height, length, area, and volume.

Drawing of geometric figures... the ability to reproduce them on paper with a ruler and a compass. (The protractor is not introduced at this grade level.)

Linear measurement... distance measured in both the metric and U. S. standard measurements.

Relationship of lines... refers to the spatial position of a line or a line segment to another line or line segment or several lines or line segments.

Numeration of vertices, edges, and faces... consists of the ability to count them.

IV. LIMITATIONS OF THE STUDY

Findings in this study are limited to the progress made under the S. M. S. G. fourth grade program and the geometric areas covered by it. It determined growth in only those six particular areas mentioned. No attempt to measure geometric concepts or principles as such was made. To the writer's knowledge at the present time no valid test is available to test fourth graders on concepts or principles.

Findings in this study would pertain to students in a classroom of normal intelligence and typical age classification for grade four.

Geometric vocabulary or spelling is not tested as such; however, the writer recognizes that they are influential factors affecting the performance of the students involved in this study.

CHAPTER II

REVIEW OF THE LITERATURE

Educators, influenced by accelerating technology, are reassessing the mathematics curriculum in the American schools in an effort to teach more mathematics to more children in less time. This new intense interest has brought about many changes and it appears that many of the reforms are substantially permanent.

There appears to be three purposes in these changes: (1) to produce more and better mathematicians, (2) to produce students who compute accurately, and (3) students who can think in mathematical terms.

One of the areas of mathematics in which there appears to be a revolution in methods of teaching is geometry.

I. WHEN SHOULD THE TEACHING OF GEOMETRY BEGIN

Because geometry has many opportunities for concrete experiences and visual learnings it is being introduced in many elementary schools. Of course, because it can be taught does not necessarily mean that it needs to be, nor, even that it should.

Jean Piaget and associates as psychologists made a detailed study of how children come to measure which they hope will develop an

educational approach to geometry based on the laws of mental development. These are based first on qualitative development, secondly on metrical operation, and finally when areas and volume can be calculated.

A child needs to use systematic points of view before he can construct lines, understand space relationships, such as parallelism, angles, and intersections. These eventually lead to understanding of Euclidian principles.

For the learning of measurement homogeneity must be recognized before a unit system of measure can be developed. Without measurement no reference system can be developed.

Piaget used for this study children from the ages of one year seven months to ten years old. Since children under four years cannot be questioned with any degree of validity to their responses much of the study had to be conducted primarily through observation (21).

For this reason many educators although recognizing the worth of the studies are doubtful of all of his conclusions.

Donovan A. Johnson is even recommending the use of folded wax paper figures and the teaching of lines and curves, the relationship of lines, and the comparison of lines in the primary grades. He recommends relating geometric concepts to pupils surroundings to prepare the children for the world in which they live.

This might be a good time to start a scientific geometrical vocabulary.

Evidence of a sensitivity to geometrical progression is shown by some very young children in the stacking of discs or cubes.

Plato's own views on the way mathematics (which really meant geometry) ought to be taught seems to fit into the "modern math" program.

"Amusement and pleasure," said Plato, "ought to be combined with instruction in order to make the subject more interesting (11:45)."

Dr. Vincent J. Glennon of Syracuse University, though he has some pertinent questions about "modern math" says, "However, we are witnessing, fortunately, a renewed effort to make use of the 2,500-year-old Socratic method, now more often referred to as the heuristic or discovery method. (8:357)."

Apparently the discovery method is utilized widely in Russia to reach higher levels of mathematical skills and higher levels of mathematical learnings by organizing mathematics clubs which highlight their activities in an Olympiad each year at the Moscow State University where the students compete in solving more complicated mathematics problems and applying them to scientific and technological situations. The Olympiads are an important part of the life of the Moscow school pupils (25).

II. AN EARLY EMOTIONAL APPROACH

An early emotional security must be inculcated in students as well as a willingness to experiment. This appears to be necessary to develop the maturity required to master geometric concepts. Perhaps then such advanced fields as analytical geometry, descriptive geometry, topology, geometry of spaces having four or more dimensions, and non-Euclidian geometry would no longer be impossible to master by so many students.

Time is needed to re-enforce these learnings. Children need to see the relationships of their learnings and of their partial learnings to the size, shape, and location of the world in which they live.

Structured classwork. There appears to be a fairly consistent agreement that teaching geometry in just the tenth grade will not suffice.

Mr. Irwin Brune writes:

> From the kindergarten on the concepts, rules, and operations of arithmetic and algebra dominate pupils' experiences in mathematics. Few, deny it, and if the teacher has been good, still fewer bemoan it.
>
> A proper study for all children is geometry--the geometry of form. Here pupils perceive, compare, measure, and generalize. Here they sharpen intuition without plunging too far into abstractions (4:213).

To structure a course in geometry for elementary students is receiving much attention by educators and by publishing companies to meet the demands of our society.

III. MEANS AND METHODS

In kindergarten, block arranging is really an informal introduction to geometry and many children can produce rather complicated geometric structures for they appear to be sensitive to symmetry.

Dr. Brune states that tots plopping cutouts in proper places is a geometric activity and the handling of squares, cubes, triangles, and spheres really prepares these youngsters for further work with such forms. He feels that all to frequently we terminate such activities and go to memorizing fact and operating with numbers. He would like more geometry for the sake of geometry.

Florence Moore has incorporated the recognition and identifying of geometric figures, (namely, line, circle, half circle, triangle, rectangle, square, and octagon) into an art or drawing lesson for children in the primary grades. This is accomplished by tracing around glasses, bricks, boxes, blocks, etc. The forms are given their correct geometric names. Then the forms are utilized to construct men or animals, etc (18).

Teachers of elementary mathematics are constantly on the alert to find new devices for teaching geometric forms. The pegboard has been used to advantage because the drawing of exact geometric figures especially those with curvilinear perimeters is difficult and often time consuming. Since the board is already pegged on a linear scale much measurement is eliminated. Also, with the use of vari-colored rubber bands it is possible to show figures contained within other geometric forms. For instance, two triangles within a rectangle. Areas are visualized for the students and perhaps there will be some clarification of areal relationships. Geometric formulae too may be more readily explainable and, therefore, understandable.

The pegboard has been used successfully in concepts related to number of axes, rays, lines, and line segments. It is useful in teaching the various polygons and other symmetrical forms.

Science teachers. Even if a teacher is not interested in mathematics, they are often eager for the young student to utilize relationships relative to measurement. It is difficult for children to understand let alone answer such questions as: How large is the moon? How far is it to a planet? What is the weight of the earth?

If children realize that long ago astute persons searching for answers to these same questions were able to solve them because they

were possessed of mathematical knowledge, the children may develop a real sincere interest in spatial relationships. Franklyn Branley of the Hayden Planetarium feels it is possible for students in upper elementary grades to discover these truths for themselves if they become versed in geometric relationships and measurements. He has published book materials relative to this in his writings on astronomy (3).

Textbooks. Textbooks are beginning to include chapters in geometric learnings and it is quite possible to find on library shelves geometry books with special appeal to "young fry." There will be more.

One of the most delightful is a fascinating book intriguingly illustrated and concisely written in simple language for grade or junior-high age children. It is called Take Shapes, Lines, and Letters. It speaks of mathematics as being of two worlds:--a physical one joined to a world of ideas by the mind which moves from one to another.

In content it presents activities to illustrate understandings in several fields.

Mathematics in Art, -- lines create moods, curves are peaceful, spirals rhythmic. Proportion is relationship. Third dimension is perspective.

Mathematics in Music, -- tone, intervals

Mathematics with Letters, -- C for circle, A for Area, D = R X T (distance = rate x time) formula

Mathematics with Charts, -- graphs, line graphs, circle graphs, and scale drawings

Secret Codes, -- Explains mathematical sequence and repetition (1).

IV. SCHOOL MATHEMATICS STUDY GROUP

The culture of our modern world has demanded that mathematics in our schools be both well selected and well taught, - how? The School Mathematics Study Group was formed for this purpose. It was financed by the National Science Foundation.

This group was rather unorthodox in that it started first to look at the high school mathematics program. A suggested program was first developed to try to meet its needs, its abilities, and its demands in mathematics.

Next a program was prepared for grades seven and eight.

In 1961 at Stanford University they commenced on a course of study for grades four, five, and six. It was published as a sample curriculum in 1962. It is the writer's understanding that the curriculum for the primary grades is available for use in September 1964.

The grade-four course of study is used in this research. It has three units devoted to geometrical studies. It is hoped that it is presented so that children may grasp it easily. To help determine the areas most readily learned is one of the purposes of this study.

CHAPTER III

PROCEDURES USED IN THE STUDY

The study began on the third day of October 1963 at the H. M. Gilbert School, School District Number Seven, Yakima, Washington.

There were twenty-nine pupils enrolled in the study. They were a heterogenous group of children in a regular fourth grade classroom. Table I, located on Page 15, presents the demographic data concerning the subjects in this study.

The first testing session was to establish the intellectual level of the class as determined by the California Mental Maturity Test, Form S-5. The I. Q. 's ranged from a high of 131 to a low of 74. The average for the group was 109.

No attempt was made to classify the children or to group them for teaching purposes. They all received the same instruction.

