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ABSTRACT

Results of a study designed to gather evidence about the effect of student's overt verbalization on performance and retention after instruction on a set of geometric concepts are reported. The independent variable, overt verbalization, was manipulated following the procedure used by Pereira (1973) which involved an experimenter questioning subjects during and after instruction. Instruction was carried out using semi-programmed materials developed by Frayer (1970) concerning terms and concepts related to geometric figures. The sample was 40 sixth-grade girls drawn randomly from 76 volunteers in three Wisconsin parochial schools. The results on both a terminal test and a retention test failed to indicate a significant main effect for either type of verbalization (during or after instruction). In retrospect, a different study with a more adequate instructional program is warranted to test the hypotheses under investigation. Appendices contain the instructional materials. (Author/MNS)

Working Paper No. 189

THE EFFECT OF OVERT VERBALIZATION ON THE LEARNING AND RETENTION OF GEOMETRY CONCEPTS

by Thomas A. Romberg

December 1977

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Report from the Project on
Studies in Mathematics

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WISCONSIN RESEARCH AND DEVELOPMENT
CENTER FOR COGNITIVE LEARNING

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ABSTRACT

This paper reports the results of a study designed to gather evidence about the effect of subjects' overt verbalization on performance and retention after instruction on a set of geometric concepts. The independent variable, overt verbalization, was manipulated in this study following the procedure used by Pereira (1973) which involved an experimenter questioning subjects during or after instruction. Instruction was carried out using semi-programmed materials developed by Frayer (1970). A post test-retention test, 2 X 2 factorial experimental design with random assignment of subjects to treatments was followed. The results on both a terminal test and a retention test failed to indicate a significant main effect for either verbalization during or after instruction. In retrospect, a different study with a more adequate instructional program is warranted to test the hypotheses under investigation.

I

INTRODUCTION

This is a report of a study conducted to gather evidence about the effect of subjects' overt verbalization on performance and retention after they have been taught a set of geometric concepts. The effect of overt verbalization on learning has long been the concern of researchers in several fields. However, their findings to date are filled with contradictions, inconsistencies, and disagreements. Often the research cannot be generalized to encompass the learning of mathematics. As a result, some mathematics educators have become proponents of verbalization, while others maintain that learning to verbalize a mathematical experience adds nothing to one's understanding of a concept or a rule, or even that it interferes with the ability to apply the concept or the rule.

Hendrix (1961), on one side of the issue, advocates that teachers delay verbalization of discovered generalizations on two grounds: (1) that there is evidence that a student does not have the linguistic capacity to state his discovery with precision and that imprecise verbalization may have undesirable effects, and (2) that there is research showing that a student who immediately attempts to state his discovery is less able to use that discovery than one who possesses a nonverbal awareness of the discovery.

On the other hand, Ausubel (1968) argues that the verbalization of a subverbal insight is an integral part of the thinking process, suggesting that leaving a discovery at a nonverbal lebel would actually abort the thinking process. He criticizes Hendrix's view that verbalizing an insight before it is used may interfere with its transfer to other situations as illogical and lacking in empirical support. He does concede, however, that attempting to verbalize a nonverbal insight before the concept or rule is clearly understood interferes with its transferability. There is clear evidence that "talking about" what one is doing is an important influence on the development of thought in the concrete operational stage (Lovell, 1971). The question is not whether verbalization is important but rather when in an instructional sequence subjects should verbalize.

This is the fourth study in a sequence of studies designed to ascertain the significance of overt verbalization to the learning of mathematics. The independent variable, overt verbalization, was manipulated in this study following the procedure used by Pereira (1973). A series of questions were posed by the experimenter to subjects both during the learning task and after the task had been completed. The subject's response to those questions was operationally defined as overt verbalization.

Treatments differed only in whether subjects were asked questions and expected to respond to the questions or not. Thus, four instructional situations in which overt verbalization could be examined were considered: (1) children were not questioned either during or after they had completed mathematical activities (see Figure 1), (2) subjects were not questioned while doing the activities and responded verbally to questions afterwards, (3) subjects responded verbally to questions both during and after they had completed activities, and (4) subjects responded verbally to questions while doing mathematical activities and then were not questioned after the activities.

		Questioned During Learning	
		No	Yes
Questioned after Learning	No	Group 1	Group 4
	Yes	Group 3	Group 2

Figure 1. The four treatment groups used in this study.

In the previous studies in this series, dramatic differences between these four treatment groups were found when students were expected to discover the rules which underlie a group structure. For terminal performance, short term retention, long term retention, and transfer performance, students performed significantly better when they were not expected to respond to questions during learning and verbally responded to questions after instruction. In fact, in each study, verbalizing during instruction appeared to interfere with learning.

These findings led to a series of questions about the generalizability of the procedure. In particular, would similar results be obtained if subjects were to learn concepts?

To examine this question, the semi-programmed instructional materials developed by Frayer (1970) to teach geometric concepts were adapted for use in this study. Also, the tests Frayer developed were used to measure terminal performance and retention.

The following statistical hypotheses were investigated in this study. The experimental design used as a posttest-only "true experimental design" with random assignment of subjects to treatments using the two treatment factors illustrated in Figure 1.

H_1: The means of subjects' performance on a terminal test are the same whether they are required to respond verbally to questions or not, after mathematical-concept learning activities.

H_2: The means of subjects' performance on a terminal test are the same whether they are required to respond verbally to questions or not during mathematical-concept learning activities.

H_3: There is no interaction effect between the means of subjects' performance on a terminal test whether they are required to respond verbally or not both during and after mathematical-concept learning activities.

H_4: The means of subjects' retention scores are the same whether they are required to respond verbally to questions or not after concept learning activities.

H_5: The means of subjects' retention scores are the same whether they are required to respond verbally to questions or not <u>during</u> mathematical-structural learning activities.

H_6: There is no interaction effect between the means of subjects' retention scores when they are required to respond verbally to questions <u>both during and after</u> mathematical-concept learning activities.

In addition to these hypotheses comparing the treatment groups on each total test, comparisons between the groups on the 11 sub-sections of each test and on the 7 concepts were planned.

II

METHOD

To investigate the above hypotheses, a two-by-two factorial experiment was carried out. The instructional period lasting approximately two hours was conducted individually with each subject on a Saturday morning in the research facilities at the Wisconsin Research and Development Center for Cognitive Learning. The terminal performance (completion) test was individually administered immediately after instruction. The retention (multiple-choice) test was given 10 days later in each school.

SUBJECTS

The subjects for this study were 40 sixth-grade girls drawn randomly from a population of 76 girls who volunteered for the study. The volunteers were from three parochial schools in Madison, Wisconsin.

Only girls were used in this study since girls had been used in a previous study (Pereira, 1973). Each girl was randomly assigned to one of the four treatment groups. All 40 girls selected were paid five dollars for their participation in the study.

INSTRUCTIONAL MATERIALS

Two lessons were adapted from a 1970 study by Frayer. In that study she developed semi-programmed lessons to study the effect of number of instances and emphasis of relevant attribute values on concept learning. She developed three basic lessons.

1. A background lesson where point, line segment, line, ray, and angle were introduced.
2. An attributes lesson where right angle, closed curve, simple curve, plane, polygon, parallel, adjacent, opposite, and equal length were described and examples given.
3. A concepts lesson where the concepts of quadrilateral kite, trapezoid, parallelogram, rectangle, rhombus, and square were introduced.

For each concept, the definition, two positive, and two negative instances were presented. Frayer achieved experimental variation by developing two similar attributes and concepts lessons (to vary the number of instances) and varied emphasis in the concepts lessons adding questions designed to direct attention to the relevant attribute values of the concept instance (e.g., "Does this figure have 4 sides?") and reviewed the relevant attribute values at the conclusion of each concept's presentation (e.g., "How many sides does a quadrilateral have?").

Since the results of her experiment indicated a significant effect for emphasis of attributes and no significance for number of instances, only the one attributes lesson and the one concepts lesson which emphasized attributes were adapted for this study. The only adaptation of these materials was to put an asterick (*)

after specific frames (copies of the lessons appear in Appendix A). This asterisk was a cue to the interviewer to pose certain questions to the subjects in Groups 2 and 4. The questions used in Lesson 1 on attributes are shown in Table 1.

TABLE 1

Questions Used with Lesson 1 on Attributes

Questions
Q1--page 5. What are the two kinds of figures dealt with in the lesson? How are they different?
Q2--page 6. What is this saying?
Q3--page 9. Is the difference between plane and solid figures clear? Can you give some examples of plane and solid figures in this room?
Q4--page 11. What property should a simple closed figure have to be called a polygon? Is there a restriction on the number of sides, size of angles?
Q5--page 14. Let student give reasons for each question in Item 20.
Q6--page 15. Put in your words what you understand about parallel, adjacent and opposite sides of a polygon.

The questions used in Lesson 2 on concepts are shown in Table 2.

TABLE 2

Questions Used with Lesson 2 on Concepts

Questions	
Q1--page 4.	What type of figures does this lesson seem to discuss? What is the distinction between the different types?
Q2--page 7.	Is it difficult to decide if a certain quadrilateral is a kite? What are the things you look for?
Q3--page 9.	If your friend asks you what is a trapezoid, what would you say?
Q4--page 12.	Can you guess why a parallelogram is given that name? What is so special about it? Is there any restriction on the size of the angles?
Q5--page 14.	What is the restriction on the rectangle that no other quadrilateral should have? Is there any property that the adjacent sides should have?
Q6--page 17	Do you think that rhombuses are difficult to understand? What makes a quadrilateral a rhombus?
Q7--page 19.	List all the properties that a square has. Could two squares have unequal angles?

The questions subjects were asked after they had finished working through the lessons were of two kinds. Interviewers first went over the answers with each subject to find where they made mistakes. They then questioned them to see if they still agreed with the answer given earlier. Finally, questions similar to those asked during instruction were asked on the items marked with an asterisk (*).

TESTS

For her study Frayer developed two similar tests, a completion test and a multiple-choice test. Both tests are comprised of items as indicated in Table 3.

TABLE 3

Content of Tests by Item Type and Concept

	Concept							
Item Type	Quadrilateral	Kite	Trapezoid	Parallelogram	Rectangle	Rhombus	Square	Total Items
1	4	1	1	1	1	1	1	10
2	4	1	1	1	1	1	1	10
3	1	1	1	1	1	1	1	7
4	1	1	1	1	1	1	1	7
5	1	1	1	1	1	1	1	7
6	1	1	1	1	1	1	1	7
7	1	1	1	1	1	1	1	7
8	1	1	1	1	1	1	1	7
9	1	1	1	1	1	1	1	7
10	1	1	1	1	1	1	1	7
11	1	1	0	1	1	1	0	5
								81

The item types conform to the 11 levels of concept mastery proposed by Frayer, Frederick, and Klausmeier (1969). Descriptions of these 11 levels appear in Table 4.

TABLE 4

Objectives Related to the Eleven Levels of Concept Learning

Objectives
1. Given the name of an attribute value, the student can select the (supply) an example of the attribute value.
2. Given an example of an attribute value, the student can select (supply) the name of the attribute value.
3. Given the name of a concept, the student can select the (supply) an example of the concept.
4. Given the name of a concept, the student can select (supply) the names of the irrelevant attributes of the concept.
5. Given the definition of a concept, the student can select (supply) the name of the concept.
6. Given the name of a concept, the student can select (supply) the correct definition of the concept.
7. Given the name of a concept, the student can select (supply) the names of the irrelevant attributes of the concept.
8. Given the definition of a concept, the student can select (supply) the name of the concept.
9. Given the name of a concept, the student can select (supply) the correct definition of the concept.
10. Given the name of a concept, the student can select (supply) the name of a concept supraordinate to it.
11. Given the name of a concept, the student can select (supply) the name of a concept subordinate to it.

The completion test consisted of questions parallel to those on the multiple-choice test but requiring production of the answers. The sequence of items in the multiple-choice and completion tests was the same. In general, the pattern was to ask one question of each item type 1-11, then repeat the cycle until the questions of each item type for all concepts were completed. The sequence of item types differed for each concept.

For this study the Frayer completion test was used to assess terminal performance and the multiple-choice test was used to assess retention. Copies of the tests are in Appendix B.

PROCEDURE

Before the day of the experiment, the time room schedule shown in Table 5 was set up. The subjects were randomly assigned to a treatment and then to a room at a specific time and informed when

TABLE 5

Treatment by Time by Room Schedule

Treatment	T_1		T_2		T_3		T_4	
Time \ Room	1	2	3	4	5	6	7	8
8:30 - 9:30								
9:30 - 10:30								
10:30 - 11:30								
1:00 - 2:00								
2:00 - 3:00								

to report. The interviewers were six advanced graduate students in mathematics education at the University of Wisconsin-Madison. They were assigned randomly to the room by time sequence except that they were not allowed to administer the same treatment in consecutive periods or more than twice during the total experiment. The investigator administered the materials to all the subjects in Group 1 to ensure there was no verbalization either during or after the lessons.

When the subjects arrived for the experiment, they were escorted to the assigned room. The rooms were small and expecially designed for laboratory experiments (they are sound proofed and environmentally controlled). Each room was equipped with a desk and two chairs. The terminal test was administered in a similarly controlled, but large experimental classroom.

The instructions given to each interviewer are presented in Appendix C. The procedure involved seating the subject, introducing oneself, exploring the purpose of the study, and describing what was expected of each participant. Then a set of descriptive data was collected and the introductory word list gone over at least twice. When Groups 2 and 4 reached an *, they were stopped and questions were asked. When they finished both parts, the subjects in Groups 2 and 3 were asked to review their work, see where they made mistakes and go over their answers. At the end of the session, they were directed to the test room where they were given the Completion test.

Ten days later (on a Tuesday), during the school day, the investigator visited two of the schools and administered the multiple-choice test. The four subjects from the third school came to the R & D Center after school the same day to take the test.

III

RESULTS

Potentially 38 non-independent scores could be obtained for each subject: The total test scores, 11 subtest scores based on item type tests, 7 concept scores for the multiple-choice test, and the same pattern of scores for the completion test.

In the initial section of this chapter, reliability estimates and item statistics are presented for both the multiple-choice completion tests. Subsequently, analyses of variance on total scores for both tests are reported. If the results of this overall analysis had warranted it, further detailed analysis of differences of treatments by item type and by concepts would have been reported.

