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A COMPARATIVE STUDY IN PROBLEM SOLVING ABILITY OF A GROUP OF NEGRO AND WHITE CHILDREN OF AVERAGE INTELLIGENCE BY SOCIO-ECONOMIC LEVEL

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A COMPARATIVE STUDY IN PROBLEM SOLVING ABILITY OF A GROUP OF NEGRO AND WHITE CHILDREN OF AVERAGE INTELLIGENCE BY SOCIO-ECONOMIC LEVEL

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CHAPTER I

INTRODUCTION

Psychologists and educators have continually experimented in an effort to determine what effect children's environments have on their ability to solve problems. Investigations of children reveal characteristic differences in their ability to use their symbolic processes in problem solving. Hensley[1] concluded from his study of the ability of two groups of children to solve multiple choice problems using Teska's[2] Problem Box that comparisons on the basis of mental age, chronological age and intelligence revealed that within the limits of his study, the ability to solve problems was probably more a function of mental age than chronological age or intelligence.

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[1]Horace Gene Hensley, "A Comparative Study in Problem Solving of Bright and Dull Children" (unpublished Ph.D. dissertation, University of Oklahoma, 1957), pp. 42-43.

[2]Percy T. Teska, "Performance of Dull and Bright Children in a Non-language Multiple Choice Problem Situation" (unpublished Ph.D. dissertation, University of Wisconsin, 1942), pp. 28-31.

Jansen[3] declared that research has been incomplete as a basis for definite conclusions about the effects of racial differences on intelligence. Teska[4] and Prothro asserted that:

> . . . we must recognize that our conception of intelligence itself is culturally conditioned--that it is dependent upon what is at a premium in our society. Since success in school activities is the goal of children, our tests are based upon items that measure those abilities that normally produce such success.

Surey's[5] lengthy review of comparative studies was concluded with the following statement:

> . . . The remarkable consistency in test results, whether they pertain to school or preschool children, to high school or college students, to drafts of World War I or World War II, to the gifted or the mentally deficient, to the delinquent or criminal; the fact that the colored-white differences are present not only in the rural South and urban South, but in the border and northern areas; the fact that relatively small average differences are found between the IQ's of northern-born and southern-born Negro children in northern cities; the evidence that the tested differences appear to be greater for abstract than for practical or concrete problems; the evidence that the differences obtained are not due primarily to a lack of language skills, the colored averaging no better on non-verbal tests than on verbal tests; the fact that cultural environment of the whites appeared to be no more complex, rich, or stimulating than the environment of the Negroes; the fact that in many comparisons (including those in which the colored appeared to best advantage) the Negro subjects have been either more representative of their racial group or more high selected than have the comparable white subjects; all point to the presence of some native differences between Negroes and Whites as determined by intelligence tests.

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[3]Arthur R. Jansen, "How Much Can We Boost I.Q. and Scholastic Achievement?", Harvard Educational Review, XXXIX, No. 2, (Spring, 1969) 1-117.

[4]E. Terry Prothro and Percy T. Teska, Psychology, A Biosocial Study of Behavior, Ginn and Company, Boston, 1950, p. 489.

[5]Audrey M. Shurey, The Testing of Negro Intelligence, J. P. Bell Co. Inc., Lynchburg, Va., 1958.

Brazziel[6] and others asserted that full potential is not being measured by traditional intelligence tests.

Prothro[7] and Teska reported that "comparative studies of racial performance on intelligence tests support the idea that cultural differences rather than racial differences are the important factors."

Munn's[8] analysis of what is involved in problem solving identifies it as an implicit process:

> . . . an organism is said to reason when, confronted by some problem, it attempts or achieves solution in terms of relevant past stimulation. As in sensorimotor learning, there may be much trial-and-error activity prior to solution. In the case of reasoning, however, the trial-and-error activity is implicit, or if explicit, very much abbreviated.
>
> When the problem which confronts the organism is that of finding a general principle, of developing a concept or generalization, the reasoning process is sometimes referred to as generalizing.

Munn[9] outlines the progression of problem solving as follows:

> The presence of such processes is evidenced by (1) sudden solutions (suggesting the existence of insight), (2) putting two and two together in the solution of a novel problem, and (3) discerning and utilizing a principle. Such "higher processes" are probably related rather than distinct.

The ability of children to discover and to apply to new situations the solving principle of a given problem was investigated by Roberts.[10]

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[6] William F. Brazziel, "A Letter from the South," Harvard Educational Review, XXXIX, No. 2 (Spring, 1969), 348-356.

[7] Prothro, loc. cit.

[8] Norman L. Munn, Psychological Development, Houghton Mifflin, 1938, Cambridge, p. 355.

[9] Norman L. Munn, The Evolution and Growth of Human Behavior, "A Revision of Psychological Development," Houghton Mifflin Company, Boston, 1955, p. 325.

[10] K. E. Roberts, "The Ability of Pre-School Children to Solve

"You open one door and see if you can make an aeroplane fall." He found that the ability to solve the problem and give a verbal generalization increased with chronological and mental age. Hensley's[11] study generally confirmed Roberts and Teska's[12] findings.