Following this the first sessions were testing ones. The first to determine the ability of the students to identify sixteen geometric figures. These figures are shown in Table II, located in Appendix A. They were reproduced on ditto sheets for each child. The correct geometric terminology was to be written on the dotted line beneath each figure. The figures became successively more refined and discrimination became a considerable factor in the labeling of them. No help

TABLE I

FOURTH GRADERS PARTICIPATING

Individual	Sex	I. Q. *	Age
1. 201	M	131	9- 8
2. 101	F	128	9- 9
3. 102	F	127	10- 2
4. 103	F	126	9- 3
5. 202	M	123	10
6. 104	F	123	9- 5
7. 105	F	121	9- 3
8. 203	M	118	10
9. 106	F	117	9-10
10. 107	F	116	9
11. 204	M	113	9- 5
12. 108	F	111	9-11
13. 109	F	110	9- 3
14. 110	F	109	9- 4
15. 205	M	108	10- 2
16. 111	F	106	10- 6
17. 112	F	105	9-11
18. 113	F	103	9- 5
19. 206	M	102	10- 1
20. 207	M	102	9- 7
21. 208	M	101	9- 9
22. 209	M	99	9-10
23. 210	M	99	9- 9
24. 211	M	98	10- 3
25. 212	M	97	9- 4
26. 213	M	96	10- 6
27. 214	M	95	9- 7
28. 114	F	92	10- 1
29. 115	F	74	10- 4

* Determined by California Mental Maturity Test

was given, no instruction offered, and no discussion permitted between the children. Twenty minutes were allowed for this test.

On this same day a sheet depicting seven of the most basic geometrical solids was given each child. (See Table III located in Appendix A.) Each child wrote the best possible name under each figure. After twenty minutes these papers also were collected.

These were corrected and tallied. They were not returned to the students.

One week later each child was given a compass, a ruler, several pieces of newsprint, a pencil and an eraser.

Fourteen geometric figures drawn on 3' x 4' tag board were hung on the wall in front of the room. (See Table IV located in Appendix A. for a list of them.) The children were asked to draw the figure exactly as they saw it. No attempt was made to have the children identify these.

Sixty minutes were allowed for the drawing. Children were cautioned to draw the ones they knew they could do first. Papers were collected, corrected, and tallied.

The third testing period was one week later. This was to determine their ability to measure. Each child was issued a ruler with both the metric scale and the U. S. scale of measure. They were also given a ten inch piece of string. (See Table V located in Appendix A.)

This proved to be rather difficult for the children seemed rather frustrated not knowing which side of the ruler to use. They wanted to know the purpose of the string. It seemed almost impossible to answer questions without instructing. The time given for this test was one hour.

The fifth test to be administered was on line relationships. (See Table VI located in Appendix A.) Although the instructor had allowed one hour for this test the students seemed to feel they were finished at the end of a forty minute period.

The sixth test of the series was given during a morning session. Each child was allowed to handle the seven geometrical forms listed in Table VII located in Appendix A. They were to count the corners, edges, and faces of them and record their findings on the form provided. They did this one at a time until all had done it. Each child was permitted as much time as he needed to complete the task.

This completed the initial testing program preceding instruction. All papers were collected, corrected, and tallied.

Instruction. Following Christmas vacation time instruction was started on the geometry jnits in the S. M. S. G. text. Forty to forty-five minutes daily was given to instructing and to working the exercises as set forth in the text. The regular page by page procedure was

followed. However, the teacher utilized the enrichment suggestions in the teacher's manual as was recommended. The only deviations being those individuals spontaneously volunteered and those special interests that some children followed. No special enrichment was provided by the teacher.

Instruction stopped when the material had been covered. Immediately following this, covering a one week period, the children were given the six groups of tests that compromise Test II located in Appendix B. Test II had a one to one correlation with the original test. In some cases the order of the questions was changed or the position of the geometrical form changed. Size of the figures also was altered.

All organized or structured instruction ceased at this time.

During the week of June 1 through June 5, 1964, the original test was again administered. The same time was allotted for each of the six tests given. It was evident, however, that many children did not feel they needed to utilize all the time allowed.

Both Test II and Test III were corrected and tallied. Records were kept on the number of problems correctly answered and individual records were kept as to the total correct in each area.

CHAPTER IV

I. SUMMARY AND ANALYSIS

The introduction of geometry in the fourth grade was accepted in a non-commital manner by many students. Some, however, expressed a knowledge that it was something you took in high school and that it was difficult.

Some children even upon completion of the daily lessons failed to accept it as math. This term already appeared to be associated with numerical operation only. On the basis of the first testing situation the following data were obtained. These data are summarized on Table XIV, located on Page 20.

Section I. Identification of geometric figures. From the information presented in Table XIV, it is of interest to note that all children could name at least one of the figures; however, five could name only one. The highest number named on the original testing by any one child was seven. This child named sixteen or all of them on the final test. She was the girl with the highest I. Q. score (128). She was the only child to identify them all. See Appendix C, Individual Record Sheet, Student 101, Page 62.

TABLE XIV

CORRECT ANSWERS
(Test I)

Number of Problem	SECTIONS I Geometric Figures	II Geometric Solids	III Drawings	IV Measurements	V Lines	VI Numeration
1.	3	1	23	11	28	58
2.	1	0	13	8	6	61
3.	2	0	19	9	9	50
4.	6	1	15	9	9	67
5.	2	1	15	10	0	60
6.	1	11	8	22	19	68
7.	0	1	29	0	26	44
8.	26		12	20	15	
9.	3		3	18	22	
10.	11		12	18	10	
11.	0		21	1	10	
12.	9		0	3	4	
13.	23		14	7	3	
14.	0		6		3	
15.	1					
16.	1					
Total	89	15	190	136	164	408

Those who could name only one on the first test could name, eight, ten, seven, three, and seven on the third test. These children had a wide range of intelligence scores.

In the original testing no child could ascribe the correct name to figure seven (simple closed curve), figure eleven (quadrilateral), or figure fourteen (equilateral triangle). In the final testing twenty-one children named the simple closed curve, ten children the quadrilateral, and only two the equilateral triangle. See Tables XV and XVI on Pages 22 and 23 following.

On the second test the simple closed curve was labeled correctly twenty-four times, the quadrilateral nineteen times, and the equilateral triangle five times.

Section II. Identification of solids. Initially there was little ability demonstrated by these children to ascribe correct geometrical terms to solids. The cone was the only form identified correctly by more than one child. It was labeled correctly by eleven students. No child could identify a rectangular prism nor a triangular prism. Seventeen children could identify none of them.

This is the area in which there appeared to be the greatest growth after instruction ceased. Though only fifteen solids were identified on Test I, and seventy-six on Test II, the third testing showed

TABLE XV

CORRECT ANSWERS
(Test II)

Number of Problem	SECTIONS					
	Geometric Figures	Geometric Solids	Drawings	Measurements	Lines	Numeration
1.	26	25	26	28	28	70
2.	20	12	13	21	26	76
3.	4	7	22	27	2	56
4.	23	16	19	27	11	72
5.	17	5	26	21	27	78
6.	24	4	13	29	19	80
7.	27	7	29	4	24	59
8.	21		19	26	26	
9.	16		3	25	28	
10.	19		20	16	18	
11.	15		24	26	24	
12.	18		16	18	7	
13.	11		18	10	14	
14.	3		13		6	
15.	5					
16.	15					
Total	264	76	261	278	260	491

TABLE XVI

CORRECT ANSWERS
(Test III)

Number of Problem	SECTIONS I Geometric Figures	II Geometric Solids	III Drawings	IV Measurements	V Lines	VI Numeration
1.	27	12	27	29	29	72
2.	16	11	16	16	7	76
3.	9	14	17	28	16	63
4.	25	14	14	26	11	78
5.	20	17	19	22	16	74
6.	21	28	11	27	28	81
7.	21	19	29	4	27	55
8.	25		17	25	26	
9.	12		4	24	26	
10.	12		19	27	22	
11.	10		26	22	15	
12.	13		17	16	14	
13.	23		19	22	26	
14.	2		13		16	
15.	6					
16.	21					
Total	263	115	248	288	279	499

115 identified correctly.

The highest score on the third test was seven. Four girls, measured intelligence scores of 92, 103, 116, and 128, achieved this score.

On the final test eleven children could identify the triangular prism and fourteen the rectangular prism. Four children could not name as many on the third test as on the second.

In the identification of geometric solids, although there was only fifty-seven per cent accuracy, there was an improvement in achievement of 666 per cent. Greatest pupil growth was demonstrated in this area.

Section III. Drawing of geometric figures. In the initial testing every child could draw a circle. No child could draw a rectangular based pyramid and only three could draw an octagon.

The drawing of the cone appeared more difficult than the drawing of a cylinder. Several children failed to use a curved line as a base and attempted to draw the base with line segments. These children used curves on either end of the cylinder.

The children who scored highest in this area were children who evidenced proficiency in art work. The two with perfect scores frequently have works chosen for art exhibits by the art director.

On the final testing the octagon was the most difficult figure to draw for the largest number of children.

Section IV. Linear measurement. On the initial testing eleven children could not measure a line segment in inches. On the final testing they could all do this, but one could not measure it in centimeters. On the initial test no child could do the ratio-measurement of a building drawn to scale. Example: If two inches represented twenty-four feet, then a one and one-half inch line segment would represent what distance? However, even with the complication of fractional determinants, four children were able to compute the distance represented by the inch and one-half segment. Problems adding feet alone were done correctly by twenty children in the initial testing and by twenty-five in the final test. One child could add feet and inches on the first test. Twenty-two were able to do so on the final test.

Regarding successful achievement in the final testing, the section of linear measurement with seventy-six per cent of the problems answered correctly, was highest. This area was second in degree of growth with 111 per cent improvement in achievement.