TEST INFORMATION

The reliability estimates and item statistics reported in this section are based on data for all 40 subjects completing each test during the experiment.

TEST STATISTICS

Tests were analyzed by the FORTRAN Test Analysis Package (Baker & Martin, 1968). Separate statistics were computed for the multiple-choice and the completion test. The means, standard deviations, ranges, standard errors of measurement, and Hoyt internal consistency reliabilities (Hoyt, 1941) for the completion total test and for the multiple-choice total test are presented in Table 6. The reliability estimates (.92 and .90) for both tests are somewhat higher than those obtained by Frayer (1970) (.86 and .87). The item characteristics (difficulty, X_{50}, point biserial correlation coefficient, and β) for the correct choices for each of tests are in Appendix D.

The mean score for the tests in Table 6 (40.75 and 49.95) are slightly higher than the comparable scores obtained by Frayer (1970) (39.46 and 44.33). Three di ferences between the studies may account for this increase in mean scores. First, the question verbal response treatment used in this study; second, administration of the lessons in one continuous non-school setting; and third, differences between the populations.

ANALYSIS OF TERMINAL TEST DATA

The summary statistics (number of subjects, means, and standard deviations) for each of the four treatment groups on the completion test used to assess terminal performance are presented in Table 7.

Since the number of items in the completion test was 81, the mean performances for all the groups is not remarkable. However, the mean difference of over 10 items between Groups 4 and 1 is striking. Group 4's mean performance is more than a standard deviation above Group 1's performance.

To test the three statistical hypotheses related to terminal performance, an analysis of variance was carried out. The probability

TABLE 6

Psychometric Characteristics of the Tests

Test	Number of Items	Mean Score	Standard Deviation	Range of Scores	Standard Error of Measurement	Hoyt Reliability
Completion	81	40.75	12.95	19-80	3.59	.92
Multiple-Choice	81	49.95	11.85	30-79	3.79	.90

TABLE 7

Summary Statistis on the Terminal Test for the Four Treatment Groups

Group	Number of Subjects	Mean	S.D.
1	10	35.30	10.32
2	10	38.00	10.76
3	10	42.80	15.22
4	10	46.90	13.61

value for commiting a Type 1 error was set at .05. Table 8 summarizes that analysis.

TABLE 8

Analysis of Variance for Effect of Verbalization During and After Instruction on Scores on the Terminal Test

Source of Variation	df	MS	F	P
After (A)	1	115.60	.72	.400
During (D)	1	4.90	.03	.862
Interaction (A x D)	1	672.40	4.21	.048*
Error	36	159.74	--	--

*p < .05

H_1: The means of subjects' performance on a terminal test are the same whether they are required to respond verbally to questions or not, *after* mathematical-concept learning activities.

The row means for a main effect of verbalizing after instruction were 41.10 and 40.40 for absence and presence, respectively. This coupled with an F of .03 clearly indicates that verbalizing after instruction had no effect on terminal performance.

H_2: The means of subjects' performance on a terminal test are the same whether they are required to respond verbally to questions or not *during* mathematical concept learning activities.

The column means for a main effect of verbalizing during instruction were 39.05 (absence) and 42.45 (presence). This small difference on terminal performance, however, is not significant ($F = .72$).

H_3: There is no interaction effect between the means of subjects' performance on a terminal test whether they are required to respond verbally or not *both during and after mathematical-concept learning activities*.

The striking difference in the group means discussed when presenting the group summary statistics is reflected in the significant interaction which was found ($F = 4.21$). This interaction is portrayed in Figure 2. Clearly, verbalizing (either during [Group 4] or after [Group 3] produced mean scores higher than that for the no verbalizing group--Group 1. It is difficult to explain why

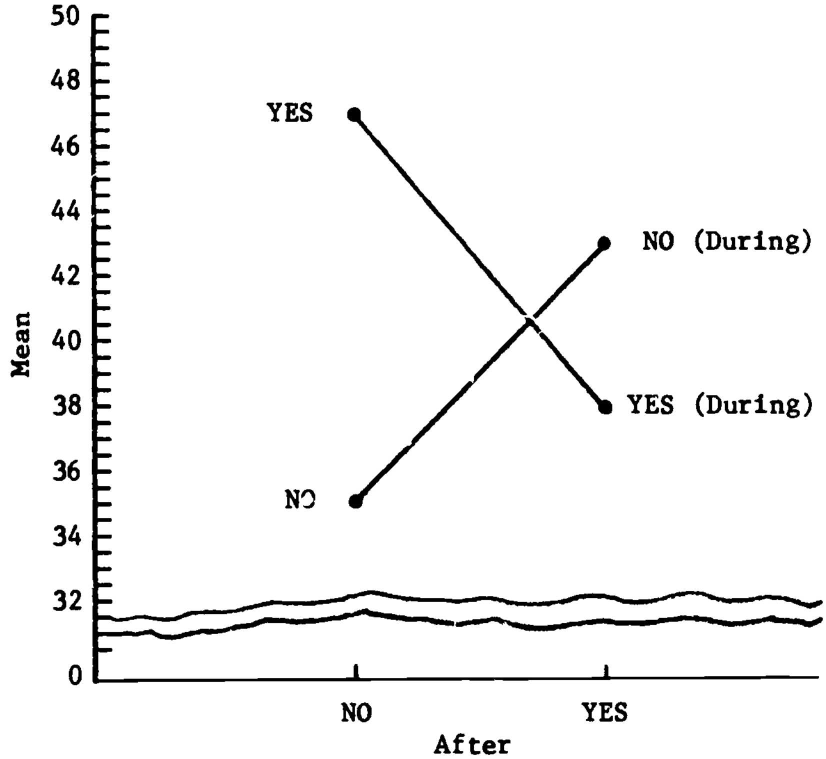

Figure 2. Terminal Test cell means for effect of verbalization during and after instruction.

verbalizing about one's answer twice--both during and after--would produce such a small effect. One can only guess that some of the repeated questioning interfered with learning.

ANALYSIS OF RETENTION TEST DATA

The summary statistics (the number of subjects, means, and standard deviations) for each of the four treatment groups on the retention test used to assess retention are presented in Table 9.

TABLE 9

Summary Statistics on the Retention Test
for the Four Treatment Groups

Group	Number of Subjects	Mean	S.D.
1	10	46.60	9.87
2	10	49.60	9.35
3	10	49.50	13.79
4	10	54.10	14.20

To test the three statistical hypotheses related to retention, another analysis of variance was performed. Table 10 summarizes that analysis.

TABLE 10

Analysis of Variance for Effect of Verbalization
During and After Instruction on the Retention Test

Source of Variation	df	MS	F	P
After (A)	1	6.40	.04	.83
During (D)	1	144.40	1.00	.32
Interaction (A x D)	1	136.90	.95	.34
Error	36	144.17	----	----

H_4: The means of subjects' retention scores are the same whether they are required to respond verbally to questions or not <u>after</u> concept learning activities.

The row means for a main effect of verbalizing after instruction were 50.35 and 49.55 for absence and presence, respectively. Clearly, verbalizing after interaction had no effect on retention.

H_5: The means of subjects' retention scores are the same whether they are required to respond verbally to questions or not <u>during</u> mathematical-structural learning activities.

The column means for a main effect of verbalizing during instruction were 48.05 (absence) and 51.85 (presence). The small retention difference is not significant (F = 1.00).

H_6: There is no interaction effect between the means of subjects' retention scores when they are required to respond verbally to questions <u>both during and after</u> mathematical-concept learning activities.

Unlike the terminal test group means, the interaction effect on the retention test is not significant (F = .95). The pattern of interaction, however, is similar (see Figure 3). Here verbalizing once during instruction produced a high mean, but verbalizing once after instruction was not as striking as it had been on the terminal test.

The group means for the four groups on the retention test are basically similar to the means on the terminal test. Group 4 did the best; Group 1 the poorest; and the others in between. The mean

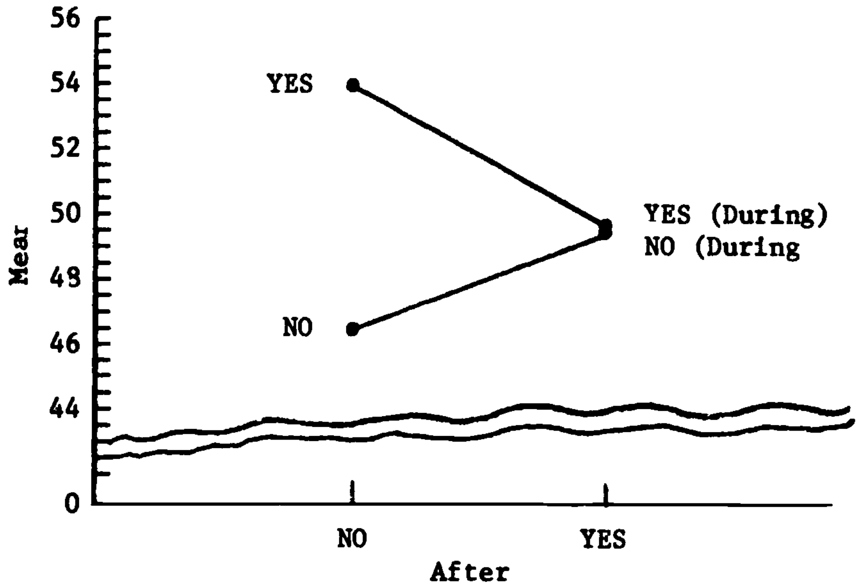

Figure 3. Retention Test cell means for effect of verbalization during and after instruction.

for Group 4 is now not quite a standard deviation above Group 1. If the retention tests had been corrected for guessing (which was not done), the absolute means for the four groups would have been nearly the same on the two tests. This suggests that what had been learned was retrained.

IV

SUMMARY

The overall results of this study fail to support the contention that overt verbalization has an important effect on the learning of concepts.

As a consequence:

1. No additional data analyses were performed.
2. There is a need to either rethink the hypotheses about verbalization and its effect on learning, or to redesign a study more adequate for investigating the hypotheses.

At this time it still seems plausible that overt verbalization has an effect on learning, although the timing of verbalization to be effective in instruction may differ for concepts, or rules, or skills.

In retrospect, a differently designed study may illuminate the effects of verbalization on concept learning. In particular, three limitations of this study could be overcome. First, since no pretest was administered and there was no "test only" group, there is no real evidence of learning. Although the concepts to be learned were supposedly unfamiliar to the subjects, one cannot assume that any significant learning took place. Second, seven concepts at eleven levels is undoubtedly too many to assimilate in a short time. Finally, learning geometric concepts from programmed learning materials, while nice for experimental reasons, cannot be considered ideal instruction and was certainly unfamiliar to the subjects. Small group activities with physical objects probably would have been more effective.

In conclusion, it is my belief that this study proved to be inadequate to test the question under investigation.

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APPENDIX A

Lesson I: Geometry
(on attributes)

and

Lesson II: Geometry
(on Concepts)

LESSON I: GEOMETRY

Name______________________________________

School______________________________________

Grade_______Date___________________________

Starting Time______________________________

Finishing Time_____________________________

Lesson I

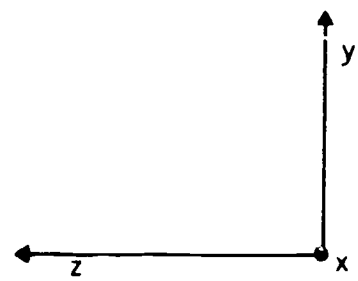
WORD LIST

Here is a list of words that are used in this lesson. Some of the words may be new for you.

Look carefully at each word as I read it to you. Then say the word aloud with me when I repeat it.

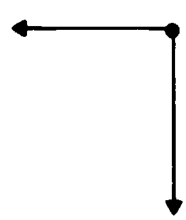
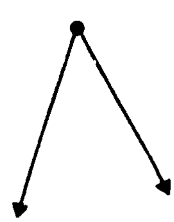
1. angle
2. curve
3. figure
4. polygon
5. line
6. line segment
7. intersect
8. parallel
9. adjacent
10. opposite

1. Look at the angle made by rays XY and XZ in the figure below.

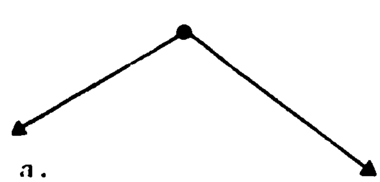
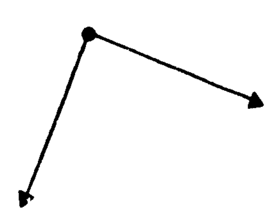


This is a picture of a special kind of angle called a <u>right angle</u>. This kind of angle may also be called a "square corner."

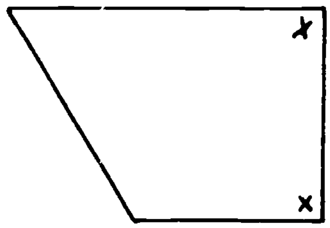
Now look at the angles drawn below. Which one looks like a right angle?__________ a

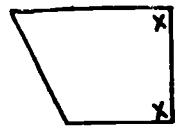
a.  b. 

Now look at the drawings below. Which one looks like a right angle?__________ b

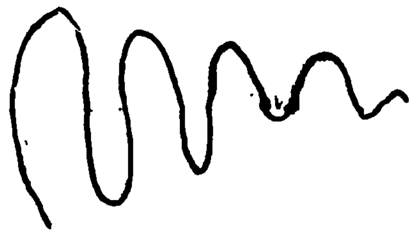
a.  b. 

Put an X by the right angles in the figure below.





2. Using your pencil, trace the drawing shown below.



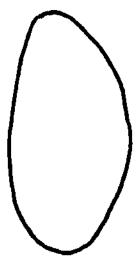
Did you come back to where you started?__________ No

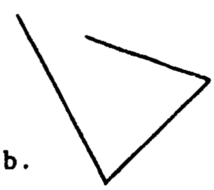
Does the drawing have endpoints?__________ Yes

3. A curve which has endpoints is called an <u>open</u> curve.

Which of the drawings below shows an

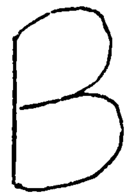
open curve?__________ b

a. 