Teska concluded, after a thorough review of previous tests used to measure problem solving ability, that the mazes and puzzles were weak as tests of problem solving because the data used did not yield to inductive reasoning. He also concluded that the tests of syllogistic reasoning emphasized the deductive element to the exclusion of the inductive element. The tests of concept formation, while well balanced as problem solving tests within the confines of a given age level, were limited because it was difficult to develop a list of concepts common to both younger and older subjects that were not too difficult or complex for the younger or too simple for older subjects. Teska's multiple choice technique claims the ability to test over a wide age range. Using Teska's Problem Box and the problems he developed, the generalizations necessary for the solution should arise logically from the data--that is, inductively--and can be checked systematically against the data--that is, deductively--and at the same time can be stated with clarity in the language of the young subject. Teska's multiple choice technique with its wider variety of clues gives a wide range to inductive processes but still retains the systematic

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Problems in Which a Simple Relationship is Kept Constant," Journal of Genetic Psychology, 1932, 40, 118-135.

[11]Hensley, loc. cit., pp. 42-43.

[12]Teska, "Performance of Dull and Bright Children," pp. 26, 51-52.

means of checking hypotheses and was proven an adequate test of the problem solving process.

Teska's study of dull and bright children, using his multiple choice Problem Box with the problems arranged from simple to complex and presented in their order of difficulty, revealed that: (1) Bright subjects were superior to dull in percent of problems solved at each age level. The youngest of the bright subjects were superior to the oldest dull subjects. (2) The bright subjects were superior to the dull in the number of trials at each age level (ages 8, 10, 12, 14). The youngest of the bright subjects required fewer trials than the oldest of the dull subjects. (3) Increases in percentage of solutions were found at each successive age level for both bright and dull subjects. (4) Decreases in the average number of errors were found at each successive age level for both bright and dull subjects. (5) Increase in the percentage of solutions were found with increase in mental age. (6) Decrease in number of trials required was found with increasing mental age. (7) Comparisons on the basis of mental age, chronological age, and intelligence revealed that predictive value of brightness for the degree of success in the problem solving situation used was greater than that of either mental or chronological age. (8) Comparison of dull and bright of the same mental age revealed that the bright subjects were superior in percentage of problems solved. (9) Comparison of dull and bright of the same mental age revealed that the bright subjects were superior to the dull in requiring fewer trials for solution. (10) Failure of the dull subjects to solve the more complex problems was traceable to: (a) Failure to understand the problem. (b) Failure to define, isolate, and organize the data. (c)

Failure to propose promising and adequate hypotheses. (11) With two exceptions, failure was not traceable to unsystematic or inadequate testing of the correct hypothesis. (12) The failure in the inductive step, the proposing of adequate and promising hypotheses, would appear to be the chief point of differentiation between the bright and dull subject.

For the purpose of this study the writer accepts the criteria by Hensley as the definition of problem solving. Hensley[13] concluded that a good test of problem solving should include the opportunity for persons to use all the steps in the problem solving process as defined by Dewey, Vinacke and Symonds. The problem task should include, therefore, a situation conducive to the perception of the problem, which provides the motive for its solution, adequate data for isolation, definition, and organization; a possible solution which may be determined by further analysis and organization; and conditions whereby an individual may test hypotheses against the data. The test should also provide for the occurrence of both inductive and deductive reasoning.

The writer accepts Hensley's conclusions concerning the five methods used for testing reasoning that Hensley's study reviewed. Problem solving using the multiple choice technique seems to be adequate for testing people over all levels of chronological ages. Various people experience the problem solving process in a less than uniform fashion, possibly because the process itself is complex with its many variables that often differ with different problems.

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[13] Hensley, loc. cit., pp. 2-19.

Statement of the Problem

The purpose of this study was to build a multiple choice Problem Box and to use it to compare the problem solving ability of average children (IQ's 95-105) who were representative of a lower socio-economic white neighborhood, a lower socio-economic black neighborhood and a higher socio-economic white neighborhood. Problem solving ability was measured by three criteria; first, the ability to solve each of ten Problem Box problems, second, by the number of trials required to solve each of the ten problems and third, by the ability to solve each of the ten problems with a correct verbal generalization to the solution of the criterion.

The multiple choice problem box method was chosen so that reading and vocabulary elements would be held to a minimum so as to test only problem solving. This study has used as its problems the same ones used by Teska and Hensley.[14] However, the problems have been adapted to the Problem Box that was built for this study.

The following hypotheses have been tested:

1. There is no statistically significant difference in the problem solving ability as measured by the proportion of subjects in Group I versus Group II solving or not solving each of the ten problems on the Problem Box.

2. There is no statistically significant difference in the problem solving ability as measured by the proportion of subjects in Group I versus Group III solving or not solving each of the ten problems on the Problem Box.

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[1] *Ibid*.

3. There is no statistically significant difference in the problem solving ability as measured by the proportion of subjects in Group II versus Group III solving or not solving each of the ten problems on the Problem Box.

4. There is no statistically significant difference in the problem solving ability as measured by the number of trials used to solve each of the ten problems on the Problem Box for subjects in Group I versus Group II.

5. There is no statistically significant difference in the problem solving ability as measured by the number of trials used to solve each of the ten problems on the Problem Box for subjects in Group I versus Group III.

6. There is no statistically significant difference in the problem solving ability as measured by the number of trials used to solve each of the ten problems on the Problem Box for subjects in Group II versus Group III.

7. There is no statistically significant difference in the problem solving ability as measured by the proportion of subjects in Group I versus Group II solving or not solving with correct verbal generalization, each of the ten problems on the Problem Box.