Section V. Line relationships. In the initial test twenty-eight of the twenty-nine children were able to tell which of two segments was the longer.

Though much space was given in the text to the unreliability of the eye as a tool for measurement, many children failed to recall this fact two months later. Problem two depicts this. Note the scores on the three tests: Table XV, Page 22; Table XVI, Page 23; and Table XVII, Page 29.

Test I	Test II	Test III
6	26	7

This was the lowest final scoring on any problem in this section.

Although no child could name a right angle in the initial testing, sixteen of them could on the final testing. This is another instance where they did much better immediately following the instruction.

Some children observed that two lines crossed but failed to state that they intersected.

The children were able to answer with a high degree of accuracy those questions relating to points on a line or in a plane. This accuracy held through the subsequent tests and even improved.

Section VI. Numeration of corners, edges, and faces. This was the area in which the children scored highest on the initial testing. They were most accurate in counting corners. Least accurate in counting edges.

The enumeration of the surfaces of the cone was the most frequently missed. The surfaces of the cylinder next.

The greatest accuracy tallied was on the pyramid. The sphere was the next less frequently missed. Since it possesses neither corners nor edges all of the error occurred enumerating the surface.

The least improvement was shown in enumeration but the initial success was greatest. There was a twenty-two per cent improvement. This was the second area in accuracy, seventy-four per cent correctly answered on the final test.

There was found to be a correlation between the intelligence scores and the achievement scores of the subjects in this study. The correlation between these two variables was .459. This correlation was statistically significant at the .05 level of confidence.

II. CONCLUSION

The study satisfied the investigator that fourth graders progressed under organized instruction, that they possessed some knowledge at the onset of the study, and that learning was not uniform in all areas.

At first glance it would appear that the girls enjoyed greater success than the boys. In this group of students eight of the girls and only four of the boys had I. Q. 's over 110. The two lowest intelligence

scores belonged to girls, yet, one of these attained the second highest score in achievement. The highest I. Q. in the group was that of a boy, 131. He ranked seventh in the group in achievement. The average I. Q. for girls was 111 and for boys, 106. This is a variable which makes definite conclusions about sex as a determinant most difficult.

That there was a positive relationship between intelligence scores and achievement of the subjects in this study was evidenced by the correlation of .459. However, this correlation was interpreted as indicating only a marked degree of relationship between these two variables.

From this research it is evident that there was growth in these six areas. In no case was it less than a twenty-two per cent improvement nor a fifty-seven per cent degree of accuracy.

Geometric learnings are possible in all of these areas. Fourth graders seem to grasp the terminology and the relationships. See Table XVII on Page 29 following.

There appears to be good retention in these learnings. See Table XVIII on Page 30. The least is in the ability to draw the geometric figures. There appeared to be considerable learning after instruction ceased in the identification of solids.

The total per cent of problems answered correctly at the termination of the study was sixty-five per cent. A compilation of the

TABLE XVII

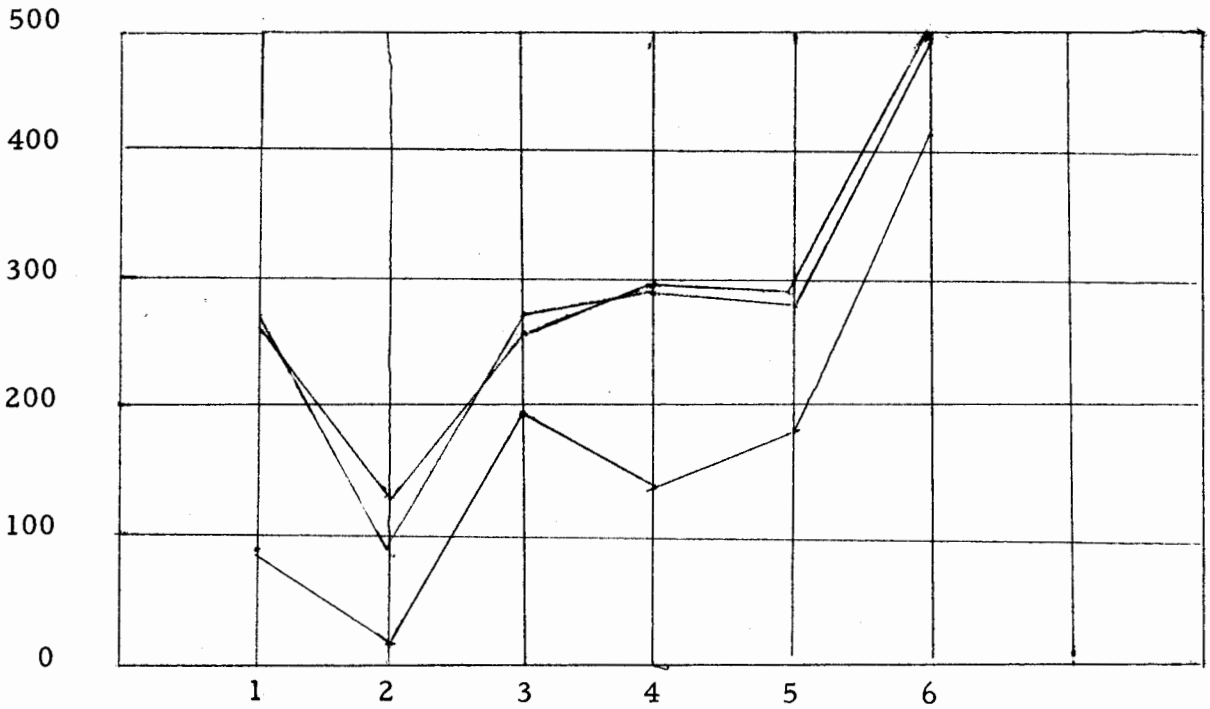
CLASS RESULTS OF THREE TESTS

KEY

Test I ———————

Test II ———————

Test III ———————



1. Identification of figures
2. Identification of solids
3. Drawing of geometric figures
4. Linear measurement
5. Line relationships
6. Numeration of corners, edges, and faces

TABLE XVIII

COMPILATION OF NUMBER OF CORRECT PROBLEMS

Area Tested	Possible Correct Number	Correct Number Test I	Correct Number Test II	Correct Number Test III	Final Per Cent Correct
Identification of figures	464	89	264	263	57%
Identification of solids	203	15	76	115	57%
Drawing of geometric figures	406	190	261	248	61%
Linear measurement	377	136	278	288	76%
Line relationships	406	164	260	279	69%
Corners, edges, faces	609	408	491	499	74%
Totals	2465	1002	1630	1692	65%

number of problems answered correctly in each of the given areas is snown on Table XVIII on Page 30.

From this study it would appear that teaching basic geometrical learnings would meet with success in grade four.

III. IMPLICATIONS

Lack of retention seems to be a factor in identifying figures. The inability of students to identify the equilateral triangle caused the writer to wonder if it was terminology or the failure of the students to note the refinement of the three equal sides of the triangle. Some children referred to it as a pyramid on Test II and on Test III.

It was interesting to note that children often gave two dimensional names to the forms with four properties. They called a cube, a square, and a pyramid, a triangle. This would indicate to the observer a geometric awareness but only partial learning.

Children were also inclined to label the figures with non-geometric terms such as dunce cap for cone, box for rectangular prism, and ball for sphere. This implies an awareness of shape associated with surroundings but lack of classification.

The drawing of geometric figures was an extremely difficult area to correct. Many children were careless in the use of the ruler.

Some spent a considerable share of the allotted time on one drawing though they were cautioned to draw those first which they knew they could do. These tendencies appeared less evident in the final testing.

In enumeration of corners, edges and faces the investigator used a tetrahedron as a model. Would the students have done as well if a rectangular based pyramid had been used?

The writer feels that learnings relative to linear measurement and scale relationships could very profitably be started at an age earlier than nine or ten. This might enable the areal and volume concepts to be introduced by grade four.

Geometric terminology is apparently lacking in these children's experiences and perhaps a structured vocabulary could be presented at this time or sooner for it appears it can be developed. The writer feels that social usage of the terms by those children who mastered them contributed to growth after instruction had ceased in this area.

Observation: In watching boys playing a game the investigator observed them refer to a form as a pyramid which they had formerly designated a tent. No other areas showed this growth following cessation of instruction.

It would appear that the areas where vocabulary is a factor seemed most difficult. Also refinements in the forms appear to give

fourth graders some difficulty. For instance: triangle, isosceles triangle, and equilateral triangle. All three forms were triangles to most of the children but the length of sides had no significance to many in labeling them, if they did observe the line relationships.

IV. NEED FOR FURTHER RESEARCH

Several channels for further investigation in this area which might prove valuable are evident to the writer. What is the relationship between children's knowledge or feeling for line relationships in their true geometric relationship and their artistic ability? From this study there appears to be a relationship in their ability to draw geometric figures and selection of art work for exhibits and fairs.

Another area for possible study would be the introduction of concepts and general theories. It seems some could be introduced as such as early as the fourth grade and at the same time show their practical application and usage in our culture.

Are volume and area delayed longer than the optimum time being introduced?

Could geometry be included successfully when teaching computational facts even more successfully than as separate units in elementary programs?

It is evident to the writer that there are several areas of high interest to educators to be explored in the field of geometry and its place in the elementary curriculum.