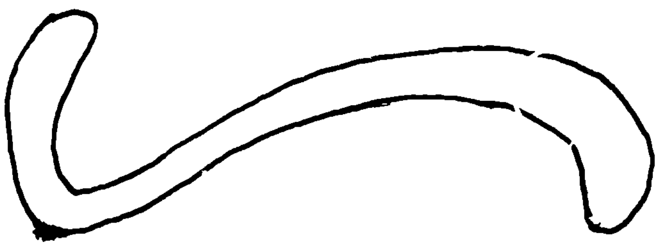
b. 

Which of these drawings is an open curve?__________ a

a. 

b. 

4. Now trace the next drawing with your pencil.

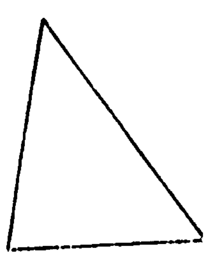


Did you come back to where you started?__________ Yes

Does the drawing have endpoints?__________ No

5. A figure that is drawn by returning to the starting place has no endpoints and is called a <u>closed</u> curve.

Which of the following figures has no endpoints and so could be called a closed curve?__________ a

a. 

b. 

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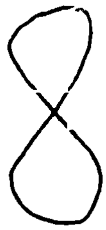
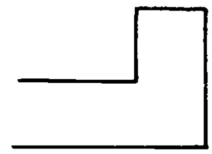
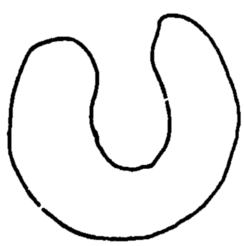
Which of these figures is a closed curve? ________ a

a.  b. 

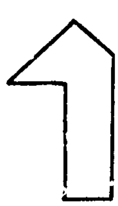
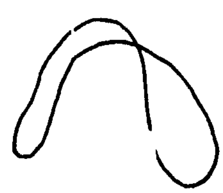
6. A closed curve which can be drawn without crossing itself at any point is called a simple closed curve. Look at the drawing below:



Does the drawing cross itself when you draw it? ________ No

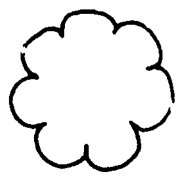
Is it a simple closed curve? ________ Yes

7. Now look at the next drawings.

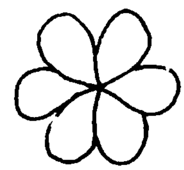
a.  b. 

Which is a simple closed curve? ________ a

Which of the figures below is a simple closed curve?____________ a



a.



b.

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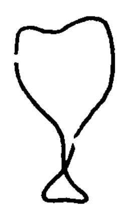
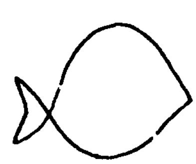
8. The drawing shown below crosses itself at one point. It is <u>not</u> a simple closed curve. We will call this kind of curve a <u>non-simple</u> closed curve.



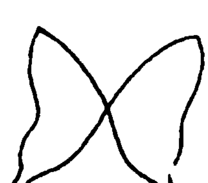
Which of the drawings below is a non-simple closed curve?____________ b

a.

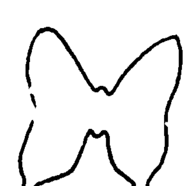


b.

Which of the drawings below is a non-simple closed curve?____________ a



a.



b.

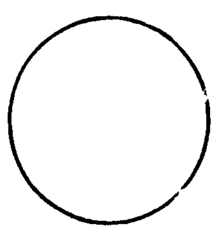
9. Think of the top of a table. Now imagine that the table is beginning to grow longer and longer, and wider and wider, getting bigger without end. A flat surface like this that goes in all directions without end is called a plane.

The top of your desk is flat and is something like a plane. Is your desk like a whole plane or only part of a plane? ________

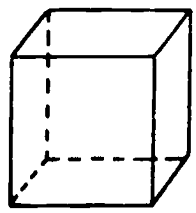
only part

(because the desk has edges and doesn't go in all directions without end)

10. Figures which are made up of points all in the same plane are called plane figures. Look at the figure drawn below. All of its points are in one plane, so it is called a plane figure.



Now look at the next picture. It is a picture of a block. Some of the points which make up the block are in different planes. Since its points are not in one plane, the block is not a plane figure. We call figures like this that have points in different planes solid figures. The dotted lines show the parts of the figure that we can't see.



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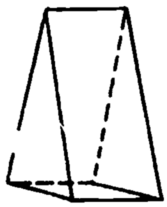
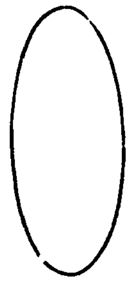
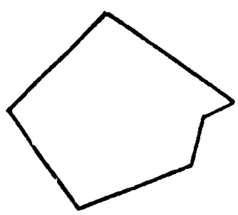
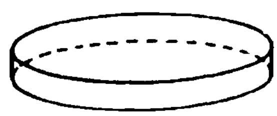
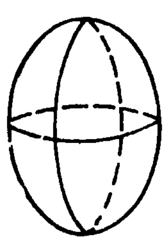
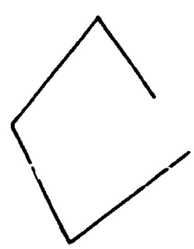
Which of the following figures represents a plane figure?__________ b

a.  b. 

Which of the following figures represents a plane figure?__________ a

a.  b. 

Which of the following drawings represents a solid figure?__________ a

a.  b. 

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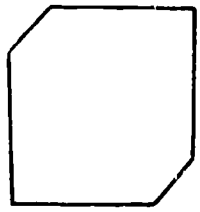
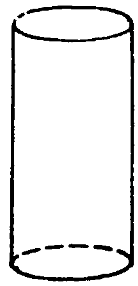
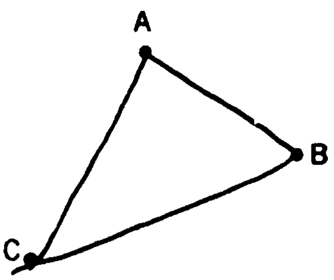
Which of the following drawings represents

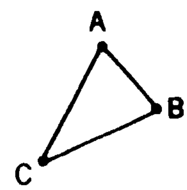
a solid figure? b

a. 

b. 

11. Connect the points below with line segments $\overline{AB}$, $\overline{BC}$ and $\overline{CA}$.

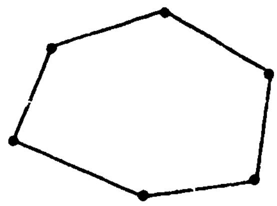




Is your figure a simple closed curve? ______ Yes

Is your figure a plane figure? ______ Yes

12. We give a special name to a plane simple closed curve which is made by joining line segments. We call it a <u>polygon</u>. Look at the figure below.



Is it a simple closed curve?________ Yes

Is it a drawing of a plane figure?________ Yes

Is it made of line segments?________ Yes

Is it a polygon?________ Yes

13. Now look at this figure.

Is it a drawing of a plane figure?________ Yes

Is it made up of line segments?________ Yes

Is it a simple closed curve?________ No

Is it a polygon?________ No

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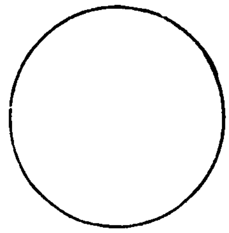
14. Now look at the drawing below.



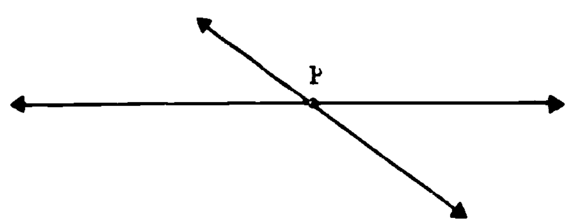
Is it a drawing of a plane figure?________ Yes

Is it a simple closed curve?________ Yes

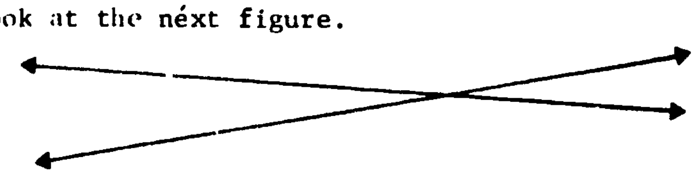
Is it made up of line segments?________ No

Is it a polygon?________ No

15. Two lines are drawn below. The two lines go through the same point P. We call P a common point of the lines. When two lines have a common point, we say the lines <u>intersect</u>.



Now look at the next figure.



Do the lines have a common point?________ Yes

Do the lines intersect?________ Yes

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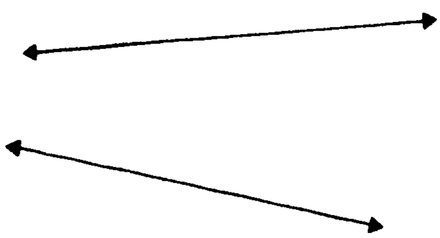
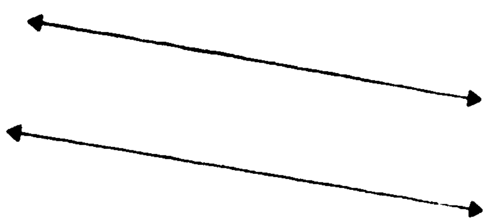
Remember that the picture of a line shows only <u>part</u> of a line. Do the lines shown below intersect even though the picture doesn't show a common point? ______________



Yes

16. When two lines in the same plane do <u>not</u> intersect, we say that the lines are parallel.

Look at the following figure.



Do the lines intersect? ______________

Are the lines parallel? ______________

No

Yes

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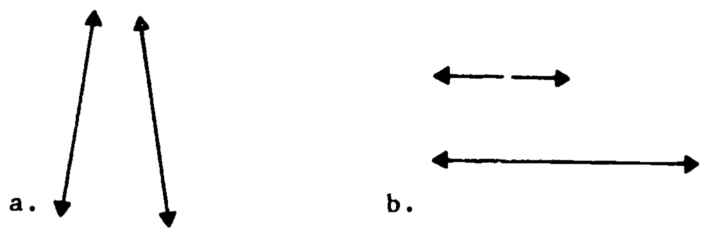
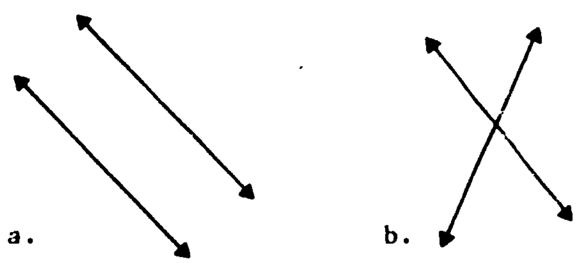
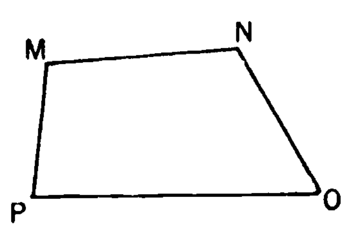
Which of the pairs of lines below seem to be parallel?______________ b



Which of the following pairs of lines seem to be parallel?______________ a



17. Now look at the next drawing.

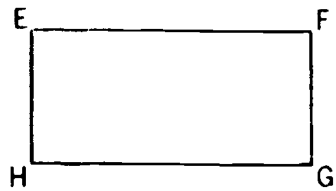


Is $\overline{MN}$ parallel to $\overline{PO}$?______________ No

Is $\overline{MP}$ parallel to $\overline{NO}$?______________ No

How many pairs of parallel sides does this figure have?______________ 0 pair

18. Look at this figure.



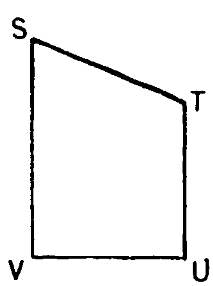
Is $\overline{EF}$ parallel to $\overline{HG}$? ____________ Yes

Is $\overline{EH}$ parallel to $\overline{FG}$? ____________ Yes

How many pairs of parallel sides does this figure have? ____________ 2 pairs

---

19. Now look at this figure.

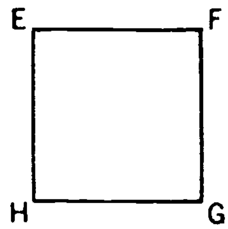


Is $\overline{ST}$ parallel to $\overline{VU}$? ____________ No

Is $\overline{SV}$ parallel to $\overline{TU}$? ____________ Yes

How many pairs of parallel sides does this figure have? ____________ 1 p.

20. In a polygon, line segments which have the same endpoint are called <u>adjacent</u> sides. Look at the polygon shown below.



Do $\overline{FE}$ and $\overline{FG}$ have the same endpoint?________ Yes

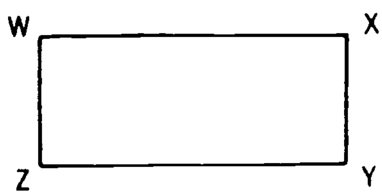
Are $\overline{FE}$ and $\overline{FG}$ adjacent sides?________ Yes

Do $\overline{EH}$ and $\overline{FG}$ have the same endpoint?________ No

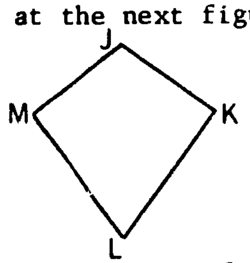
Are $\overline{EH}$ and $\overline{FG}$ adjacent sides?________ No

---

21. Look at the polygon shown below. $\overline{WX}$ and $\overline{ZY}$ are <u>opposite</u> sides. $\overline{WZ}$ and $\overline{XY}$ are <u>opposite</u> sides.



Now look at the next figure.



What side is opposite from side $\overline{JK}$?________ $\overline{ML}$ (or $\overline{LM}$)

What side is opposite from side $\overline{KL}$?________ $\overline{JM}$ (or $\overline{MJ}$)

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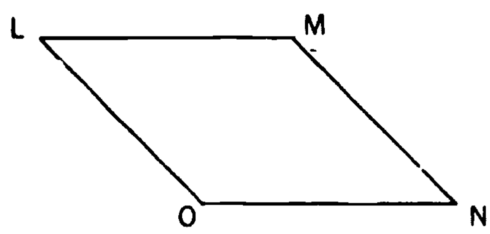
22. Look at the next figure.