8. There is no statistically significant difference in the problem solving ability as measured by the proportion of subjects in Group I versus Group III solving or not solving with correct verbal generalization each of the ten problems on the Problem Box.

9. There is no statistically significant difference in the problem solving ability as measured by the proportion of subjects in

Group II versus Group III solving or not solving with correct verbal generalization each of the ten problems on the Problem Box.

10. Zero correlation exists between the mean number of trials and achieving verbal generalizations for subjects in each separate Group I, II, and III respectively.

The following comparisons of problem solving ability will be made among the three grade levels and among the three groups. These comparisons include average problems solved, mean trials and average problems solved with verbal generalizations for (1) subjects with the lower M.A.'s versus subjects with higher M.A.'s within each grade level and group, (2) subjects with lower C.A.'s versus subjects with higher C.A.'s within each grade level and group, and (3) subjects with lower I.Q.'s (95-100) versus subjects with higher I.Q.'s (100-105). These comparisons will be attempted to see if subject's problem solving ability increases as M.A., C.A. and I.Q. increases.

Selection of Schools and Subjects

The schools and subjects selected for this study were also a part of another experimental study by J. R. Prickett.[15] While Prickett's study included a larger sample, including subjects whose I.Q. was 90 to 110, this study used all of Prickett's subjects who had I.Q. 95 to 105.

The selection of schools was made from three lists prepared from the master list of Oklahoma City Elementary Schools. One list contained the names of all the schools which served predominantly the lower

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[15] J. R. Prickett, "Associative Learning Rates of Second, Fourth and Sixth Grade Black and White Students with a Socio-economic Difference" (unpublished Ed.D. dissertation, University of Oklahoma, 1970), pp. 21-25.

socio-economic black population. Another list included names of the schools which served the lower socio-economic white population. The third list named the schools which served the higher socio-economic white population in which none of the students were from low socio-economic homes. A table of random numbers was used by Prickett to select the school from each list.

The same procedure was used to select the subjects. A master list was made for each school by grade level which included all students in the second, fourth and sixth grades who had average intelligence according to existing group intelligence test scores on file in the school records. A table of random numbers was used to select the subjects for each school and grade level. A sample of 180 subjects was then identified that met the selection criteria of average intelligence (90-110) on the Stanford Binet Intelligence Scale Form L-M.

The persons selected to administer the complete Binet Scale to each subject were all well qualified (Masters Degree) with experience in individual Binet testing techniques. All four examiners were recommended and approved by the Special Education Department at the University of Oklahoma and by the Psychological Services Department of the Oklahoma City Public School System. It was from this large group of subjects that the 84 subjects used in this study were selected. The criteria of selection of the 84 subjects was an I.Q. score between 95 to 105 on the Stanford Binet Intelligence Scale Form L-M. The lists of subjects by schools contained name, grade level, sex, M.A., C.A., and I.Q. were furnished by J. R. Prickett and the Oklahoma City Public School System.

After permission had been secured in writing from each parent the test of problem solving ability was administered to each subject. All subjects were administered the Problem Box individually in a special room in each of the elementary school buildings where the subjects attended school. Subjects were isolated from regular school activities for the purpose of administering the test. All subjects were tested with the Problem Box by one examiner who had thorough orientation and training in the use of the Problem Box.

Listed on Table 1 are all the subjects used in this study. All subjects are identified by group, grade placement, chronological age, mental age and intelligence quotient scored on the Stanford Binet Scale.

Limitations

This study was limited to students in three types of schools in the Oklahoma City Public School System who were placed in the second, fourth and sixth grades during the school year 1969-70. Only students who scored within the average range of intelligence with IQ scores 95-105 on the Stanford Binet Intelligence Scale Form L-M and who were tested within the past six months were used in this study.

Special notice was directed to four types of data: (1) average number of problems solved, (2) average number of trials, (3) frequency of verbal generalizations, (4) average trials used for each problem solved and that was also generalized and average number of trials used for each problem solved that was not generalized.

Definitions

Terms used in this study are defined as follows:

Problem Solving Ability means that ability which is exhibited by persons when they utilize both inductive and deductive reasoning processes in order to achieve correct solutions to problems.[16]

Average Intelligence as used in this study means students scores on the Stanford Binet Intelligence Scale Form L-M within the IQ range of 95-105.

Teska's Problem Box means the apparatus described below and used by Teska and Hensley.[17] The box was built by Percy T. Teska, Professor of Education, University of Oklahoma. Teska's Problem Box was a portable unit approximately fifteen inches high, twelve inches wide and thirteen inches deep. On the face of Teska's Problem Box was a window divided equally into four quadrants. Subjects sat in front of the box facing the divided window. Subjects were instructed that one of the four buttons, located next to each of the four parts of the divided window, would cause a light to flash red. Subjects were instructed to find the button which could cause the light to flash red every time. An example of a correct solution to a particular problem was pressing the button next to the square, no matter in which quadrant the square appears. After a delay of five seconds another set of images appeared on the quadrant window for the subject's consideration. Subjects were allowed up to 160 trials if needed to solve the problem. Problems were considered solved

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[16]"Above, p. 6."

[17]Hensley, loc. cit.

when subjects were able to get the reward light to flash red five or six times in succession or if the subject volunteered a statement assuring the examiner that he had solved that particular problem. Teska's pilot study results were used to arrange his ten problems in order of their difficulty.