APPENDIX A

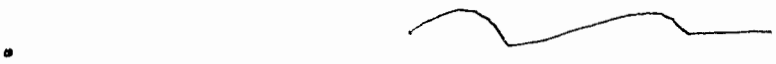
Tests of Geometric Ability

Test I

Sections I through VI

TABLE II
TEST I
SECTION I

IDENTIFICATION OF FIGURES



1. point _____

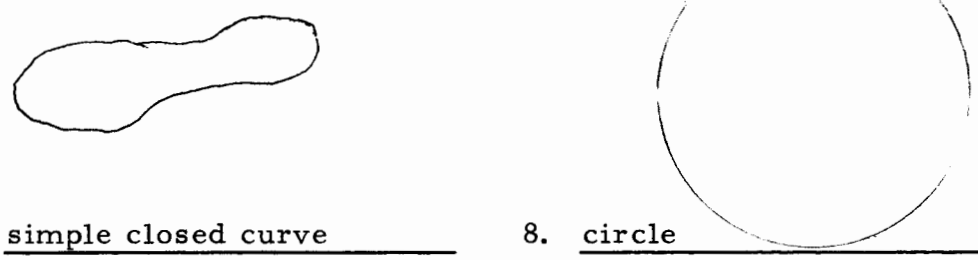
2. curve _____

3. arc _____

4. line segment _____

5. line _____

6. ray _____

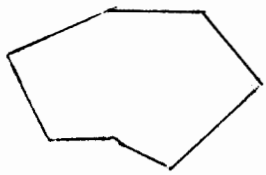


7. simple closed curve _____

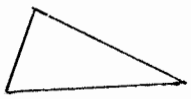
8. circle _____

TABLE II (Continued)
TEST I
SECTION I

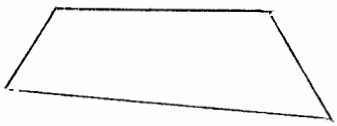
IDENTIFICATION OF FIGURES



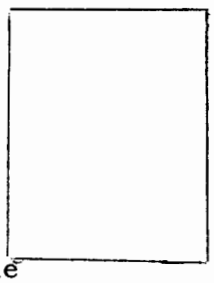
9. polygon



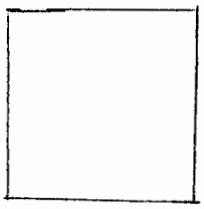
10. triangle



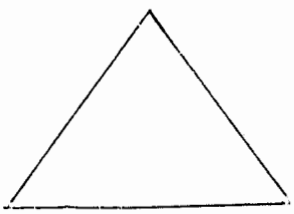
11. quadrilateral



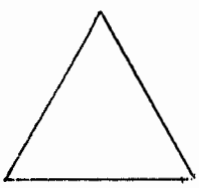
12. rectangle



13. square



14. isosceles triangle

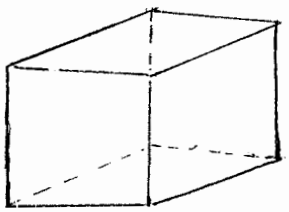


15. equilateral triangle

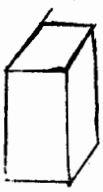
16. plane

TABLE III
TEST I
SECTION II

IDENTIFICATION OF GEOMETRIC SOLIDS

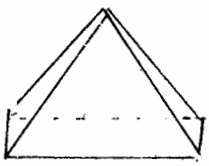


1. cube

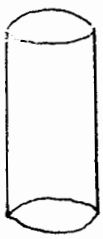


2. rectangular prism

3. triangular prism

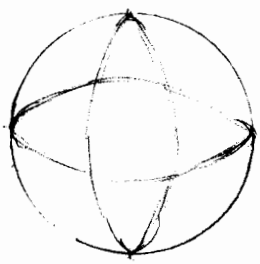


4. pyramid



5. cylinder

6. cone



7. sphere

TABLE IV
TEST I
SECTION III

REPRODUCTION OF GEOMETRIC DRAWINGS

The following list of drawings were reproduced from large charts by the students:

1. Right triangle
2. Parallelogram
3. Rectangle
4. Square
5. Isosceles triangle
6. Equilateral triangle
7. Circle
8. Sphere
9. Octagon
10. Cone
11. Cylinder
12. Pyramid (Tetrahedron)
13. Triangular prism
14. Rectangular prism

These figures were reproduced using only a pencil, ruler, and compass. The use of the protractor is not introduced at the fourth grade level.

TABLE V
TEST I
SECTION IV

LINEAR MEASUREMENT

1. A _____ B

1. In inches how long is $\overline{AB}$?
. . . . . .

2. C _____ D

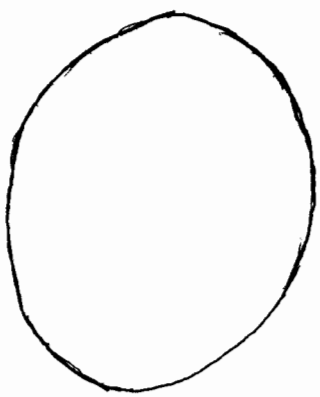
2. In inches how long is $\overline{CD}$?
. . . . . .

3. E _____ F

3. In centimeters how long is $\overline{EF}$?
. . . . . .

4. G _____ H I _____ J

4. In inches how long are $\overline{GH}$ and $\overline{IJ}$ together?
. . . . . .

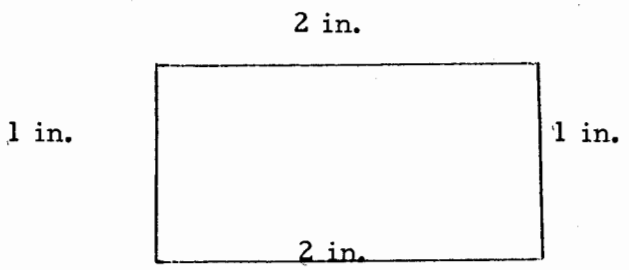
5. 

5. How many inches is it around drawing 5?
. . . . . .

TABLE V (Continued)
TEST I
SECTION IV

LINEAR MEASUREMENT

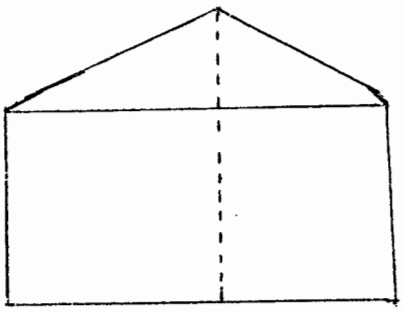
6.



6. How many inches is it around this drawing?

. . . . . .

7.

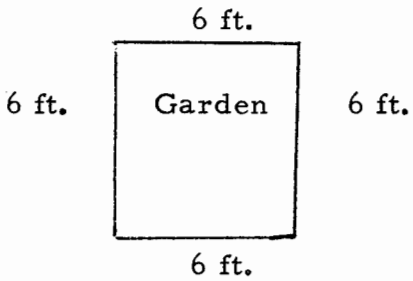


7. This picture stands for a house. How high is the house?

. . . . . .

24 feet

8.



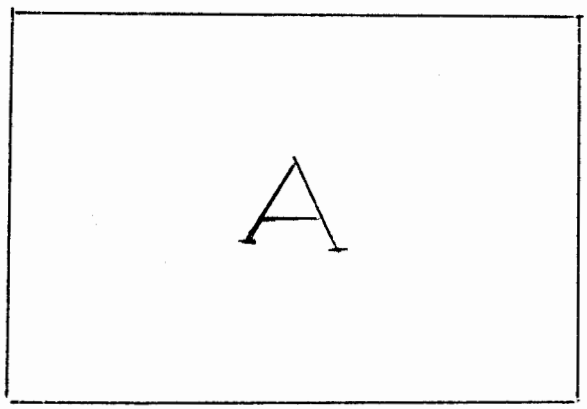
8. How many feet of wire would it take to fence this garden?

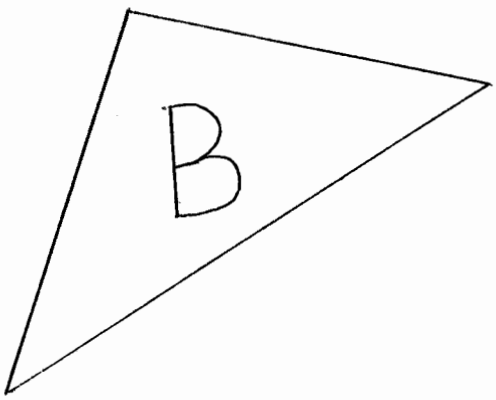
. . . . . .