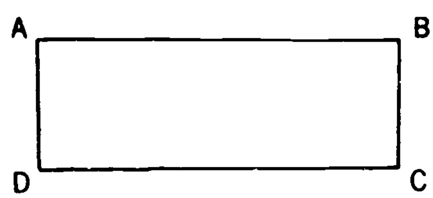
Are $\overline{LM}$ and $\overline{MN}$ adjacent sides or opposite sides?________ | adjacent

Are $\overline{LM}$ and $\overline{ON}$ adjacent sides or opposite sides?________ | opposite

Are $\overline{LO}$ and $\overline{MN}$ adjacent sides or opposite sides?________ | opposite

---

23. Now look at the next figure.



Does $\overline{AB}$ seem to be the same length as $\overline{CD}$?________ | Yes

Does $\overline{AB}$ seem to be the same length as $\overline{AD}$?________ | No

---

Remember to write the time you finish on the front cover.

Lesson II: Geometry

Name________________________________

School______________________________

Grade_______Date____________________

Starting Time_______________________

Finishing Time______________________

Lesson II

WORD LIST

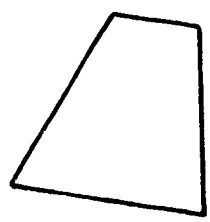
The following is a list of words that are used in this lesson. You probably already know some of them. Lets us be sure you know how to pronounce each one. I will read each word for you twice. Join me in saying each word the second time.

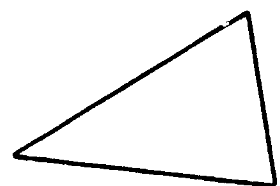
1. triangle
2. pentagon
3. hexagon
4. quadrilateral
5. kite
6. trapezoid
7. parallelogram
8. rectangle
9. square
10. rhombus

1. Remember that a polygon is a plane simple closed curve which is made by joining line segments. There are special names given to polygons depending on how many line segments are joined to make them.

   One special kind of polygon is a triangle. A triangle has 3 sides.

   Which of the following figures is a triangle?__________ b

a. 

b. 

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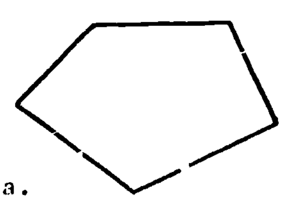
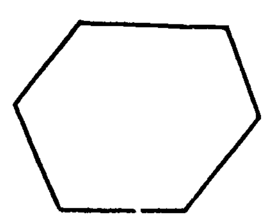
2. Another special kind of polygon is a pentagon. A pentagon has 5 sides.

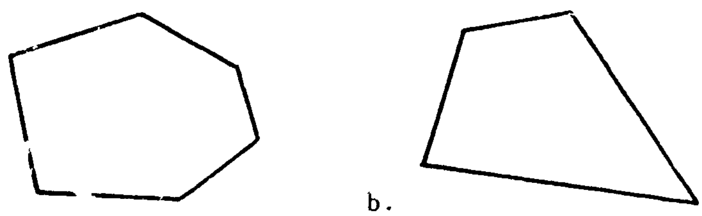
   Which figure is a pentagon?__________ a

a. 

b. 

3. Still another special kind of polygon is a <u>hexagon</u>.
A hexagon has 6 sides.

Which figure is a hexagon?_____ ________ a



a. b.

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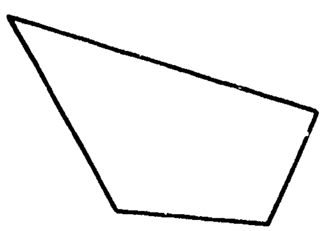
4. Any polygon made up of 4 line segments is called a quadrilateral. Look at the drawing below.

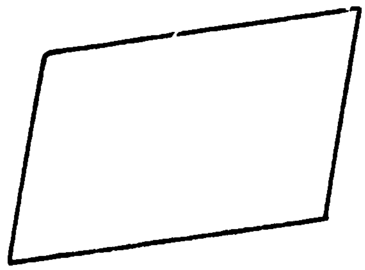


Does the figure have 4 sides?___________ Yes

Is the figure a quadrilateral?__________ Yes

53

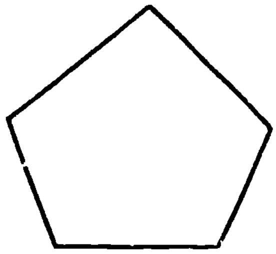
5. Look at the next drawing.



Does the figure have 4 sides?________________ Yes

Is the figure a quadrilateral?________________ Yes

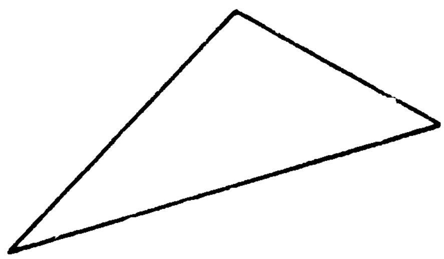
6. Here's another figure.



Does the figure have 4 sides?________________ No

Is the figure a quadrilateral?________________ No

7. Look at the next drawing.



Does the figure have 4 sides?____________ No

Is the figure a quadrilateral?____________ No

8. Now let's see if you can remember the things that are true of all quadrilaterals.

Are quadrilaterals open or closed curves?____________ closed

Are quadrilaterals plane or solid figures?____________ plane

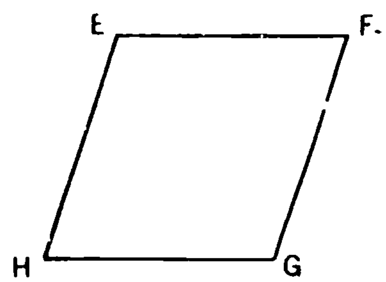
Are quadrilaterals simple or non-simple curves?____________ simple

Are the sides of quadrilaterals line segments?____________ yes

How many sides does a quadrilateral have?____________ 4

*

9. In the rest of this lesson you will be studying about special kinds of quadrilaterals. One special kind of quadrilateral is called a <u>kite</u>. A kite is any quadrilateral that has at least 2 pairs of adjacent sides of equal length. Look at the drawing below.



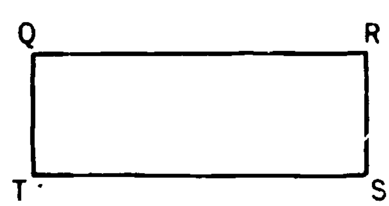
$\overline{EH}$ and $\overline{EF}$ are adjacent sides. Are they equal in length?__________ Yes

$\overline{GH}$ and $\overline{GF}$ are adjacent sides. Are they equal in length?__________ Yes

Is the figure a kite?__________ Yes

---

10. Now look at the next figure.



Are $\overline{QT}$ and $\overline{QR}$ equal in length?__________ no

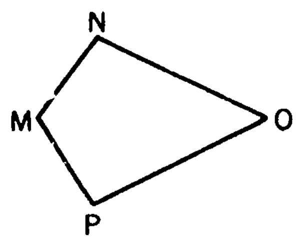
Are $\overline{ST}$ and $\overline{SR}$ equal in length?__________

Are $\overline{RQ}$ and $\overline{RS}$ equal in length?__________ no

Are $\overline{TQ}$ and $\overline{TS}$ equal in length?__________ no

Is the figure a kite?__________ no

11. Here's another figure.

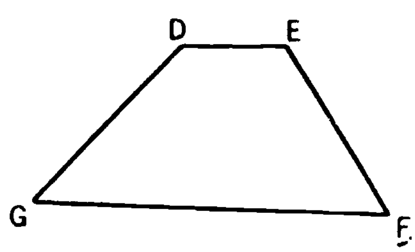


Are $\overline{MP}$ and $\overline{MN}$ equal in length?__________ Yes

Are $\overline{OP}$ and $\overline{ON}$ equal in length?__________ Yes

Is the figure a kite?__________ Yes

12. Look at the next drawing.



Are $\overline{DE}$ and $\overline{DG}$ equal in lengtn?__________ No

Are $\overline{ED}$ and $\overline{EF}$ equal in length?__________ No

Are $\overline{FE}$ and $\overline{FG}$ equal in length?__________ No

Are $\overline{GF}$ and $\overline{GD}$ equal in length?__________ No

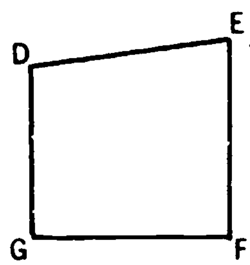
Is the figure a kite?__________ No

13. Can you remember the things that are true of all kites?

How many sides does a kite have?________	4
Are kites plane or solid figures?________	plane
Are kites open or closed curves?________	closed
Are kites simple or non-simple curves?________	simple
How many pairs of adjacent sides of equal length does a kite have?________	at least 2

*

14. Another special kind of quadrilateral is called a <u>trapezoid</u>. Any quadrilateral which has only 1 pair of sides parallel is called a trapezoid. Look at the next figure.



Are sides $\overline{DE}$ and $\overline{GF}$ parallel?________	No
Are sides $\overline{DG}$ and $\overline{EF}$ parallel?________	Yes
Does the figure have only 1 pair of parallel sides?________	Yes
Is the figure a trapezoid?________	Yes

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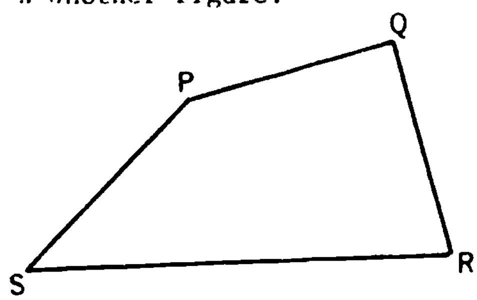
17. Here's another figure.



Are sides $\overline{PQ}$ and $\overline{RS}$ parallel?________________ No

Are sides $\overline{PS}$ and $\overline{QR}$ parallel?________________ No

Does the figure have only 1 pair of

parallel sides?______________ No

Is the figure a trapezoid?__________ No

---

18. Now let's see if you can remember what things are true about all trapezoids.

How many sides does a trapezoid have?__________

Are trapezoids plane or solid figures?______________ plane

Are trapezoids open or closed curves?______________ closed

Are trapezoids simple or non-simple curves?________

______________________ simple

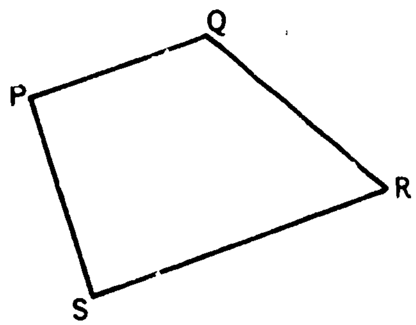
How many pairs of parallel sides do trapezoids

have?______________ only 1 p..

*

59

15. Now look at the drawing below.



Are sides $\overline{PQ}$ and $\overline{SR}$ parallel?__________ Yes

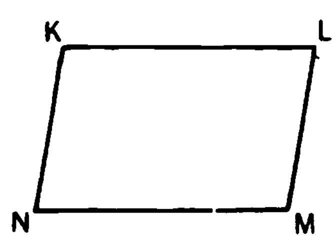
Are sides $\overline{PS}$ and $\overline{QR}$ parallel?__________ No

Does the figure have only 1 pair of

parallel sides?__________ Yes

Is the figure a trapezoid?__________ Yes

16. Look at the figure below.



Are sides $\overline{KL}$ and $\overline{NM}$ parallel?__________ Yes

Are sides $\overline{KN}$ and $\overline{LM}$ parallel?__________ Yes

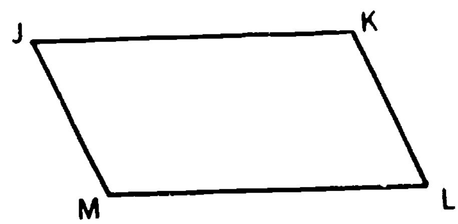
Does the figure have only 1 pair of

parallel sides?__________ No

Is the figure a trapezoid?__________ No

60

19. Still another special kind of quadrilateral is called a parallelogram. A quadrilateral which has 2 pairs of parallel sides is called a parallelogram. Look at the the drawing below.



Are sides $\overline{JK}$ and $\overline{ML}$ parallel?__________ Yes

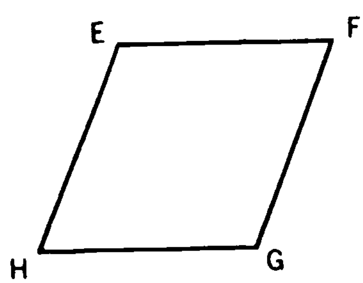
Are sides $\overline{JM}$ and $\overline{KL}$ parallel?__________ Yes

Does the figure have 2 pairs of parallel sides?__________ Yes

Is the figure a parallelogram?__________ Yes

---

20. Now look at the next drawing.



Are sides $\overline{EF}$ and $\overline{HG}$ parallel?__________ Yes

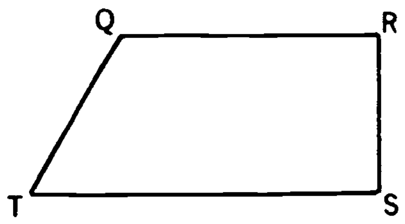
Are sides $\overline{EH}$ and $\overline{FG}$ parallel?__________ Yes

Does the figure have 2 pairs of parallel sides?__________ Yes

Is the figure a parallelogram?__________ Yes

61

21. Here's another drawing.



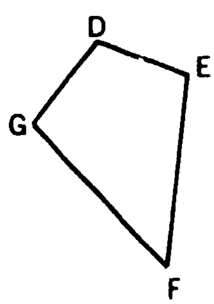
Are sides $\overline{QR}$ and $\overline{TS}$ parallel?________ Yes

Are sides $\overline{QT}$ and $\overline{RS}$ parallel?________ No

Does the figure have 2 pairs of parallel sides?________ No

Is the figure a parallelogram?____________ No

22. Look at the next figure.



Are sides $\overline{DE}$ and $\overline{FG}$ parallel?____________ No

Are sides $\overline{DG}$ and $\overline{EF}$ parallel?____________ No

Does the figure have 2 pairs of parallel sides?________ No

Is the figure a parallelogram?____________ No

23. Some things are true of all parallelograms.

How many pairs of parallel sides does a parallelogram have? ________ 2 pairs

Are parallelograms plane or solid figures? ________ plane

How many sides does a parallelogram have? ________ 4

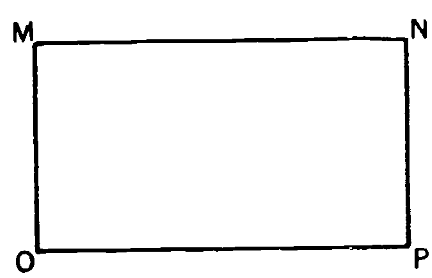
Are parallelograms open or closed curves? ________ closed

Are parallelograms simple or non-simple curves? ________ simple

*

---

24. There are still other kinds of quadrilaterals. Any quadrilateral which has 2 pairs of parallel sides and 4 right angles is called a <u>rectangle</u>. Look at the drawing below.