Lower white, Group I, designates the group of students selected from the predominantly white school serving a socially and economically disadvantaged area as designated by the administration of the Oklahoma City Public School System.

Lower black, Group II, designates the group of students selected from the predominantly black school serving a socially and economically disadvantaged area as designated by the administration of the Oklahoma City Public School System.

Higher white, Group III, designates the group of students selected from the predominantly white school serving a socially and economically favored area as designated by the administration of the Oklahoma City Public School System.

Problem Box means the apparatus built by the author and described below. Two identical boxes were built specifically for this study so it would allow the examiners to test a larger number of subjects in a given period of time.

The Problem Box

The testing apparatus (called hereafter the Problem Box) presented a preselected series of geometric figures upon a frosted glass viewing window. The Problem Box used in this study measured ten inches high and twenty inches wide. In the center of the slightly-tilted face of the Problem Box was a $4\frac{1}{2}$ inch by $4\frac{1}{2}$ inch screen, on which the stimuli was presented. Four pull switches, one for each quadrant, were located within one inch of the screen. Nine series of objective answers with twenty consecutive responses were built into the Problem Box. For example, a subject could be presented twenty consecutive but different trials for each problem and had one of four possible choices for each trial. However, the reward light would light only when the correct switch was pulled on any given trial.

Images that were seen by the subjects were exposures of 127 Ektrachrome X negative film images of two geometrical forms against a black background. The slides were projected onto the screen by a 35 mm Kodak 850 Carousel Projector which was located internally in the Problem Box. By using Teska's problems the experimenter offered the subject the opportunity to demonstrate his problem solving ability through the use of a non verbal task. In doing so the examiner offered to the average subject the opportunity to demonstrate his ability to solve problems without having his previous reading, vocabulary and other language skills or their absence, to aid or hinder his problem solving ability.

Used in this study was a series of pictures of a square and a triangle in one of eight relationships to each other at each successive trial. The eight different relationships as to their location on the screen allowed for the introduction of clues of color, shape, and position on the screen in relationship to each other. These relationships also offered sufficient challenge to persons regardless of their chronological age. With the exception of the introduction of the color clue, the eight specific relationships as to where the geometric figures were located on the screen, were presented consistently for all the problems. These eight different relationships allowed for simpler problem solving tasks like always the figure on the left or always the figure on the right of the screen to be used as a problem. More complex problems like always the square when the two geometric figures appear adjacent and always the triangle when they appear opposite, with false clues of color and shape that must be ignored, was also tested.

The problems used in this study were the same as Teska's[18] original ones used in 1942. While four other relationships were possible, including both figures appearing together on the right or left, they were not used. The Problem Box that was built for this study was constructed in such a way that, if an experimenter chooses, the other four relationships could be tested by preparing a series of slides for that purpose.

A pull switch beside each quadrant of the screen provided the subject, who sat in front of the Problem Box, an opportunity to make his choice. On any given trial, only one of the four pull switches caused the red reward light to flash. Subjects were allowed to pull only one switch on any given trial. After the subject had selected a correct switch, the red light remained on for five seconds. If an incorrect switch was selected, no light came on. In either event, after the switch was pulled, the figures continued to be shown for five seconds per trial. After a five-second delay, the red reward light, if lighted, went out, and consecutively the figures changed and another set of figures appeared

[18]Teska, "Performance of Dull and Bright Children," p. 37.

on the screen. For more technical information see schematic drawing included in the Appendix.

Test Procedure

After the experimental Problem Box was constructed and the slides arranged in the proper sequence in four slide holders, a standard answer sheet was then printed for each of the ten problems. The test was administered to a rather broad sample of persons. Some of the subjects were asked to verbalize their thoughts aloud and the writer was able to utilize this information when the final standardized instructions were written. In addition to this experience the writer reviewed and adopted most of the original instructions that Teska used in his problem box experiment.

The following operational rules have been followed in this study: (1) A maximum number of 100 consecutive trials have been allowed each subject for each of the ten problems. (2) Two types of solutions have been acceptable to score a plus response. A given problem will be considered solved after ten consecutive red lights are obtained or after a subject has volunteered a verbalization of the correct solution of the problem. (3) No session has been terminated before the subject had an opportunity to attempt each problem in the series. (4) Each subject has been given the same directions and demonstration on the first problem, and each problem has been presented in identical order for all subjects.

The subjects in this study have been given these directions: "One of these four pull switches (the examiner says, placing a finger on each switch) will make this light flash red." The examiner has then pulled the correct switch for the solution for problem one which is the pull switch by the side of the square, therefore causing the red light to light. After the switch has been pulled, the light and the picture remain on for five seconds, then the light will go off and a new picture will appear on the screen. When the directions have been repeated for a second time, the subjects were then told "Now you pull the switch that will make the red light come on every time." After at least 18 trials or when it has become obvious by the subjects performance that he has not comprehended the directions, he was given another demonstration like the one before. If after 100 trials the subject had not solved the problem he was told the solution to the demonstration problem.

After a subject has lighted ten red lights in succession and has not volunteered a verbal solution to the problem, the examiner asked this question, "You are causing the light to flash red every time, how do you do it?" or if the subject still does not seem to understand he will be asked, "How do you tell which switch to pull next?" Each response for every slide has been recorded on the special answer sheet. A separate answer sheet has been used for each of the ten problems and from these answer sheets the primary data for this study has been derived.