TABLE V (Continued)
TEST I
SECTION IV

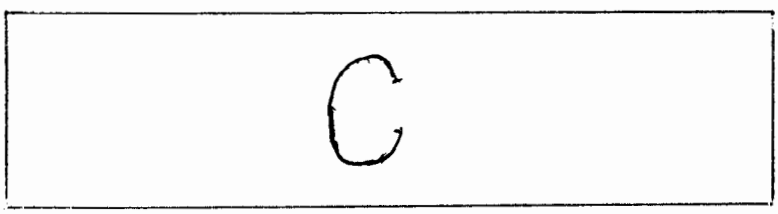
LINEAR MEASUREMENT

9. What is the distance around figure A? . . . . . .





10. What is the distance around figure B? . . . . . .

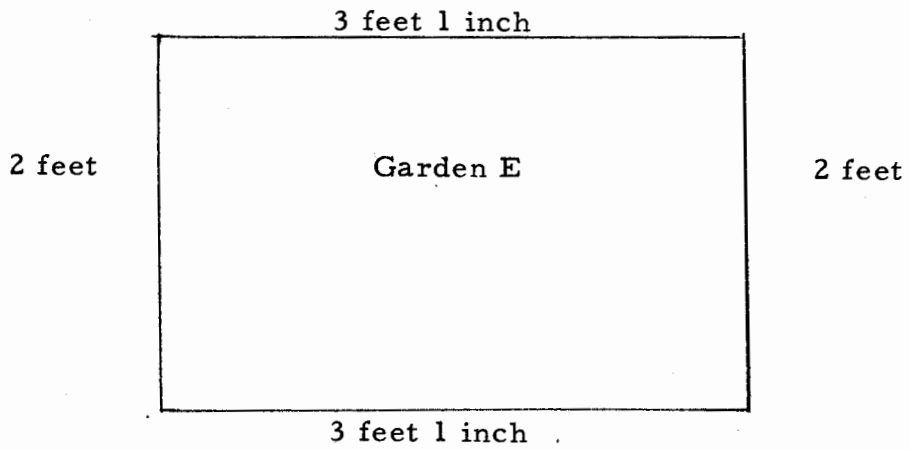


11. What is the perimeter of figure C? . . . . . .

TABLE V (continued)
TEST I
SECTION IV

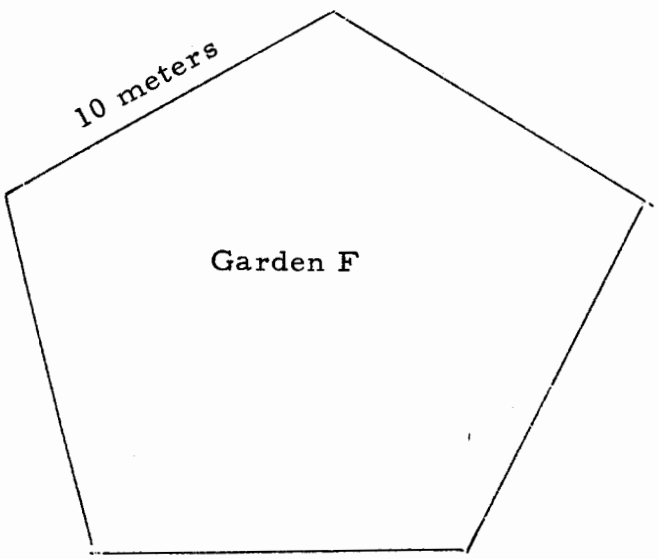
LINEAR MEASUREMENT

12.



12. What is the distance around Garden E?
. . . . . .

13.



13. How many meters of wire would it take to put a fence around Garden F? . . . . . .

TABLE VI
TEST I
SECTION V

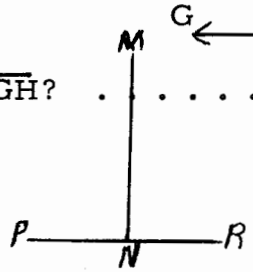
LINE RELATIONSHIPS

1. A _____ B C _____ D

1. Which is longer $\overline{AB}$ or $\overline{CD}$? . . . . . .

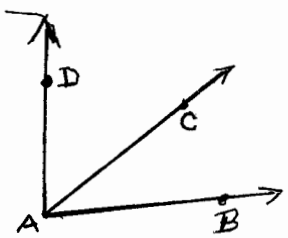
2. E ⟷ F G ⟷ H

2. Which is longer $\overline{EF}$ or $\overline{GH}$? . . . . . .



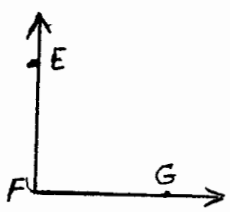
3. Which is longer $\overline{MN}$ or $\overline{PR}$? . . . . . .

4.



4. Which angle is larger, ∠DAC or ∠DAB? . . . . . .

5.



5. What kind of an angle is ∠EFG? . . . . . .

TABLE VI (Continued)
TEST I
SECTION V

LINE RELATIONSHIPS

6.

A B C D E F

6. Are points A, B, C, D, E, and F on the same line?

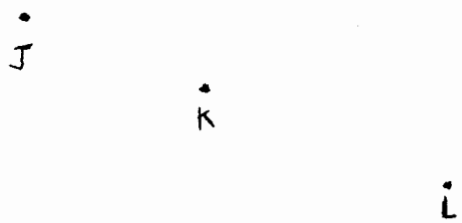
Yes . . . . . No . . . . . .

7.

M N P Q

7. Are points M, N, P, and Q on the same line? . . . . .

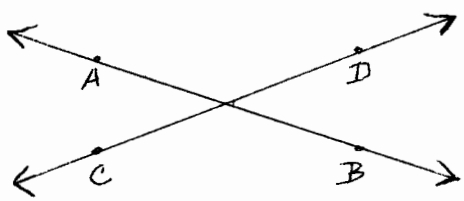
8. and 9.



8. Are points J, K, and L on the same line? . . . . . .

9. Are points J, K, and L in the same plane? . . . . . .

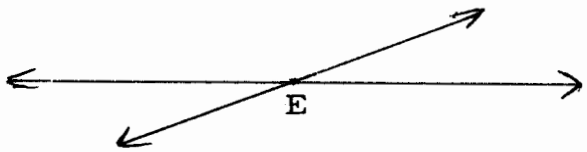
10.



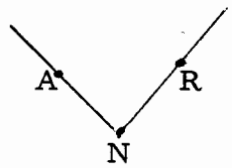
10. What does line AB do to line CD? . . . . . .
. . . . . .

TABLE VI (Continued)
TEST I
SECTION V

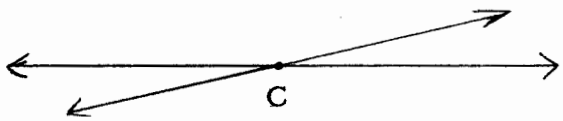
LINE RELATIONSHIPS

11. 

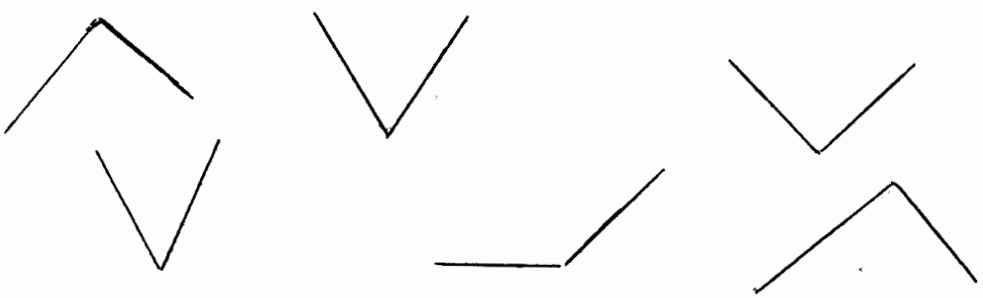
11. What is point E in the above? . . . . . .

12. 

12. Name the vertex in the above drawing? . . . . . .

13. 

13. How many lines can be drawn through point C?
. . . . . .

14. 

14. Draw a circle around the right angles above.

TABLE VII
TEST I
SECTION VI

RECORDING OF CORNERS, EDGES, AND FACES

1. CUBE
   1. Corners . . . . .
   2. Edges . . . . .
   3. Faces . . . . .
2. TRIANGULAR PRISM
   1. Corners . . . . .
   2. Edges . . . . .
   3. Faces . . . . .
3. CYLINDER
   1. Corners . . . . .
   2. Edges . . . . .
   3. Faces . . . . .
4. SPHERE
   1. Corners . . . . .
   2. Edges . . . . .
   3. Faces . . . . .
5. RECTANGULAR PRISM
   1. Corners . . . . .
   2. Edges . . . . .
   3. Faces . . . . .
6. PYRAMID
   1. Corners . . . . .
   2. Edges . . . . .
   3. Faces . . . . .
7. CONE
   1. Corners . . . . .
   2. Edges . . . . .
   3. Faces . . . . .

APPENDIX B

Tests of Geometric Ability

Test II

Sections I through VI

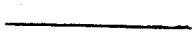
TABLE VIII
TEST II
SECTION I

IDENTIFICATION OF GEOMETRIC FIGURES

1. point . . . . . .

2. curve . . . . . .

3. arc . . . . . .



4. line segment . . . . . .

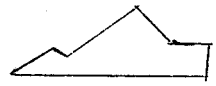
5. ray . . . . . .

6. simple closed curve . . . . . .

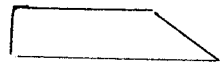
7. circle . . . . . .

8. line . . . . . .

9. polygon . . . . . .

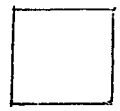


10. quadrilateral . . . . . .

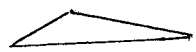


11. rectangle . . . . . .

12. square . . . . . .



13. triangle . . . . . .



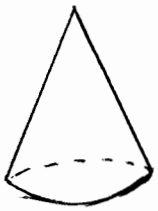
14. isosceles triangle . . . . . .

15. equilateral triangle . . . . . .

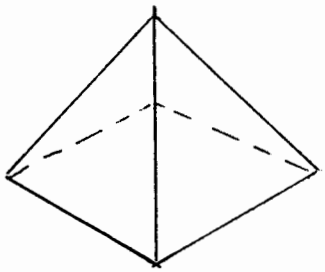
16. plane . . . . . .

TABLE IX
TEST II
SECTION II

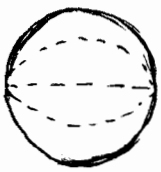
IDENTIFICATION OF GEOMETRIC SOLIDS



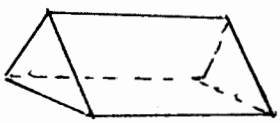
1. cone . . . . . .