Does the figure have 4 right angles? ________ Yes

Is $\overline{MN}$ parallel to $\overline{OP}$? ________ Yes

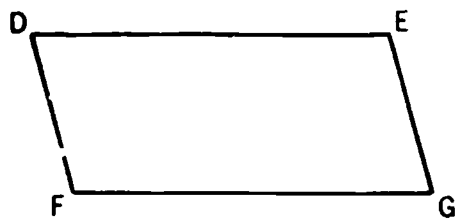
Is $\overline{MO}$ parallel to $\overline{NP}$? ________ Yes

Does the figure have 2 pairs of parallel sides? ________ Yes

Is the figure a rectangle? ________ Yes

63

25. Now let's see if the next figure is a rectangle.



Is $\overline{DE}$ parallel to $\overline{FG}$?__________ Yes

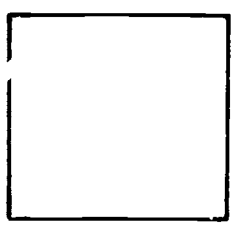
Is $\overline{DF}$ parallel to $\overline{EG}$?__________ Yes

Does the figure have 4 right angles?__________ No

Is the figure a rectangle?__________ No

---

26. Look at the next drawing.



Does the figure have 2 pairs of

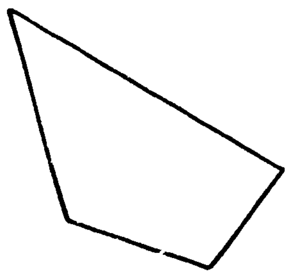
parallel sides?__________ Yes

Does the figure have 4 right angles?__________ Yes

Is the figure a rectangle?__________ Yes

64

27. Now let's see if the next figure is a rectangle.



Does the figure have 2 pairs of parallel sides?______ No

Does the figure have right angles?______ No

Is the figure a rectangle?______ No

28. Can you remember the things that are true of all rectangles?

How many sides does a rectangle have?______ 4

Are rectangles plane or solid figures?______ plane

Are rectangles open or closed curves?______ closed

Are rectangles simple or non-simple curves?______ simple

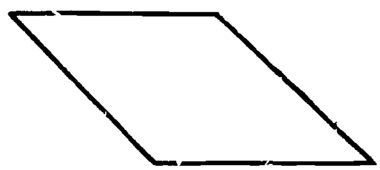
How many pairs of parallel sides do rectangles have?______ 2

How many right angles do rectangles have?______ 4

*

65

29. Another special kind of quadrilateral is called a rhombus. Any quadrilateral which has all sides of equal length is called a rhombus. Look at the next figure.

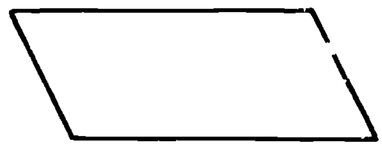


Are all the sides equal in length?__________ Yes

Is the figure a rhombus?__________ Yes

---

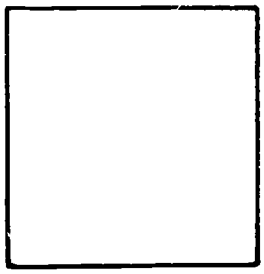
30. Now look at the drawing below.



Are all the sides of equal length?__________ No

Is the figure a rhombus?__________ No

31. Here's another figure.

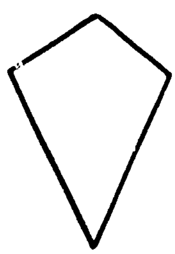


Are all the sides of equal length?____________ Yes

Is the figure a rhombus?____________ Yes

---

32. Now look at the next figure.



Are all the sides of equal length?____________ No

Is the figure a rhombus?____________ No

67

33. Now let's see if you can remember the things that are true of all rhombuses.

How many sides does a rhombus have?________ 4

Are rhombuses plane or solid figures?________ plane

Are rhombuses open or closed curves?________ closed

Are rhombuses simple or non-simple curves?________

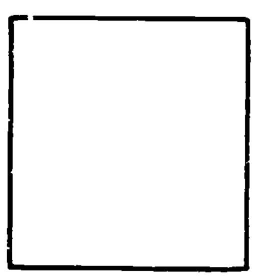
________ simple

How many sides of equal length do rhombuses

have?________ all (4)

*

34. The last special kind of quadrilateral we will study is called a square. A quadrilateral which has all sides of equal length and 4 right angles is called a square. Look at the figure below.



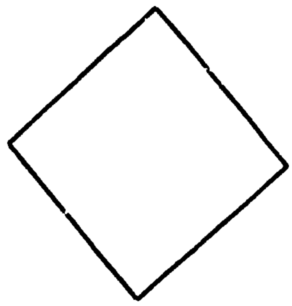
Does the figure have all sides of equal

length?________ Yes

Does the figure have 4 right angles?________ Yes

Is the figure a square?________ Yes

35. Now look at the next figure.

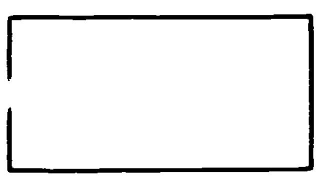


Does it have all sides of equal length?________ Yes

Does it have 4 right angles?________ Yes

Is it a square?________ Yes

36. Look at the drawing below.



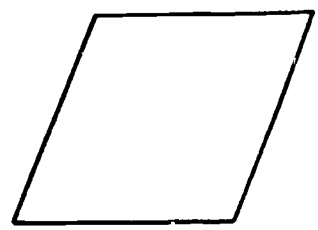
Does it have all sides of equal length?________ No

Does it have 4 right angles?________ Yes

Is it a square?________ No

69

37. Look at the next drawing.



Does the figure have 4 right angles?__________ No

Does the figure have all sides of

equal length?__________ Yes

Is it a square?__________ No

---

38. Can you remember the things that are true of all squares?

How many sides does a square have?__________ 4

Are squares plane or solid figures?__________ plane

Are squares open or closed curves?__________ closed

Are squares simple or non-simple

curves?__________ simple

How many sides are of equal length?__________ all (4)

How many right angles does a square have?__________ 4

Remember to write the time when you finish on the cover.

*

APPENDIX B

The Tests of Geometry Knowledge
(with instructions for administration)

Completion Items 1

and

The Multiple Choice Test

Name____

School______________________________________

Grade______________ Date____________________

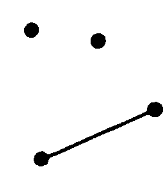
TESTS OF GEOMETRY KNOWLEDGE

Completion Items I

INSTRUCTIONS: Read each item carefully. Decide what is the best way to answer each question. For some questions, you may have to print in a number, a word, or several words in the space provided at the right side of the page. For other questions, you may have to draw some lines to finish a figure. Be as neat as possible when printing or drawing. You have a list of words that you might need so you won't have to worry about spelling.

Sample Items

1. Using a ruler, connect as many points as you need to close the figure so it has 3 sides.

1. 

---

2. This figure  is called a ____________.

2. ______________

REVISED

SOME WORDS YOU MAY NEED

Here is a list of some words you may want to use in writing your answers. You should not have to worry about correct spelling so the words are spelled for you here.

adjacent
angle
arithmetic
circle
closed
equal
figure
four
geometry
kite
length
line
line segment
none
non-simple
only
open
opposite
pair

parallel
parallalogram
pentagon
plane
point
polygon
quadrilateral
rectangle
rhombus
right
same
sides
simple
solid
square
star
straight
trapezoid
triangle

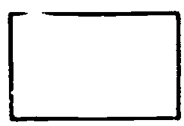
Put all answers (words or drawings) on this side of the page.

1. Draw a simple figure.

1.

---

2. What kind of angles does this figure have?

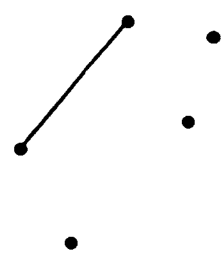


2. ______________________

---

3. Using a ruler, connect as many points as you need to finish the figure so it is a kite.

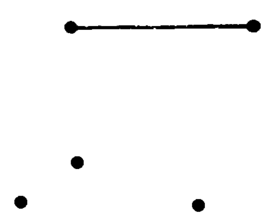
3.

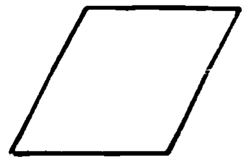


---

4. Using a ruler, connect as many points as you need to finish the figure to make a quadrilateral that is not a parallelogram.

4.



5. This quadrilateral 

could be called a kite or a parallelogram. What is another name for it? 5.__________

---

6. All squares have something special that not all rhombuses have. Squares have __________. 6.__________

---

7. What is true about the length of opposite sides of a trapezoid? 7.__________

---

8. <u>All</u> plane closed figures with 4 sides may be called __________. 8.__________

9. List all that is needed to completely describe rectangle. 9.

---

10. All kites may also be called ________. 10. ________

---

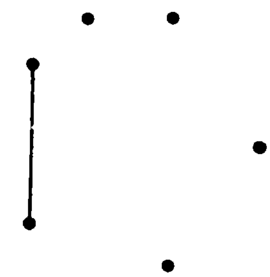
11. Give the name of one geometric figure which is a special kind of parallelogram. 11. ________

---

12. Draw a closed figure. 12.

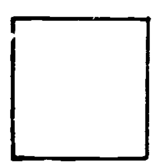
13\. Using a ruler, connect as many points as you need to close the figure so that all sides are of equal length

13\.



14\. a. The sides in this figure are all __________ in length.

b. The figure has 4 __________ angles.

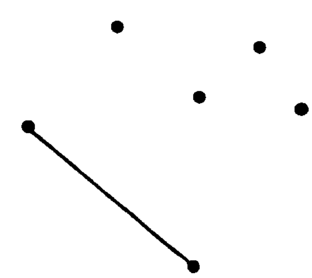


14\. a. ____________________

b. ____________________

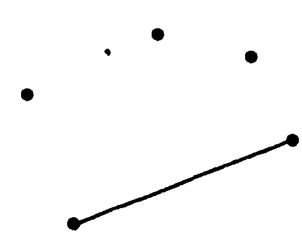
15\. Using a ruler, connect as many points as you need to finish the figure so it is a <u>trapezoid</u>.

15\.

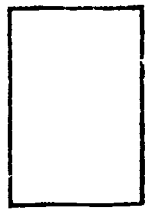


16\. Using a ruler, connect as many points as you need to close the figure so that it is <u>not</u> a quadrilateral.

16\.



17. This quadrilateral



could be called a parallelogram. What is another name for it? 17.__________________

---

18. All kites have something special that not all quadrilaterals have. Kites have __________ ________ sides of ____________ length. 18.__________________

____

---

19. What is true about the length of adjacent sides in a parallelogram? 19.__________________

---

20. No matter what kind of angles they have, <u>all</u> quadrilaterals with all sides of equal length may be called ____________________. 20.__________________

21. List all that is needed to completely describe square.

21.

---

22. All trapezoids may also be called ________.

22. ____________________

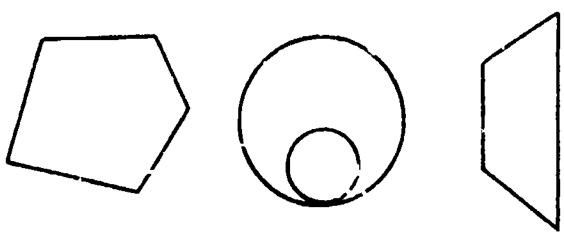
---

23. Give the name of one geometric figure which is a special kind of quadrilateral.

23. ____________________

---

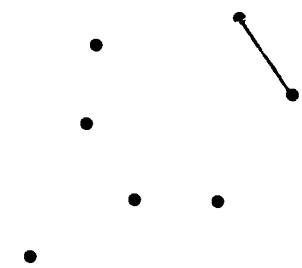
24. These plane figures are all ________.



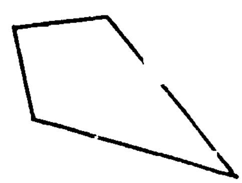
24. ____________________

25. Using a ruler, connect as many points as you need to close the figure so that it has a total of 4 right angles.

25.



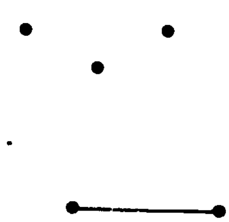
26. How many pairs of equal adjacent sides does this figure have?



26. ____________________

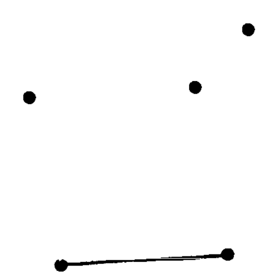
27. Using a ruler, connect as many points as you need to finish the figure so it is a parallelogram.

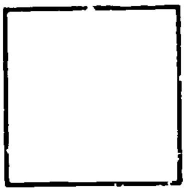
27.



28. Using a ruler, connect as many points as you need to finish the figure to make a quadrilateral that is not a rhombus.

28.



29. This quadrilateral 

could be called a parallelogram, a rhombus, or a rectangle. What is another name for it?

29.____________________

---

30. All trapezoids have something special that not all quadrilaterals have. Trapezoids have __________ pair(s) of __________ sides.