The following problems have been used to test for problem solving ability:

1. Always the square (demonstration)
2. Always the triangle
3. Always the figure to the left
4. Always the green figure
5. Triangle when both figures are red; square when both figures are green

6. Always the figure on the right--but in each trial, one figure appears red, one green. The color is a false clue which must be disregarded in the solution
7. Red-green alternation, regardless of figure
8. Square when both figures are red; triangle when both figures are green
9. Single alternation with both figures appearing red or both figures appearing green, color being a false clue to be disregarded in the solution.
10. Square when figures are in opposite corners; triangle when the figures are in adjacent corners.

Criteria for scoring a pass have been to light ten red lights in succession for problems one through nine, and on problem ten the subject had to light fifteen red lights. The reason for the deviation on the tenth problem was due to the arrangement of the slides. It was necessary to require fifteen lights to insure that the subject had solved problem ten. If the fifteen trial requirement had not been required, a subject could have applied the criteria for problem nine at one point in the series and achieved seven red lights on problem ten.

Figure 1 included in the Appendix shows the order, color and position of each of the two geometric figures used for each trial just as they were presented to each of the subjects. The printed answer sheet which was used to gather the primary data, showed the actual shapes of the geometric figures as they would appear on the Problem Box window in view of the subject. The examiner sat at the left side of and behind the subject.

TABLE 1

DESCRIPTION OF SUBJECTS
(Lower White - Group I)

Student Number	C.A.	Stanford-Binet L-M M.A.	I.Q.	Grade	Sex
1	88	86	96	2	F
2	87	88	98	2	M
3	95	94	99	2	M
4	93	90	102	2	M
5	93	96	102	2	F
6	96	102	104	2	M
7	91	96	104	2	M
8	86	90	104	2	M
9	111	108	95	4	M
10	111	112	98	4	M
11	109	110	98	4	F
12	111	112	98	4	F
13	124	126	99	4	F
14	114	118	101	4	M
15	110	116	103	4	F
16	109	118	105	4	F
17	141	142	99	6	M
18	144	144	99	6	F
19	138	140	100	6	F
20	144	146	100	6	F
21	146	148	100	6	F
22	155	156	100	6	M
23	143	150	103	6	M
24	139	148	104	6	M
25	144	152	104	6	M

TABLE 1--(Continued)

DESCRIPTION OF SUBJECTS
(Lower Black - Group II)

Student Number	Stanford-Binet L-M C.A.	M.A.	I.Q.	Grade	Sex
26	89	88	96	2	M
27	98	98	98	2	M
28	92	92	98	2	F
29	88	88	99	2	F
30	88	88	99	2	M
31	93	94	99	2	M
32	98	100	100	2	F
33	94	98	103	2	M
34	97	104	105	2	M
35	117	114	95	4	F
36	121	118	95	4	M
37	114	114	97	4	F
38	114	116	99	4	M
39	112	114	99	4	M
40	118	112	100	4	M
41	111	116	102	4	M
42	118	124	102	4	F
43	121	128	103	4	M
44	112	120	104	4	F
45	112	122	105	4	F
46	141	136	95	6	M
47	142	152	105	6	F
48	138	134	96	6	M
49	141	138	97	6	F
50	136	136	98	6	F
51	140	140	98	6	F
52	143	146	100	6	F
53	142	146	101	6	M
54	136	140	101	6	F
55	144	148	101	6	M
56	140	150	105	6	M
57	146	156	105	6	M

TABLE 1--(Continued)

DESCRIPTION OF SUBJECTS
(Higher White - Group III)

Student Number	C.A.	Stanford-Binet L-M M.A.	I.Q.	Grade	Sex
58	91	88	95	2	M
59	93	90	95	2	M
60	97	94	95	2	M
61	93	92	97	2	M
62	95	96	99	2	F
63	90	90	99	2	F
64	91	92	100	2	F
65	94	96	100	2	F
66	92	96	103	2	M
67	115	114	96	4	M
68	114	112	96	4	F
69	112	112	97	4	F
70	117	118	98	4	M
71	114	116	99	4	M
72	111	114	100	4	F
73	116	120	101	4	F
74	114	120	102	4	M
75	120	130	105	4	F
76	140	134	95	6	M
77	138	134	96	6	F
78	136	134	97	6	F
79	141	140	98	6	F
80	144	144	99	6	M
81	136	138	100	6	F
82	139	142	100	6	F
83	145	152	103	6	F
84	136	144	104	6	M

CHAPTER II

RESULTS

Eighty-four boys and girls were used as subjects in this comparative study. Table 1 reports the description of each subject. Detailed results of the Problem Box testing are presented in tabular form within this chapter. Tables 2 through 12 reveal the following experimental results as reported for each of the three groups of children tested: (1) Which of the ten problems were solved and the total number solved by each subject within each group. (2) The χ^2 values of the proportion of subjects who passed-failed each of the ten problems between each group. (3) The number of trials used to solve each problem by each subject within each group. (4) The mean and standard deviations of the number of trials used to solve each of the ten problems by each group. (5) The t tests are reported between independent means for each of the ten problems between each of the groups. (6) Which of the ten problems were solved by subjects through achieving the correct verbal generalization, and the total number of problems solved within each group. (7) The χ^2 values of the proportion of subjects who passed-failed each of the ten problems through achieving the correct verbal generalization between each of the three groups. (8) A point biserial correlation within each of the three groups between mean trials used for each of the ten problems solved with correct verbal generalization (q) and problems solved but not verbally generalized (p). The proportions and mean trials for each variable are also indicated.