4. pyramid . . . . . .

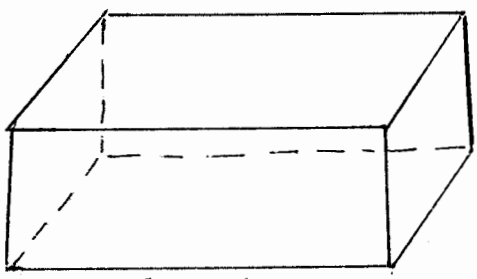


2. sphere . . . . . .

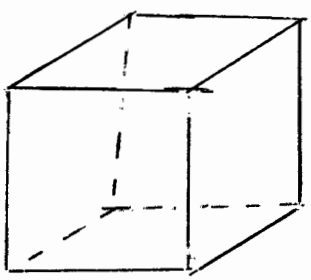


5. triangular prism . . . . . .

3. cylinder . . . . . .



6. rectangular prism . . . . . .



7. cube . . . . . .

TABLE X
TEST II
SECTION III

REPRODUCTION OF GEOMETRIC DRAWINGS

The following list of drawings were reproduced from large charts by the students:

1. Right triangle
2. Parallelogram
3. Rectangle
4. Square
5. Isosceles triangle
6. Equilateral triangle
7. Circle
8. Sphere
9. Octagon
10. Cone
11. Cylinder
12. Pyramid (Rectangular base)
13. Triangular prism
14. Rectangular prism

TABLE XI
TEST II
SECTION IV

LINEAR MEASURE

1.

A _____ B

In inches how long is AB? 1. . . . . 3 inches . . . . . .

2.

C _____ D

In inches how long is CD? 2. . . . . 4 1/2 inches . . . . . .

3.

E _____ F

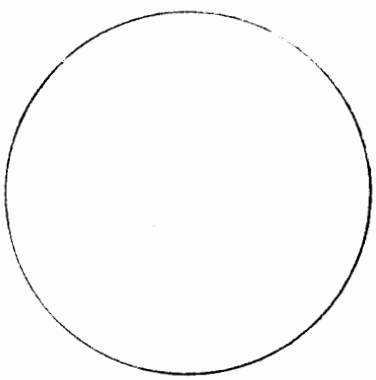
In centimeters how long is EF? 3. . . . . 12 centimeters . . . . . .

4.

G _____ H I _____ J

In inches how long are GH and IJ together? 4. . . . . 5 inches . . . .

5. To the nearest inch how far is it around figure 5?

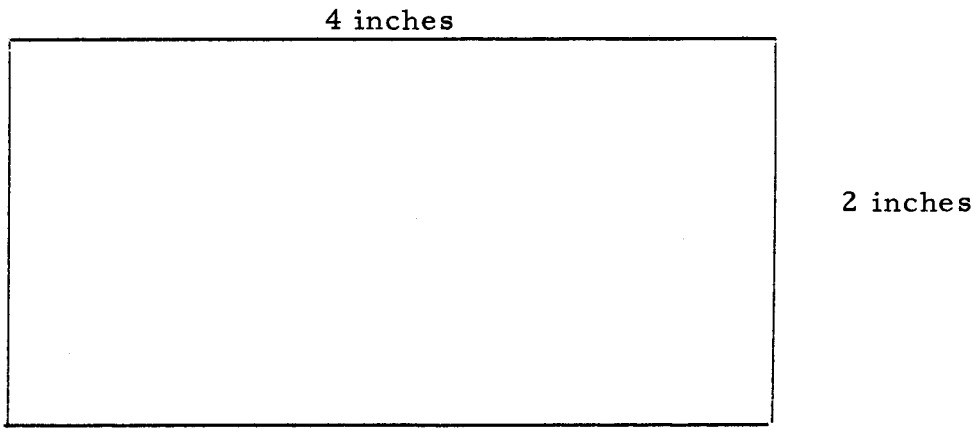


5. . . . . 6 inches . . . . . .

TABLE XI (Continued)
TEST II
SECTION IV

LINEAR MEASURE

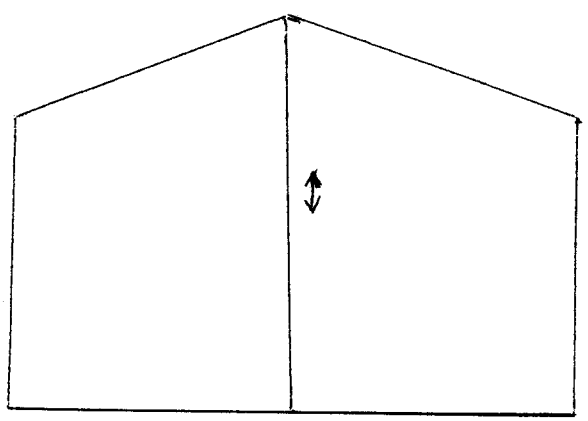
6.



6. How many inches is it around this drawing?

6. . . . . 12 inches . . . . . .

7.



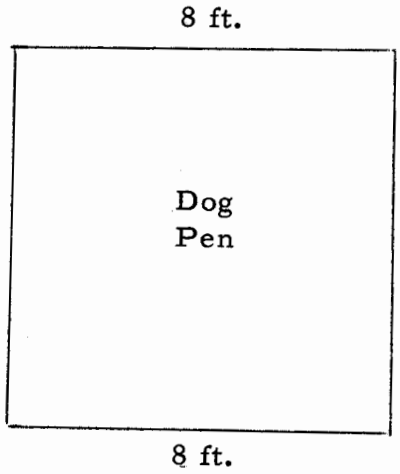
7. This picture stands for a house. How high is the house?

7. . . . . 24 feet . . . . . .

TABLE XI (Continued)
TEST II
SECTION IV

LINEAR MEASURE

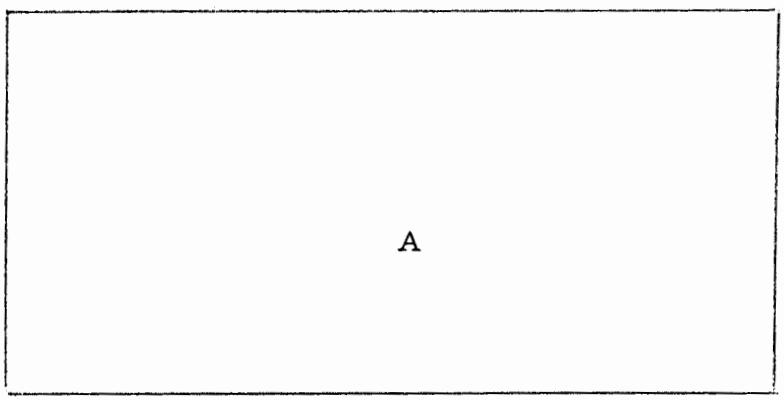
8.



8. How many feet of wire would it take to fence this dog pen?

8. . . . 32 feet . . . .

9.

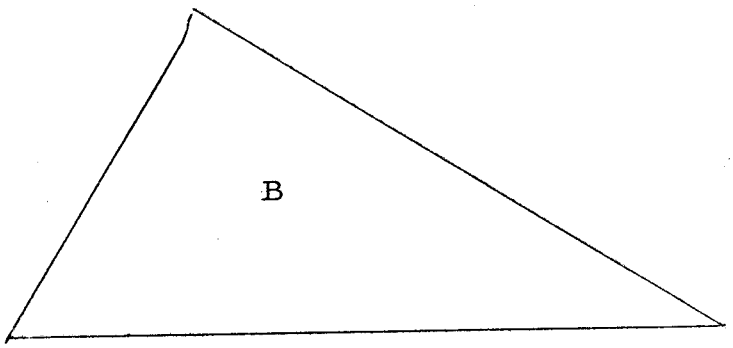


9. What is the distance around A? . . 12 inches . . . . . .

TABLE XI (Continued)
TEST II
SECTION IV

LINEAR MEASURE

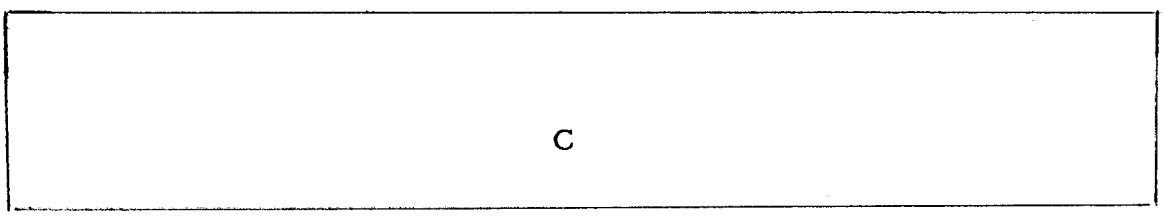
10.



10. What is the distance around B?

10. . . . . 9 inches . . . . . .

11.



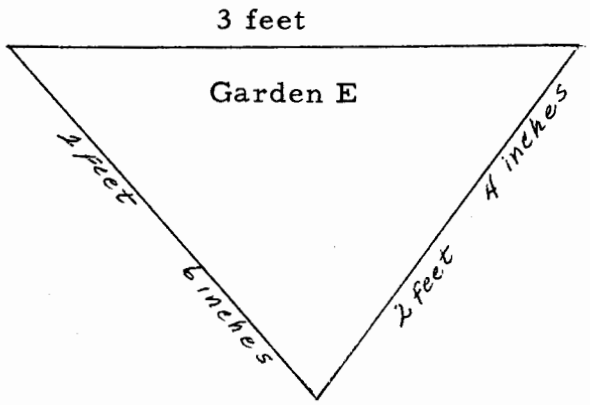
11. What is the perimeter of C?