30.____________________

____________________.

---

31. What is true about the number of parallel sides in quadrilateral?

31.____________________

---

32. No matter how long the sides are, <u>all</u> parallelograms with four right angles may be called __________.

32.____________________

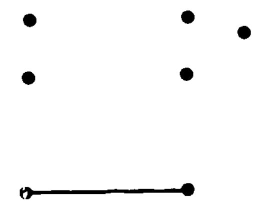
33. List all that is needed to completely describe kite. 33.

34. All parallelograms may also be called ________. 34.________

35. Give the name of one geometric figure which is a special kind of rhombus. 35.________

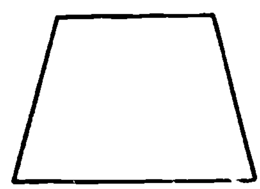
36. Draw a plane figure. 36.

37. Using a ruler, connect as many points as you need to close the figure so it has 4 sides of equal length and 4 right angles.

37. 

---

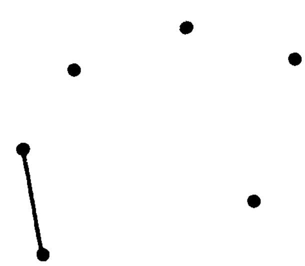
38. How many irs of parallel sides does this fi ve?



38.________________________

---

39. Using a ruler, connect as many points as you need to finish the figure so it is a <u>quadrilateral</u>.

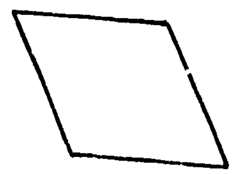
39. 

---

40. Using a ruler, connect as many points as you need to finish the figure to make a quadrilateral that is <u>not</u> a rectangle.

40. 

41. This quadrilateral



could be called a rhombus or a parallelogram. What is another name for it?

41. ____________________

---

42. All parallelograms have something special that not all quadrilaterals have. Parallelograms have ________ pair(s) of __________ sides.

42. ____________________

____

---

43. What is true about the angles in a rhombus?

43. ____________________

---

44. All rhombuses with four right angles may be called __________.

44. ____________________

45. List all that is needed to completely describe <u>trapezoid</u>. 45.

---

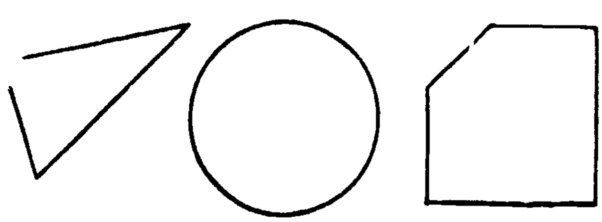
46. All quadrilaterals may also be called ________. 46.________________

---

47. Give the name of one geometric figure which is a special kind of rectangle. 47.________________

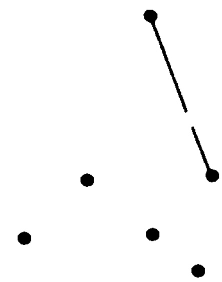
---

48. Here are 3 plane figures. In what way are they alike?

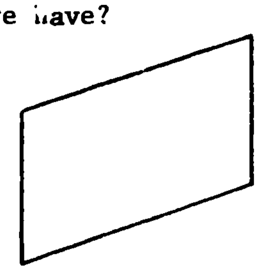


48.________________

49. Using a ruler, connect as many points as you need to close the figure so it has 2 pairs of adjacent sides of equal length.

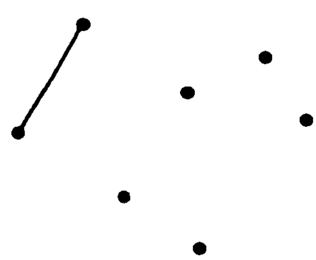
49. 

50. How many pairs of parallel sides does this figure have?

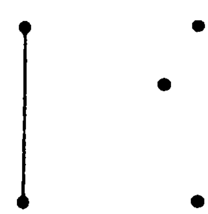


50. ______________________

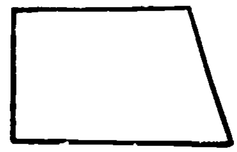
51. Using a ruler, connect as many points as you need to finish the figure so it is a <u>rhombus</u>.

51. 

52. Using a ruler, connect as many points as you need to finish the figure to make a quadrilateral that is <u>not</u> a square.

52. 

53. This figure



could be called a quadrilateral. What is another name for it?

53. ______________

---

54. How many sides do quadrilaterals have?

54. ______________

---

55. What is true about the length of adjacent sides of rectangles?

55. ______________

---

56. <u>All</u> quadrilaterals with 2 pairs of adjacent sides of equal length may be called ____________.

56. ______________

57. List all that is needed to completely describe parallelogram. 57.

---

58. All rhombuses may also be called ________ or ____________. 58.____________________

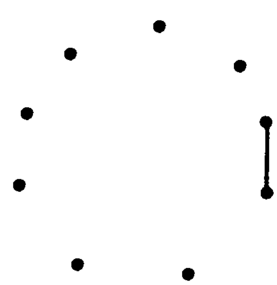
____

---

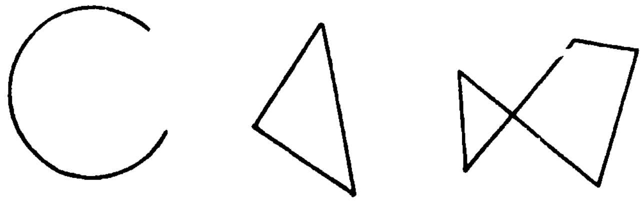
59. Using a ruler, connect as many points as needed to close the figure so it has only 1 pair of sides parallel. 59.

---

60. Using a ruler, connect as many points as needed to close the figure so it has only 4 sides. 60.



61. How are all 3 figures alike?

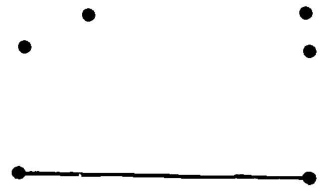


61. ______________________

---

62. Using a ruler, connect as many points as you need to finish the figure so it is a <u>rectangle</u>.

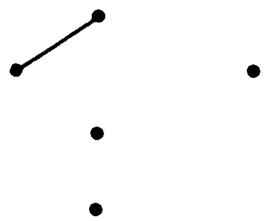
62.



---

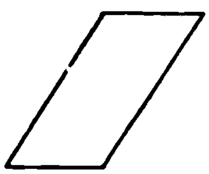
63. Using a ruler, connect as many points as you need to finish the figure to make a quadrilateral that is <u>not</u> a kite.

63.



---

64. This figure



could be called a quadrilateral. What is another name for it?

64. ______________________

65. All rhombuses have something special that not all parallelograms have. Rhombuses have __________ sides that are __________.

65.__________ __________

____

---

66. What length must a side on any square be?

66.__________

---

67. All quadrilaterals with only 1 pair of parallel sides may be called __________.

67.__________

---

68. List all that is needed to completely describe quadrilateral.

68.

69. All rectangles may also be called _________ or _________.

69. ____________________

____

---

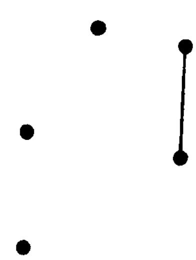
70. Give the name of one geometric figure which is a special kind of kite.

70. ____________________

---

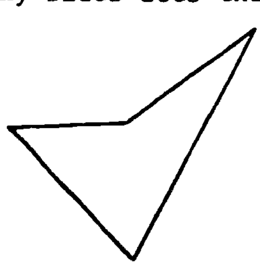
71. Using a ruler, connect as many points as needed to close the figure so it has 2 pairs of parallel sides.

71.



---

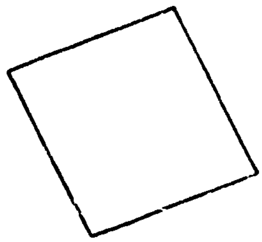
72. How many sides does this figure have?



72. ____________________

92

73. The sides in this figure are all ________ in length.

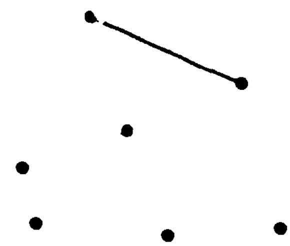


73. ________ ____________

---

74. Using a ruler, connect as many points as you need to finish the figure so it is a square.

74.



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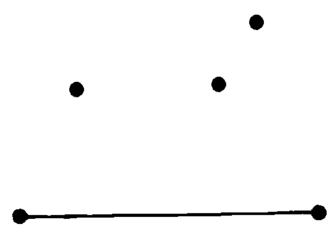
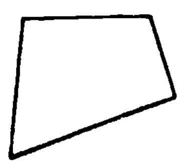
75. Using a ruler, connect as many points as you need to finish the figure to make a quadrilateral that is not a trapezoid.

75.



---

76. This polygon



could also be called a ________.

76. ______ ____________

77. All rectangles have something special that not all parallelograms have. Rectangles have 4 _______________. 77.______________

---

78. What is true about the number of parallel sides in a kite? 78.______________

---

79. No matter what kind of angles they have or how long the sides, all quadrilaterals with 2 pairs of parallel sides may be called ____________. 79.______________

---

80. List all that is needed to completely describe rhombus. 80.______________

94

81. All squares may also be called __________ or __________ or __________ or __________.

81.__________

____

____

____

Tests of Geometry Knowledge: Multiple Choice Test

Form CC

Directions for Administrators

Today you will take a test to show how much you have learned from the lessons you took last week.

Now I'm going to pass out the geometry test booklets. Do not open your booklets until I tell you what to do.

(Distribute test booklets.)

INSTRUCTIONS: Read the questions carefully.
Each question has four possible answers.
Decide which answer best fits the question.
Circle the letter next to your choice.
If you change your mind, erase the first mark completely.

Now we'll do two practice questions. Look at Example 1 in the box on your booklet cover. Read the question to yourself and decide which of the four possible answers given is the right one. (Pause.) It is answer "b." Look at the letters below the question. (Hold up a booklet and point to correct place.) To show the answer "b" is correct, the box "b" has been circled. Now do Example 2. (Pause.) You should have circled the box under "c," because the figure has 3 sides.

You will do the rest of the problems in this booklet just like you have done these practice questions. Some questions will be very easy, others will be harder. Try to answer each question, even if you're not sure you're right. Do your best to finish all the questions even if you have to guess at some. You will have as much time as you need to finish the test. Be sure to keep your answers covered as much as possible.

Name______________________________________

School____________________________________

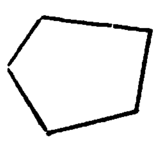
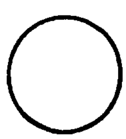
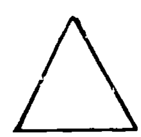
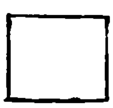
Grade____________Date_____________________

TEST OF GEOMETRY

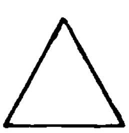
INSTRUCTIONS: Read the questions carefully.
Each question has four possible answers.
Decide which answer best fits the question.
Circle the letter next to your choice.
If you change your mind, erase the first mark completely.

EXAMPLES

1. Which of these figures is a circle?

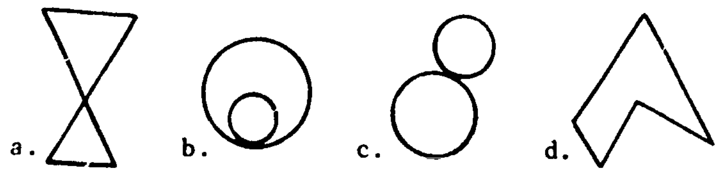
a.  (b.)  c.  d. 

2. How many sides does this figure have?

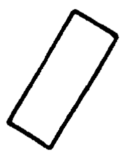


a. 1 b. 2 (c.) 3 d. 4

1. Which drawing is a <u>simple</u> figure?



2. This figure has:



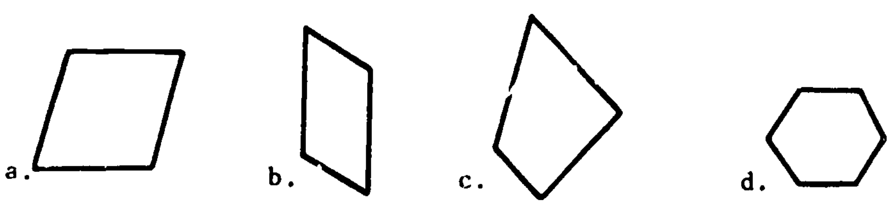
a. 4 sides of equal length

b. 2 pairs of adjacent sides of equal length

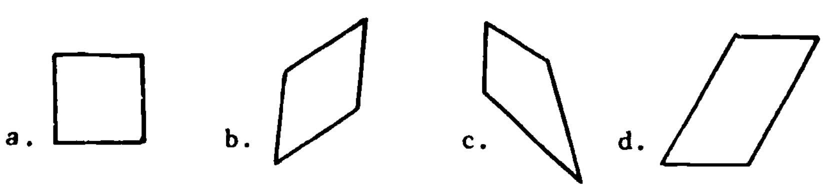
c. no sides parallel

d. 4 right angles

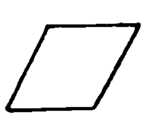
3. Which figure is a kite?



4. Which figure is <u>not</u> a parallelogram?



5. This figure is a:



a. square

b. trapezoid

c. rhombus

d. pentagon

98

6. All squares have:

a. only 2 right angles
b. only 2 sides of equal length
c. all right angles
d. each side 1 inch long

7. Not all trapezoids have:

a. closed sides
b. 4 sides
c. only 1 pair of parallel sides
d. 1 pair of sides of equal length

8. All plane closed figures with 4 sides may be called:

a. rhombuses
b. kites
c. quadrilaterals
d. squares

9. All rectangles are:

a. 4-sided figures with 4 right angles and no sides of equal length
b. 4-sided figures with opposite sides parallel and 4 right angles
c. 4-sided figures with only 1 pair of parallel sides
d. 4-sided figures with opposite sides parallel and all sides of equal length

10. All kites are also:

a. rectangles
b. parallelograms
c. trapezoids
d. quadrilaterals

11. Which is true?

a. All quadrilaterals are also parallelograms.

b. All trapezoids are also parallelograms.

c. All kites are also parallelograms.