An examination of the results revealed that no statistically significant difference at the .05 level, as measured by chi square values, existed between the proportions of subjects in the Lower White Group I versus the Lower Black Group II, the Lower White Group I versus the Higher White Group III, and the Lower Black Group II versus the Higher White Group III, between any one of the ten problems solved and not solved. The average number of problems solved by Group I was 6.92, Group II, 6.71 and Group III, 6.92. Group I second graders solved an average of 6.37 problems, Group II second graders solved 6.0 problems and Group III second graders solved 6.22 problems.

The fourth graders in each group solved an average of 7.25 problems in Group I, 6.45 problems in Group II and 7.00 problems in Group III. The sixth graders solved an average of 7.11 problems in Group I, 7.5 problems in Group II and 7.55 problems in Group III.

Tables 9 and 10 reveal no significant difference at the .05 level between any two of the three groups when the mean number of trials for each of the ten problems was calculated using the t test between independent means. The results of problem solving ability, as measured by the three criteria, are reported in Tables 2, 3, and 4 which are divided into performance levels of each group. These tables contain the data derived when subjects were placed into two categories for each grade level. These categories contained lower and higher halves of each group by (1) C.A., (2) M.A. and (3) I.Q. Tables 2, 3, and 4 also compare average trials used by each grade level, average number of problems solved by each grade level, and the average number of problems generalized by each grade level. The results reveal that the second graders used more trials to solve the ten problems than the fourth or sixth graders. The fourth graders used more trials than the sixth graders. Similar results were true for the average problems solved; that is, the second graders solved fewer of the ten problems than the fourth or sixth graders. The fourth graders solved fewer of the ten problems than the sixth graders. Second graders were not able to solve as many problems with the correct verbal generalization as fourth or sixth graders. Fourth graders solved fewer of the ten problems with correct verbal generalizations than the sixth graders.

Analysis of Data

Hypotheses one, two, three, seven, eight and nine were tested by applying the chi square test for a 2 x 2 contingency table, except when any expected frequency was less than 5, then Fisher's Exact probability test was applied as outlined in Siegel.[16]

A	B	A + B
C	D	C + D
A + C	B + D	N

$$\chi^2 = \frac{N\left(|AD - BC| - \frac{N}{2}\right)^2}{(A + B)(C + D)(A + C)(B + D)}$$

[16] Sydney Siegel. Nonparametric Statistics for the Behavioral Sciences. New York, McGraw Hill Book Co., 1956, p. 107-110.

The following steps were followed:

The observed frequencies were cast in a k x r contingency table, using the k = 2 columns for pass-failed conditions and r = 2 rows for the two groups.

The formula stated above was then computed and a determination of the significance of the observed χ^2 was accomplished by referring to table C in Siegel.[17] Using the .05 level, if the table value was equal to or larger than the computed χ^2 value then rejection of the null hypotheses was in order.

Probability was computed using Fisher Exact probability test whenever an expected frequency for any cell was less than five.

$$p = \frac{(A+B)!\ (C+D)!\ (A+C)!\ (B+D)!}{N!\ \ A!\ \ B!\ \ C!\ \ D!}$$

p means exact probability

! means factorial, for example $3! = (3)\ (2)\ (1) = 6$

Hypotheses four, five and six were tested using a t - test between independent samples.[18]

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{N_1\ S_1^2 + N_2\ S_2^2}{N_2 + N_2 - 2}\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}}$$

When: $\bar{X}_1$ and $\bar{X}_2$ were the Means of the two samples; S_1^2 and S_2^2 were the variance of the two samples; and N_1 and N_2 were the number of subjects in each sample.

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[17] Ibid., p. 249.

[18] J. P. Guilford. Fundamental Statistics in Psychology and Education. New York, McGraw Hill Book Co., 1956, pp. 183-187.

The numerator was the mean difference between the two samples. The denominator was the standard error of the difference between two independent sample means.

The question asked was whether the obtained t ratio was large enough to have had a probability of less than .05 of occurring by chance and thus enabling a rejection of the null hypotheses ($\bar{X}_1 = \bar{X}_2$).

Hypotheses ten was tested by computing the point biserial coefficient of correlation.

$$r_{pbh} = \frac{M_p - M_q\sqrt{p\,q}}{t}$$

M_p = Mean of X values for the higher group in the dichotomous variable. In this study the higher dichotomous variable (x) was the group of subjects solving the problem and also being able to verbalize the correct generalization of the problem.

M_q = Mean of X values for the lower group in the dichotomous variable. In this study variable Y was the group of subjects solving the problem but not being able to verbalize the correct generalization for the problem.

p = Proportion of cases in the higher group.

q = Proportion of cases in the lower group.

σt = Standard deviation of the combined sample in the continuously measured variable was the number of trials used to solve the problem per subject.

Any statistically significant r_{pb} will indicate that the mean trials to solution for the group who can give a correct verbal generalization will tend to be less than for the group who cannot give a correct verbal generalization. Whereas, for any one of the ten problems that a non significant r_{pb} is found will indicate that the relationship between the number of trials to solution and whether a verbal generalization will be made will be attributed to chance, i.e. Knowing whether a verbal generalization was made does not facilitate a judgment as to whether a few or many trials to solution were taken.