11. . . . . 14 inches . . . . . .

TABLE XI (Continued
TEST II
SECTION IV

LINEAR MEASURE

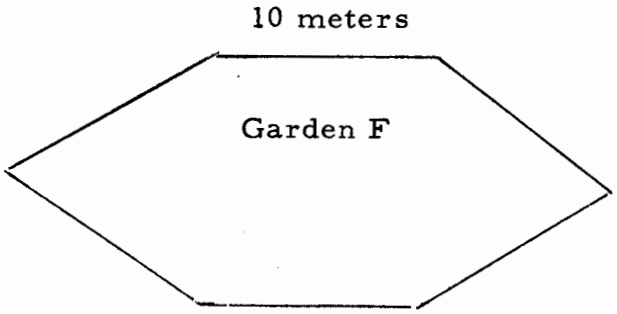
12.



12. What is the distance around Garden E?

12. . . . . 7 feet 10 inches . . . . . .

13.



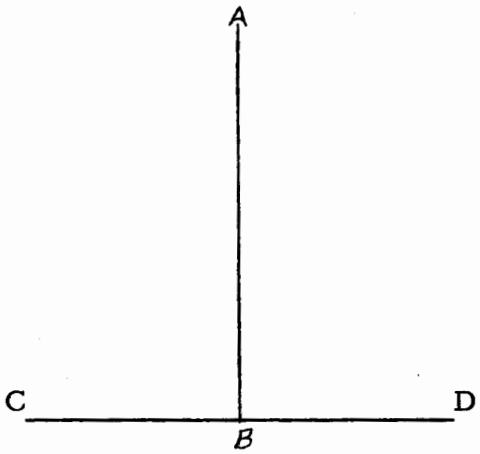
13. What is the distance around Garden F?

13. . . . . 60 meters . . . . . .

TABLE XII
TEST II
SECTION V

LINE RELATIONSHIPS

1.



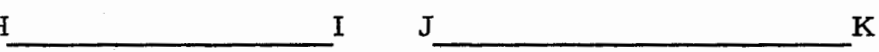
1. Which is longer AB or CD?

1. . . . CD . . . . . .

2.

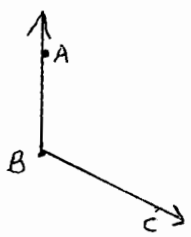
2. Which is longer EF or Gh? 2. . . . . Same Length . . . . . .

3.



3. Which is longer HI or JK? 3. . . . JK . . . . . .

4. Which angle is larger ∠ABC or ∠ADC? 4. . . . ∠ABC . . . .



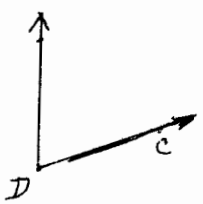
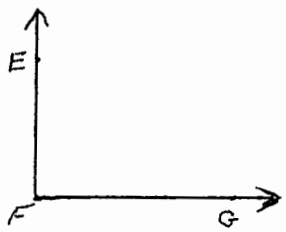


TABLE XII (Continued)
TEST II
SECTION V

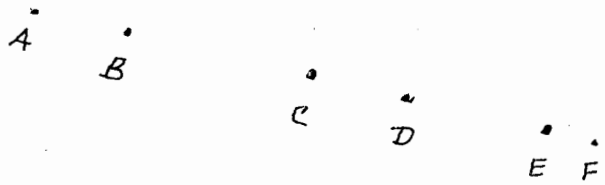
LINE RELATIONSHIPS

5. What kind of an angle is EFG? 5. A right angle

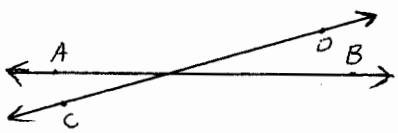


6. Are points A, B, C, D, E, F on the same line?

Yes . X . . . . No . . . . . .



7. What does line AB do to line CD? 7. Line AB intersects line CD



8. Are points L, M, N, O, P on the same line?

Yes . X . . . . No . . . . . .

L M N O P

9. Are points L, M, N, O, P on the same plane?

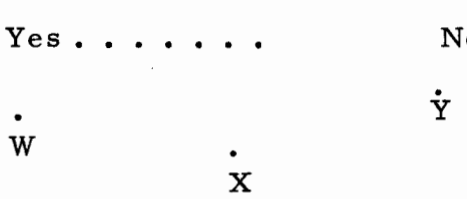
Yes . X . . . . No . . . . . .

TABLE XII (Continued)
TEST II
SECTION V

LINE RELATIONSHIPS

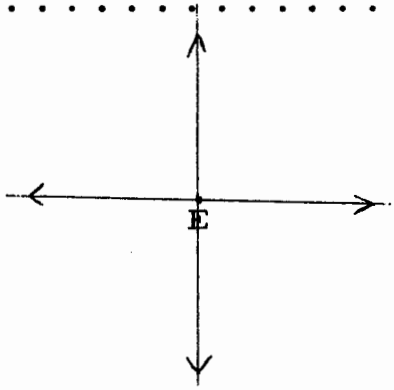
10. Are points W, X, Y on the same line?

Yes . . . . . No . . . . . .



11. Name point E. (What is it?)

11. It is the intersection . . . . . .

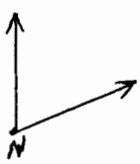


12. How many lines can be drawn through point E?

12. An infinite number . . . . . .

13. What is point N?

13. The vertex . . . . . .



14. Draw a circle around the right angles.

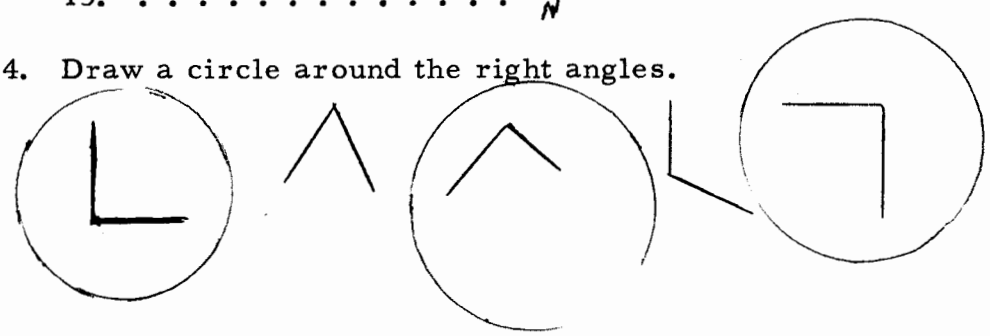


TABLE XIII
TEST II
SECTION VI

RECORDING OF VERTICES, EDGES, AND FACES

1. CUBE
   1. Vertices . . . . .
   2. Edges . . . . .
   3. Faces . . . . .

2. TRIANGULAR PRISM
   1. Vertices . . . . .
   2. Edges . . . . .
   3. Faces . . . . .

3. CYLINDER
   1. Vertices . . . . .
   2. Edges . . . . .
   3. Faces . . . . .

4. SPHERE
   1. Vertices . . . . .
   2. Edges . . . . .
   3. Faces . . . . .

5. RECTANGULAR PRISM
   1. Vertices . . . . .
   2. Edges . . . . .
   3. Faces . . . . .

6. PYRAMID
   1. Vertices . . . . .
   2. Edges . . . . .
   3. Faces . . . . .

7. CONE
   1. Vertices . . . . .
   2. Edges . . . . .
   3. Faces . . . . .

APPENDIX C

INDIVIDUAL RECORD SHEETS

Students in 100 Series are Girls

Students in 200 Series are Boys

Those With Lowest Number in the Series
have Highest I. Q.

INDIVIDUAL RECORD SHEET

Student 201

Sex M IQ 131 Age 9 - 8

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	5	10	12
2. Identification of solids	7	0	4	5
3. Drawing of geometric figures	14	10	10	12
4. Linear measurement	13	3	11	12
5. Line relationships	14	6	9	9
6. Corners, edges and faces	21	18	20	18
Totals	85	42	64	68

INDIVIDUAL RECORD SHEET

Student 101

Sex F IQ 128 Age 9 - 9

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	7	15	16
2. Identification of solids	7	0	6	7
3. Drawing of geometric figures	14	9	13	14
4. Linear measurement	13	5	11	11
5. Line relationships	14	4	13	14
6. Corners, edges and faces	21	17	17	17
Totals	85	42	75	79

INDIVIDUAL RECORD SHEET

Student 102

Sex F IQ 127 Age 10 - 2

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	5	12	11
2. Identification of solids	7	0	1	5
3. Drawing of geometric figures	14	10	11	10
4. Linear measurement	13	10	10	11
5. Line relationships	14	9	9	10
6. Corners, edges and faces	21	5	11	11
Totals	85	39	54	58

INDIVIDUAL RECORD SHEET

Student 103

Sex F IQ 126 Age 9 - 3

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	4	12	15
2. Identification of solids	7	1	1	6
3. Drawing of geometric figures	14	9	10	11
4. Linear measurement	13	7	8	10
5. Line relationships	14	8	12	14
6. Corners, edges and faces	21	14	15	18
Totals	85	43	58	74