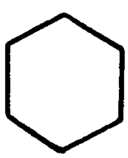
d. All rhombuses are also parallelograms.

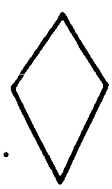
12. Which drawing is a <u>closed</u> figure?

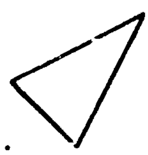
a. 

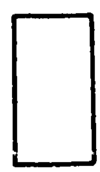
b. 

13. Which figure has all sides of equal length?

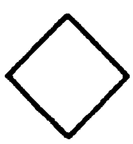
a. 

b. 

c. 

d. 

14. This figure has:



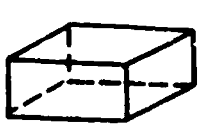
a. adjacent sides parallel and 4 right angles

b. 4 sides of equal length and 5 right angles

c. no sides of equal length and 4 right angles

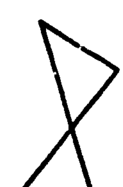
d. 4 sides of equal length and 4 right angles

15. Which figure is a trapezoid?

a. 

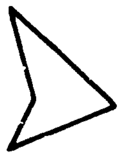
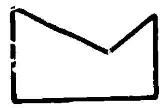
b. 

c. 

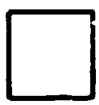
d. 

100

16. Which figure is not a quadrilateral?

a.  b.  c.  d. 

17. This figure is a:



a. rectangle
b. pentagon
c. triangle
d. hexagon

18. All kites have:

a. opposite sides parallel
b. only 1 pair of adjacent sides of equal length
c. opposite sides of equal length
d. 2 pairs of adjacent sides of equal length

19. Not all parallelograms have:

a. 4 sides
b. 2 pairs of parallel sides
c. 4 angles
d. 2 pairs of adjacent sides of equal length

20. All quadrilaterals with all sides of equal length are:

a. kites
b. rhombuses
c. triangles
d. rectangles

21. All squares are:

a. rhombuses with 4 right angles

b. parallelograms with no right angles

c. quadrilaterals with no sides of equal length

d. quadrilaterals with only 1 pair of parallel sides

22. All trapezoids are also:

a. parallelograms

b. rhombuses

c. triangles

d. quadrilaterals

23. Which is true?

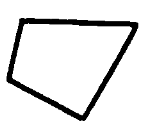
a. All pentagons may also be called quadrilaterals.

b. All kites may also be called quadrilaterals.

c. All triangles may also be called quadrilaterals.

d. All circles may also be called quadrilaterals.

24. This figure is:



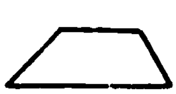
a. 4-sided

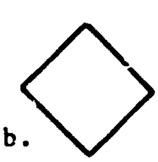
b. open

c. parallel-sided

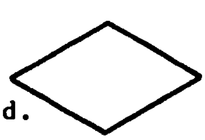
d. solid

25. Which figure has 4 right angles?

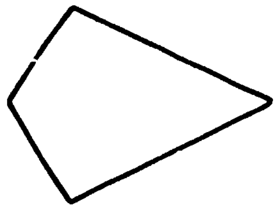
a. 

b. 

c. 

d. 

26. This figure has:



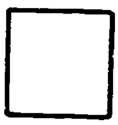
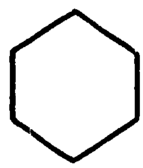
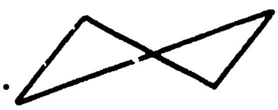
a. 2 pairs of adjacent sides of equal length

b. opposite sides of equal length

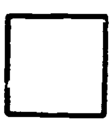
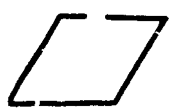
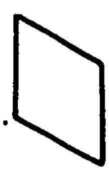
c. opposite sides parallel

d. no sides of equal length

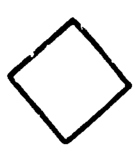
27. Which figure is a parallelogram?

a.  b.  c.  d. 

28. Which figure is not a rhombus?

a.  b.  c.  d. 

29 This figure is a:



a. triangle

b. trapezoid

c. pentagon

d. square

30. All trapezoids have:

a. 2 sides of equal length

b. 2 pairs of parallel sides

c. all sides of equal length

d. 1 pair of parallel sides

31. Not all quadrilaterals have:

a. straight sides

b. 4 angles

c. 1 pair of parallel sides

d closed sides

32. All quadrilaterals with opposite sides parallel and 4 right angles are:

a. rectangles

b. pentagons

c. squares

d. rhombuses

33. All kites are:

a. 4-sided figures with no sides of equal length

b. 4-sided figures with 1 pair of parallel sides

c. 4-sided figures with no angles equal

d. 4-sided figures with 2 pairs of adjacent sides of equal length

34. All parallelograms are also:

a. rhombuses

b. rectangles

c. quadrilaterals

d. trapezoids

35. Which is true?

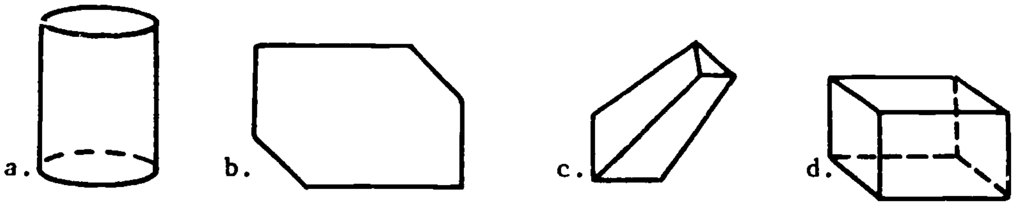
a. Every rectangle is a rhombus.

b. Every kite is a rhombus.

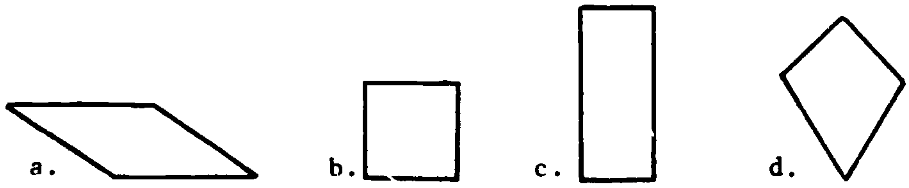
c. Every square is a rhombus.

d. Every parallelogram is a rhombus.

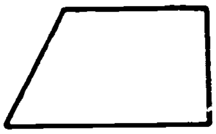
36. Which drawing represents a <u>plane</u> figure?



37. Which figure has 4 sides of equal length and 4 right angles?



38. This figure has:



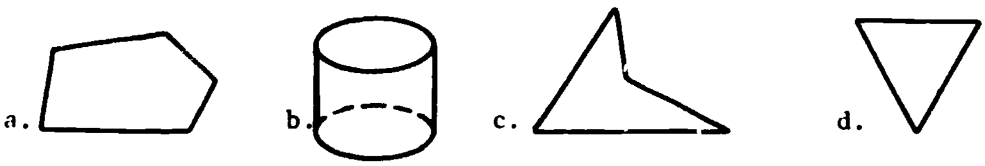
a. no parallel sides

b. all sides of equal length

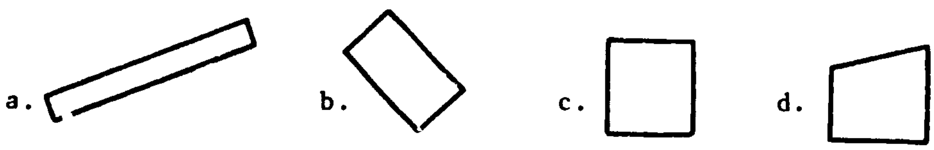
c. only 1 pair of parallel sides

d. 2 pairs of parallel sides

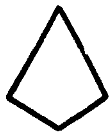
39. Which figure is a quadrilateral?



40. Which figure is <u>not</u> a rectangle?



41. This figure is a:



a. kite

b. rectangle

c. parallelogram

d. trapezoid

42. <u>All</u> parallelograms have:

a. all sides of equal length

b. no sides parallel

c. only 1 pair of parallel sides

d. 2 pairs of parallel sides

43. <u>Not</u> all rhombuses have:

a. 4 sides

b. 4 equal angles

c. all sides of equal length

d. opposite sides parallel

44. All quadrilaterals with 4 right angles and all sides of equal length are:

a. cubes

b. hexagons

c. squares

d. pentagons

45. All trapezoids are:

a. plane open figures with 4 sides

b. plane closed 4-sided figures with opposite sides of equal length

c. plane closed 4-sided figures with only 1 pair of parallel sides

d. plane closed 4-sided figures with 2 pairs of parallel sides

46. All quadrilaterals may also be called:

a. rhombuses

b. kites

c. trapezoids

d. polygons

47. Which is true?

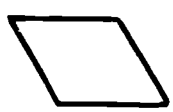
a. All rhombuses are also rectangles.

b. All squares are also rectangles.

c. All trapezoids are also rectangles.

d. All kites are also rectangles.

48. This figure is:



a. non-simple

b. solid

c. simple

d. open

49. Which figure has 2 pairs of adjacent sides of equal length?

50. This figure has:

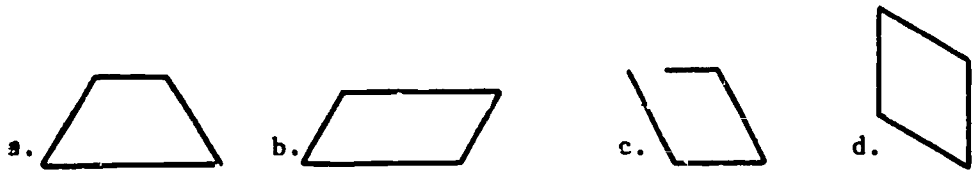
a. all sides of equal length

b. 2 pairs of parallel sides

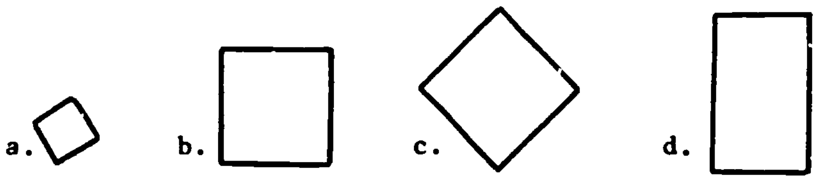
c. 2 pairs of adjacent sides of equal length

d. only 1 pair of parallel sides

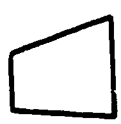
51. Which figure is a rhombus?



52. Which figure is <u>not</u> a square?



53. This figure is a:



a. kite
b. trapezoid
c. rhombus
d. parallelogram

54. <u>All</u> quadrilaterals have:

a. no sides of equal length
b. no sides parallel
c. closed sides
d. 2 sides of equal length

55. <u>Not</u> all rectangles have:

a. 2 pairs of parallel sides
b. 4 right angles
c. 4 sides of equal length
d. opposite sides of equal length

56 All quadrilaterals with 2 pairs of adjacent sides of equal length are:

a. kites

b. parallelograms

c. trapezoids

d. squares

57. All parallelograms are:

a. quadrilaterals with all sides of equal length

b. quadrilaterals with 2 pairs of opposite sides of equal length

c. quadrilaterals with 2 pairs of adjacent sides of equal length

d. quadrilaterals with only 1 pair of parallel sides

58. All rhombuses may also be called:

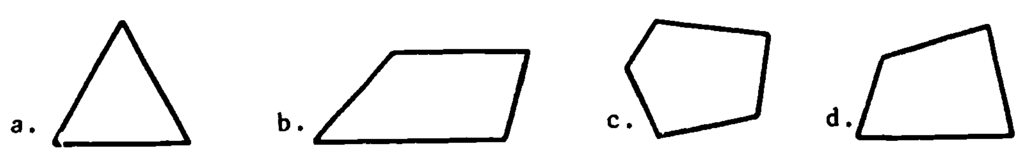
a. trapezoids

b. hexagons

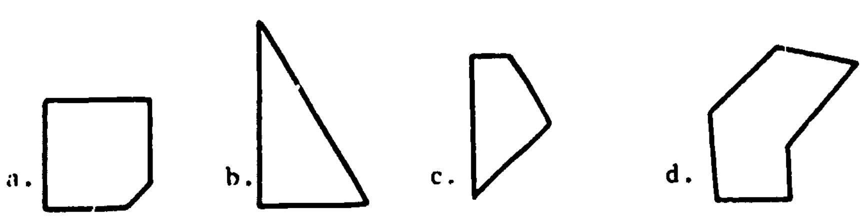
c. parallelograms

d. rectangles

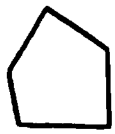
59. Which figure has only 1 pair of parallel sides?



60. Which drawing has 4 sides?

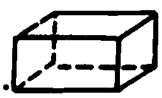
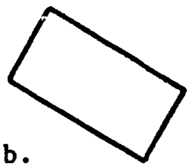
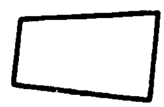


61. This figure is:

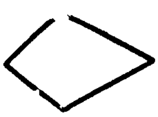
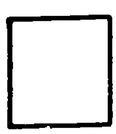
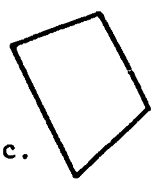
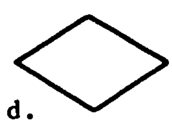


a. 4-sided
b. solid
c. plane
d. open

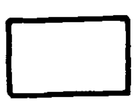
62. Which figure is a rectangle?

a. 
b. 
c. 
d. 

63. Which figure is <u>not</u> a kite?

a. 
b. 
c. 
d. 