Problem solving as measured by the method used in this study provides some means of analyzing other than significant statistical differences. Problem solving consists: first, of the ability to achieve an understanding of the problem; second, of the ability to isolate, define and organize the data; third, of the efficiency in determining the relative importance of clues and their relationship between parts of the data; fourth, of the ability to set adequate hypotheses; fifth, of the ability to thoroughly test proposed hypotheses against the data; and sixth, of the ability to formulate a generalization that embodies the principle underlying the solution.

In this study none of the problems were significantly more difficult for any one of the three groups. The demonstration problem provided the best insight into the first step of problem solving, that is, being able to understand a problem existed after the demonstrations were

TABLE 2

AVERAGE TRIALS, PROBLEMS SOLVED, AND PROBLEMS SOLVED WITH VERBAL GENERALIZATIONS OF EACH GROUP BY GRADE LEVEL WHEN SUBJECTS WERE RANKED FROM LOWEST TO HIGHEST BY M.A.

Averages		Grade 2			Grade 4			Grade 6		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Average Trials Used	Lower M.A.	60.8	60.8	64.6	53.0	63.5	49.8	43.6	49.7	44.4
	Higher M.A.	46.0	54.5	55.0	45.2	47.3	51.4	51.4	52.0	43.2
Average Problems Solved	Lower M.A.	5.5	5.4	5.8	7.0	5.3	7.4	7.4	7.6	7.6
	Higher M.A.	7.2	6.4	6.4	7.5	7.6	7.2	6.6	7.1	7.8
Average Problems Generalized	Lower M.A.	4.8	5.0	5.6	6.5	4.8	6.0	6.8	6.3	7.4
	Higher M.A.	6.2	5.4	5.0	6.5	6.5	5.2	6.6	6.1	7.6

TABLE 3

AVERAGE TRIALS, PROBLEMS SOLVED, AND PROBLEMS SOLVED WITH VERBAL GENERALIZATIONS OF EACH GROUP BY GRADE LEVEL WHEN SUBJECTS WERE RANKED FROM LOWEST TO HIGHEST BY C.A.

Averages		Grade 2			Grade 4			Grade 6		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Average Trials Used	Lower C.A.	58.5	60.8	62.0	51.2	57.5	50.4	44.0	51.0	41.6
	Higher C.A.	49.6	54.4	56.0	47.0	53.3	57.2	49.0	50.7	48.2
Average Problems Solved	Lower C.A.	6.0	5.4	6.2	7.2	6.5	7.6	7.2	7.2	7.8
	Higher C.A.	6.8	6.4	6.8	7.2	6.5	6.2	7.0	7.3	7.2
Average Problems Generalized	Lower C.A.	5.0	5.0	5.4	6.5	5.5	6.0	7.0	6.1	7.8
	Higher C.A.	5.8	4.2	6.2	6.5	5.8	5.0	6.6	6.3	6.8

TABLE 4

AVERAGE TRIALS, PROBLEMS SOLVED, AND PROBLEMS SOLVED WITH VERBAL GENERALIZATIONS OF EACH GROUP BY GRADE LEVEL WHEN SUBJECTS WERE RANKED FROM LOWEST TO HIGHEST I.Q.

Averages		Grade 2			Grade 4			Grade 6		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Average Trials Used	Lower I.Q.	51.5	60.4	57.4	53.0	61.5	48.0	43.6	47.6	43.2
	Higher I.Q.	53.0	50.0	62.8	45.0	52.0	53.2	51.8	54.0	45.8
Average Problems Solved	Lower I.Q.	6.7	5.6	6.8	7.0	5.5	7.8	7.4	7.3	5.4
	Higher I.Q.	6.0	6.8	5.4	7.5	6.8	6.8	6.6	7.3	5.8
Average Problems Generalized	Lower I.Q.	6.0	5.2	6.2	6.0	4.6	7.8	7.2	6.2	7.6
	Higher I.Q.	5.0	5.6	4.2	6.0	5.8	7.4	6.2	6.3	7.2

given by the examiner. Table 9 shows that Group II, Lower Black, subjects had the highest mean number of trials with 59.72 trials for problem one, the demonstration problem. Group I, Lower White, subjects had the next highest mean trials with 48.56 trials and Group III, Higher White, subjects had the lowest mean trials with 44.63 trials on the demonstration problem. The difference between the mean trials required for Group II was next to the largest difference observed for any of the ten problems. It can only be conjectured about why the observed difference was present on problem one since an analysis of the mean trials for problem two found that Group II had the lowest mean trials and only three trials separated all three groups. More subjects from Group II volunteered a verbal response to problem two than from either of the other two groups. No noticeable difference was indicated by the examiner in the establishment of rapport with any of the three groups tested.

Differences of the three groups tested were not obvious as to their failure to isolate the pertinent elements of the data presented and to organize the information from the data as indicated by group performances on problem nine. In problem nine, color was included as a false clue. Since problem nine was preceded by two problems in which color was the most important clue, significant differences in performance might indicate observable difference between the three groups, but none were indicated. Group III had the highest mean trials 68.04 and Group I the lowest 52.60 for problem nine. Group II had a mean of 57.41 trials but t test ratios revealed no statistically significant differences between the mean performance of the three groups.