INDIVIDUAL RECORD SHEET

Student 202

Sex M IQ 123 Age 10

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	6	15	14
2. Identification of solids	7	3	4	5
3. Drawing of geometric figures	14	10	13	12
4. Linear measurement	13	8	12	10
5. Line relationships	14	9	12	12
6. Corners, edges and faces	21	17	16	20
Totals	85	53	72	73

INDIVIDUAL RECORD SHEET

Student 104

Sex F IQ 123 Age 9 - 5

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	6	13	11
2. Identification of solids	7	1	6	6
3. Drawing of geometric figures	14	11	13	14
4. Linear measurement	13	8	10	12
5. Line relationships	14	8	12	13
6. Corners, edges and faces	21	17	18	17
Totals	85	51	72	73

INDIVIDUAL RECORD SHEET

Student 105

Sex F IQ 121 Age 9 - 3

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	4	12	11
2. Identification of solids	7	0	3	1
3. Drawing of geometric figures	14	9	10	6
4. Linear measurement	13	6	8	10
5. Line relationships	14	5	10	10
6. Corners, edges and faces	21	14	21	19
Totals	85	38	64	57

INDIVIDUAL RECORD SHEET

Student 203

Sex M IQ 118 Age 10

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	3	11	9
2. Identification of solids	7	1	3	6
3. Drawing of geometric figures	14	8	12	8
4. Linear measurement	13	6	10	8
5. Line relationships	14	7	10	11
6. Corners, edges and faces	21	12	17	16
Totals	85	37	63	58

INDIVIDUAL RECORD SHEET

Student 106

Sex F IQ 117 Age 9 - 10

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	3	3	4
2. Identification of solids	7	1	2	3
3. Drawing of geometric figures	14	5	10	6
4. Linear measurement	13	1	8	10
5. Line relationships	14	4	11	9
6. Corners, edges and faces	21	12	19	21
Totals	85	26	53	53

INDIVIDUAL RECORD SHEET

Student 107

Sex F IQ 116 Age 9

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	3	12	11
2. Identification of solids	7	0	4	7
3. Drawing of geometric figures	14	9	10	10
4. Linear measurement	13	6	12	11
5. Line relationships	14	5	10	12
6. Corners, edges and faces	21	16	19	19
Totals	85	39	67	70

INDIVIDUAL RECORD SHEET

Student 204

Sex M IQ 113 Age 9 - 5

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	5	12	12
2. Identification of solids	7	0	1	6
3. Drawing of geometric figures	14	3	8	4
4. Linear measurement	13	1	9	9
5. Line relationships	14	10	11	11
6. Corners, edges and faces	21	8	14	13
Totals	85	27	55	55

INDIVIDUAL RECORD SHEET

Student 108

Sex F IQ 111 Age 9 - 11

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	3	9	8
2. Identification of solids	7	0	2	1
3. Drawing of geometric figures	14	5	8	5
4. Linear measurement	13	5	9	9
5. Line relationships	14	6	10	12
6. Corners, edges and faces	21	12	18	20
Totals	85	31	56	55

INDIVIDUAL RECORD SHEET

Student 109

Sex F IQ 110 Age 9 - 3

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	2	4	6
2. Identification of solids	7	0	3	3
3. Drawing of geometric figures	14	1	6	2
4. Linear measurement	13	6	7	10
5. Line relationships	14	5	7	6
6. Corners, edges and faces	21	10	15	16
Totals	85	24	42	43

INDIVIDUAL RECORD SHEET

Student 110

Sex F IQ 109 Age 9 - 4

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	2	6	6
2. Identification of solids	7	0	1	1
3. Drawing of geometric figures	14	6	9	8
4. Linear measurement	13	5	9	11
5. Line relationships	14	5	8	11
6. Corners, edges and faces	21	14	20	16
Totals	85	32	53	53

INDIVIDUAL RECORD SHEET

Student 205

Sex M IQ 108 Age 10 - 2

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	1	7	8
2. Identification of solids	7	0	3	4
3. Drawing of geometric figures	14	7	7	6
4. Linear measurement	13	3	11	9
5. Line relationships	14	7	8	8
6. Corners, edges and faces	21	13	16	17
Totals	85	31	52	52

INDIVIDUAL RECORD SHEET

Student 111

Sex F IQ 106 Age 10 - 6

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	2	2	3
2. Identification of solids	7	1	1	1
3. Drawing of geometric figures	14	10	10	10
4. Linear measurement	13	7	8	9
5. Line relationships	14	4	6	9
6. Corners, edges and faces	21	16	15	16
Totals	85	40	42	48

INDIVIDUAL RECORD SHEET

Student 112

Sex F IQ 105 Age 9 - 11

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	3	7	7
2. Identification of solids	7	1	2	3
3. Drawing of geometric figures	14	4	4	8
4. Linear measurement	13	3	8	8
5. Line relationships	14	4	7	7
6. Corners, edges and faces	21	14	15	13
Totals	85	29	43	46

INDIVIDUAL RECORD SHEET

Student 113

Sex F IQ 103 Age 9 - 5

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	2	10	12
2. Identification of solids	7	0	2	7
3. Drawing of geometric figures	14	6	11	12
4. Linear measurement	13	0	11	12
5. Line relationships	14	2	10	10
6. Corners, edges and faces	21	19	21	21
Totals	85	29	65	74

INDIVIDUAL RECORD SHEET

Student 206

Sex M IQ 102 Age 10 - 1

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	3	9	12
2. Identification of solids	7	0	1	5
3. Drawing of geometric figures	14	9	12	12
4. Linear measurement	13	8	11	11
5. Line relationships	14	9	9	8
6. Corners, edges and faces	21	19	19	18
Totals	85	48	61	66

INDIVIDUAL RECORD SHEET

Student 207

Sex M IQ 102 Age 9 - 7

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	1	9	10
2. Identification of solids	7	0	3	1
3. Drawing of geometric figures	14	5	7	9
4. Linear measurement	13	8	11	12
5. Line relationships	14	5	8	10
6. Corners, edges and faces	21	15	21	19
Totals	85	34	59	61

INDIVIDUAL RECORD SHEET

Student 208

Sex M IQ 101 Age 9 - 9

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	1	11	7
2. Identification of solids	7	1	3	5
3. Drawing of geometric figures	14	4	5	3
4. Linear measurement	13	2	11	10
5. Line relationships	14	7	9	11
6. Corners, edges and faces	21	14	16	13
Totals	85	29	55	49

INDIVIDUAL RECORD SHEET

Student 209

Sex M IQ 99 Age 9 - 10

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	2	11	10
2. Identification of solids	7	2	5	5
3. Drawing of geometric figures	14	3	7	7
4. Linear measurement	13	4	9	11
5. Line relationships	14	6	10	8
6. Corners, edges and faces	21	14	14	17
Totals	85	31	56	58

INDIVIDUAL RECORD SHEET

Student 210

Sex M IQ 99 Age 9 - 9

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	4	12	10
2. Identification of solids	7	1	2	6
3. Drawing of geometric figures	14	7	14	13
4. Linear measurement	13	2	10	10
5. Line relationships	14	3	8	9
6. Corners, edges and faces	21	11	16	17
Totals	85	28	62	65

INDIVIDUAL RECORD SHEET

Student 211

Sex M IQ 98 Age 10 - 3

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	3	5	3
2. Identification of solids	7	1	1	2
3. Drawing of geometric figures	14	6	11	11
4. Linear measurement	13	0	10	9
5. Line relationships	14	6	8	8
6. Corners, edges and faces	21	17	15	17
Totals	85	33	50	50

INDIVIDUAL RECORD SHEET

Student 212

Sex M IQ 97 Age 9 - 4

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	2	4	5
2. Identification of solids	7	0	2	3
3. Drawing of geometric figures	14	1	5	5
4. Linear measurement	13	4	8	9
5. Line relationships	14	4	6	10
6. Corners, edges and faces	21	10	15	18
Totals	85	21	40	50

INDIVIDUAL RECORD SHEET

Student 213

Sex M IQ 96 Age 10 - 6

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	1	7	3
2. Identification of solids	7	0	2	1
3. Drawing of geometric figures	14	2	2	4
4. Linear measurement	13	2	6	6
5. Line relationships	14	4	5	5
6. Corners, edges and faces	21	12	12	15
Totals	85	21	34	34

INDIVIDUAL RECORD SHEET

Student 214

Sex M IQ 95 Age 9 - 7

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	2	5	7
2. Identification of solids	7	0	0	2
3. Drawing of geometric figures	14	4	5	5
4. Linear measurement	13	4	9	8
5. Line relationships	14	4	7	6
6. Corners, edges and faces	21	15	15	18
Totals	85	29	41	46

INDIVIDUAL RECORD SHEET

Student 114

Sex F IQ 92 Age 10 - 1

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	3	14	13
2. Identification of solids	7	1	7	7
3. Drawing of geometric figures	14	10	10	11
4. Linear measurement	13	8	12	12
5. Line relationships	14	4	9	10
6. Corners, edges and faces	21	18	21	21
Totals	85	44	73	74

INDIVIDUAL RECORD SHEET

Student 115

Sex F IQ 74 Age 10 - 4

Number of Correct Answers

Area Tested	Possible Right	First Test	Second Test	Third Test
1. Identification of figures	16	1	5	7
2. Identification of solids	7	0	1	1
3. Drawing of geometric figures	14	7	8	10
4. Linear measurement	13	4	9	8
5. Line relationships	14	4	6	6
6. Corners, edges and faces	21	15	20	18
Totals	85	31	49	50

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