64. This figure is a:



a. rhombus
b. parallelogram
c. square
d. kite

65. <u>All</u> rhombuses have:

a. 4 right angles
b. only 1 pair of parallel sides
c. no parallel sides
d. all sides of equal length

66. Not all squares have:
   a. all sides of equal length
   b. opposite sides of equal length
   c. 4 right angles
   d. 5 sides

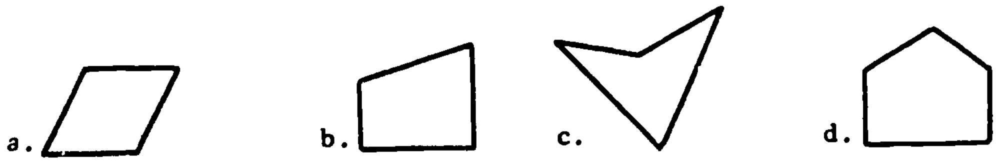
67. All quadrilaterals with only 1 pair of parallel sides are:
   a. parallelograms
   b. squares
   c. trapezoids
   d. rhombuses

68. All quadrilaterals are:
   a. plane closed figures with opposite angles equal
   b. plane closed figures with 5 sides
   c. 4-sided closed plane figures with 4 right angles
   d. 4-sided closed plane figures

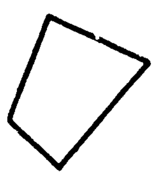
69. Every rectangle is a:
   a. parallelogram
   b. kite
   c. trapezoid
   d. rhombus

70. Which is true?
   a. Every rectangle is a kite.
   b. Every rhombus is a kite.
   c. Every quadrilateral is a kite.
   d. Every trapezoid is a kite.

71. Which figure has 2 pairs of parallel sides?

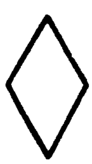


72. This figure is:



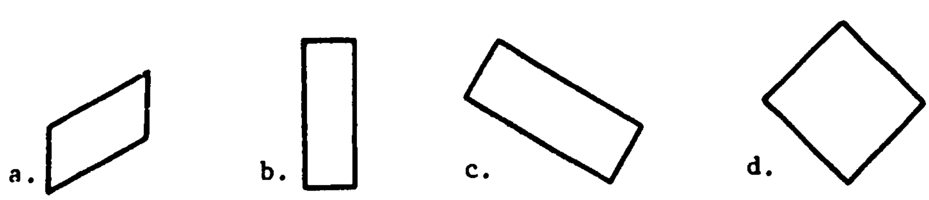
a. solid
b. closed
c. open
d. parallel-sided

73. This figure has:

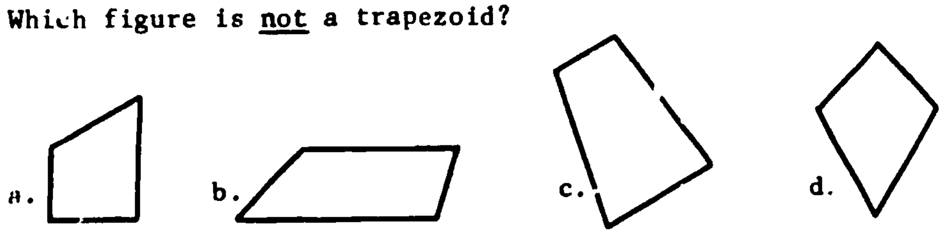


a. no sides of equal length
b. all angles equal
c. all sides of equal length
d. no angles equal

74. Which figure is a square?

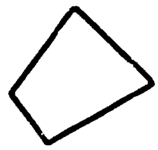


75. Which figure is <u>not</u> a trapezoid?



112

76. This figure is a:



a. parallelogram
b. rectangle
c. rhombus
d. quadrilateral

77. All rectangles have:

a. no right angles
b. all sides of equal length
c. 4 right angles
d. 2 pairs of adjacent sides of equal length

78. Not all kites have:

a. 4 sides
b. 2 pairs of opposite sides of equal length
c. 2 pairs of adjacent sides of equal length
d. closed sides

79. All quadrilaterals with 2 pairs of parallel sides are:

a. parallelograms
b. kites
c. trapezoids
d. rhombuses

80. All rhombuses are:

a. quadrilaterals with 4 right angles
b. quadrilaterals with only 1 pair of sides of equal length
c. parallelograms with all sides of equal length
d. parallelograms with all angles equal

81. All squares may also be called:

a. hexagons

b. triangles

c. trapezoids

d. rhombuses

APPENDIX C

Interview Procedure Instructions

and

Sheet to Record Subject Information

INTERVIEWER PROCEDURE

INTRODUCTION

The purpose of this study is to evaluate the effect of verbal activities (in form of oral answers to raised questions) on learning some geometric concepts. It also aims to know when is the best time to verbalize, during or after reading the material. For this purpose four groups of girls will receive different treatments while reading the same material.

Group 1: Verbalize during instruction.

Group 2: Verbalize after instruction.

Group 3: Verbalize both during and after.

Group 4: No verbalization at all.

The interviews will be done on an individual basis.

SEATING

Let subject sit at the table with material in front of her. Be sure to have an access to a pen and a blank sheet of paper to cover answers. You sit on the left of the subject (on the right if subject is left handed) with a paper to record needed information and a blank sheet to record your observations or comments. If you are assigned to treatments 1, 2, or 3, be sure to have the set of questions with you.

PROCEDURE

Start with introducing yourself to the subject. Explain the purpose of the experiment and what is expected of them (explanation below).

(Explain to girls) We are interested in studying how children can best read mathematical material. All the girls in the study will have the same material to read. Some girls will be asked questions on the material to see what kind of questions can help girls best. You will . . . (choose the appropriate description)

Group 1 be asked questions, while you are reading the material, to direct your thinking.

Group 2 be asked some questions when you finish the material.

Group 3 be asked some questions while you are reading the material and some other questions right at the end.

Group 4 not be bothered with any questions.

<u>What is expected of you:</u>

1. Read the material carefully.
2. Take a multiple choice test when you finish.
3. In a week, you will take at the school another test to see what you remember of the material.

Tests will not effect your standing at school. Nobody will identify your name and score.

Answer all of the students' questions to the best of your ability. Be sure they know how to use the programmed material, (cover answers, and check their work after they write down their answer). There is no time limit to finish the reading; however, explain that most students are able to finish the material in 40-45 minutes. Ask students to stop if they need more than 60 minutes because you have other girls to interview.

Record the needed information for each girl.

Student's name

School

Address

Telephone No.

Date of Birth

Time Started

Time Finished

Pauses (longer than 1 min.)

Go over the word list at least twice with students. Do not explain the meaning of any term. When this is done, have them start the lessons.

In groups 1 and 3, ask students to stop whenever they see * on a page so that you could talk about the material. Ask them the list of questions designed for each section (i.e. Q.1 is to be asked when they stop on page 5) of Lesson 1). You may want to change the form of the question if it is not understood. Don't insist on a correct answer; this is not essential for the present study. Avoid reinforcements and encouragements. See if subjects have any questions. If the question is mathematical, pose it back to them.

Groups 2 and 4 don't stop at * . However, you may answer some of their questions not related to the subject matter studied. If the student is under tension due to the unfamilair situation, such questions as "How are you doing?", "Do you find the material difficult?", "Did you every have similar material at school?" etc. might help to break the tension.

With students in groups 2 and 3, go over their answers with them; see where they made mistakes. Ask them if they agree with the answer given to them in the margin by asking questions similar to those being asked during instruction in groups 1 and 3.

When the student is ready to leave, record the finish time. Then ask a special favor from them not to discuss any of the material they studied with their friends for one week. Tell them this would affect results of the experiment. Then, direct her to the test room. Start on the next girl!

INFORMATION NEEDED

Student's name: ____________________

School: ____________________

Telephone No. ____________________

Date of Birth: ____________________

Time Started: ____________

Time Finished: ____________

Pauses (longer than 1 min.) ______

Comments:

APPENDIX D

ITEM PARAMETERS FOR THE COMPLETION TEST

AND ITEM PARAMETERS FOR THE MULTIPLE-CHOICE TEST

Item Parameters for the Completion Test

Item	Difficulty	Point Biserial Correlation	X_{50}	β
1	.93	.04	-20.11	.07
2	.75	.44	-1.13	.75
3	.40	.10	2.03	.13
4	.50	.32	.00	.44
5	.60	.20	-.99	.26
6	.50	.61	.00	1.17
7	.13	.39	1.82	.81
8	.38	.53	.47	.93
9	.28	.60	.75	1.32
10	.43	.13	1.15	.17
11	.50	.42	.00	.62
12	1.00	.00	.00	.00
13	.85	.29	-2.34	.49
14	.90	.14	-5.30	.25
15	.55	.56	-.18	.99
16	.78	.27	-2.00	.41
17	.80	.23	-2.60	.34
18	.23	.21	2.54	.31
19	.18	.60	1.06	1.87
20	.23	.52	1.04	1.06
21	.55	.53	-.19	.88
22	.33	.32	1.10	.46
23	.80	.25	-2.35	.38
24	.53	.15	-.33	.19
25	.58	.47	-.32	.73
26	.60	.32	-.63	.44
27	.75	.39	-1.27	.63
28	53	.51	-.10	.82
29	.88	-.08	9.26	-.13
30	.25	.57	.86	1.25
31	.13	.57	1.25	2.37
32	.40	.44	.46	.67
33	.08	.58	.00	.00
34	.45	.09	1.15	.11
35	.45	.46	.22	.71
36	.95	.17	-4.51	.39
37	.48	.57	.09	1.01
38	.70	.37	-1.06	.57
39	.75	.40	-1.23	.66
40	.55	.56	-.18	.99
41	.45	.17	.59	.22

Item Parameters for the Completion Test

Item	Difficulty	Point Biserial Correlation	$\bar{X}_{50}$	β
42	.70	.36	-.87	.76
43	.08	.48	1.61	2.02
44	.73	.06	-7.25	.08
45	.13	.15	4.67	.25
46	.20	.55	1.08	1.24
47	.38	.19	1.34	.25
48	.28	.37	1.22	.56
49	.55	.48	-.21	.76
50	.88	.29	-2.47	.53
51	.70	.32	-1.26	.46
52	.68	.46	-.76	.74
53	.33	.16	2.16	.22
54	.93	.19	-4.02	.38
55	.23	.39	1.39	.65
56	.05	.31	2.55	.85
57	.18	.37	1.69	.66
58	.30	.30	1.33	.43
59	.63	.35	-.72	.50
60	.95	.31	-2.55	.85
61	.40	.39	.51	.58
62	.88	.37	-1.96	.73
63	.55	.30	-.33	.41
64	.28	.48	.92	.85
65	.40	.41	.49	.61
66	.88	.19	-3.86	.31
67	.30	.64	.62	1.57
68	.20	.59	.68	1.21
69	.28	.44	1.03	.72
70	.25	.54	.91	1.09
71	.68	.37	-.93	.56
72	.98	.10	-7.66	.26
73	.88	.26	-2.80	.45
74	.90	.23	-3.24	.43
75	.28	.41	1.10	.65
76	.30	.58	.69	1.17
77	.43	.65	.23	1.45
78	.13	.66	.00	.00
79	.25	.26	1.93	.37
80	.10	.46	1.62	1.30
81	.48	.57	.09	1.03

Item Parameters for the Multiple-Choice Test

Item	Difficulty	Point Biserial Correlation	X_{50}	β
1	.90	.39	-1.95	.38
2	.45	.50	.20	.82
3	.00	.00	.00	.00
4	.03	-.20	-3.63	-.64
5	.05	.13	6.14	.28
6	.03	-.23	-3.20	-.77
7	.43	.20	.77	.25
8	.28	-.45	-1.00	-.74
9	.10	-.31	-2.43	-.62
10	.60	.44	-.45	.67
11	.38	.37	.67	.54
12	.00	.00	.00	.00
13	.03	-.12	-6.07	-.34
14	.85	.22	-3.04	.36
15	.13	-.42	-1.71	-.91
16	.23	-.14	-3.76	-.21
17	.15	-.31	-2.17	-.54
18	.40	.06	3.36	.08
19	.40	.36	.55	.51
20	.25	.01	67.74	.01
21	.03	-.22	-3.40	-.70
22	.50	.34	.00	.47
23	.03	-.01	-57.16	-.03
24	.23	-.36	-1.50	-.58
25	.15	-.34	-2.02	-.60
26	.15	.08	88.12	.01
27	.13	-.19	-3.77	-.32
28	.00	.00	.00	.00
29	.73	.45	-.99	.76
30	.43	.49	.30	.80
31	.08	-.06	-12.31	-.12
32	.13	-.11	-6.32	-.19
33	.55	.20	-.50	.26
34	.10	-.24	-3.06	-.46
35	.28	-.23	-1.95	-.32
36	.03	-.08	-9.13	-.22
37	.03	-.27	-2.72	-1.04
38	.03	.07	10.75	.19
39	.08	.00	644.01	.00
40	.80	.38	-1.54	.65
41	.23	-.38	-1.42	-.63

Item Parameters for the Multiple-Choice Test

Item	Difficulty	Point Biserial Correlation	X_{50}	β
42	.58	.64	-.23	1.37
43	.25	.04	11.95	.06
44	.05	-.19	-4.04	-.45
45	.25	.04	11.95	.06
46	.43	.35	.43	.49
47	.10	-.17	-4.30	-.31
48	.00	.00	.00	.00
49	.48	-.20	-.25	-.26
50	.08	-.28	-2.77	-.61
51	.33	.48	.73	.79
52	.93	.17	-4.63	.33
53	.13	-.11	-6.70	-.17
54	.00	.00	.00	.00
55	.15	-.29	-2.31	-.50
56	.40	-.01	-38.67	-.01
57	.13	-.23	-3.05	-.41
58	.20	-.19	-3.14	-.28
59	.05	-.21	-3.67	-.50
60	.03	-.13	-5.46	-.38
61	.03	-.12	-6.07	-.34
62	.00	.00	.00	.00
63	.03	-.23	-3.20	-.77
64	.03	-.07	-10.97	-.18
65	.30	.44	.89	.72
66	.63	.32	-.78	.45
67	.15	-.15	-4.64	-.23
68	.45	.58	.17	1.08
69	.20	-.27	-2.16	-.42
70	.30	-.06	-6.97	-.08
71	.08	-.23	-3.35	-.48
72	.00	.00	.00	.00
73	.05	-.12	-6.76	-.25
74	1.00	.00	.00	.00
75	.58	.10	-1.45	.13
76	.53	.44	-.11	.66
77	.30	-.38	-1.05	-.58
78	.08	.02	44.93	.03
79	.18	.14	4.51	.21
80	.23	-.06	-9.30	-.08
81	.63	.38	-.65	.56

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