Statistically significant differences were not observed among the three groups for any of the ten problems. No one group was able to solve any of the ten problems significantly better than any other of the two groups; again revealing evidence that no differences existed in the problem solving ability of any of the three groups as measured by chi square proportions except those related to chance error.

Failure of group members to solve individual problems was probably more the result of failure of the individual to arrive at adequate hypotheses, and if so, indicates the importance of inductive reasoning to problem solving. It would appear that there was no significant difference in any of the three group's inductive reasoning ability as measured by performance on problem 5 (triangle when both figures were red and square when both figures were green), problem 8 (square when both figures were red and triangle when both figures were green) and problem 10 (square when figures were in opposite corners to each other and triangle when the figures were in corners adjacent to each other), all which required second order generalizations that were dependent upon the relationship between the two geometric figures rather than upon color, position or alternation.

Early in the data gathering process the experimenter observed that some of the ten problems were more difficult than others. Therefore it was decided that a determination of the degree of difficulty would be determined by the mean trials used per problem by each group and the results were as follows: The mean number of trials used by each group for each problem was used to rank the ten problems from simplest (fewer mean trials) to the most difficult (most mean trials). Group I's order was found to be 2, 4, 8, 5, 1, 9, 6, 3, 7, 10. Group II's order was found to be 2, 4, 8, 5, 9, 1, 6, 7, 3, 10. Group III's order was found to be 2, 4, 1, 8, 5, 6, 3, 9, 7, 10. Group I and II's order of difficulty for the ten problems was more alike than was Group III's order. Group II required a larger mean number of trials on the demonstration problem and Group III required the least mean number of trials to solve the demonstration problem. The demonstration problem involved verbalized instructions and this may have accounted for the observed difference. More research would have to be done, however, to determine the significance, if any, of the reason for the difference. While there were slight differences in the order of difficulty of the ten problems as ranked by mean trials, each group's order of difficulty does not imply differences in problem solving ability and are listed here only as interesting data.

Although variations were observed between groups when the total sample trials were tallied, the order of difficulty for the ten problems was as follows: (Total of all three groups tested) 2, 4, 8, 3, 5, 1, 6, 7, 9, 10. All ten problems were solved by subjects from each of the three groups. Within all of the grade levels, all ten problems were solved by at least one person, except problem ten and it was not solved by any second graders in Group II or Group III.

One subject out of the eighty-four tested was not able to solve any of the ten problems, and he was a second grade subject from Group III. Two subjects out of the total sample solved two problems; one of them was from Group I second grade; the other one was from Group III, fourth grade. One subject solved three problems, four subjects solved four problems. Thirteen subjects solved five problems. Eleven subjects solved six problems. Eighteen subjects solved seven problems. Sixteen subjects solved eight problems, fifteen subjects solved nine problems, and three subjects solved ten problems.

Tables 7 and 11 indicate no significant difference existed at the .05 level between any two of the three groups studied as to subjects problem solving ability. No difference was measured as to the proportion of subjects solving or not solving any of the ten problems with correct verbal generalization. The χ^2 values in Table 11, of the proportion of subjects between Group I versus Group II, Group I versus Group III and Group II versus Group III, showed no statistically significant difference at the .05 level for any of the ten problems. Fisher's exact probability method was computed when the expected frequency for any cell was less than five. The differences indicated were taken to be chance errors.

Observing tables 2, 3, and 4 one can see, when the total groups performance was considered, that problem solving ability increased as chronological age and mental age increased. Stated another way, when all of the second graders problem solving performances are compared with fourth graders and then with sixth graders, the results are (1) the youngest (second grade) group required more trials to solve the ten problems, they solved the fewest number of the ten problems and they solved the fewest problems with correct verbal generalization. (2) The middle (fourth grade) group required fewer trials for the ten problems than the second graders but more than the sixth graders. (3) The oldest (sixth grade) group required the fewest trials to solve the ten problems. The same was observed to be true for comparisons by the most number of problems solved and the most number of problems correctly verbally generalized.

When comparisons within each grade level were observed, increases in mental age and chronological age had the higher predictive value for the degree of success in the problem solving situation as measured within the limits of this study. It was not within the limits of this study to make an assessment as to the specific reasons why younger children or older children could or could not achieve at problem solving.

The average number out of the ten problems possible that were solved, by correctly achieving the verbal generalization to the criterion, for Group I was 6.30. Subjects in Group II averages solving 5.75 and Group III subjects averaged solving 6.07. Averages by grade levels and by groups for the number of problems solved with correct verbal generalization of the ten problems revealed that Group I second graders averaged solving 5.50 problems. Group II second graders averages solving 5.02 problems, and Group III second graders averaged solving 5.44 problems out of a possible ten problems. The fourth graders in Group I averaged solving 6.62 out of a possible ten problems, by achieving correct verbal generalizations to the criterion, Group II subjects averaged 5.63, and Group III subjects averaged 5.44. Sixth grade subjects in Group I averaged solving 6.77 out of a possible ten problems by achieving the correct verbal generalization to the criterion; Group II subjects solved 6.33, and subjects in Group III solved 7.33.

For 95.3 percent of the group tested the Problem Box and the ten selected problems seem adequate to test their range of problem solving ability. Of the group tested, only four of the eighty-four subjects range of problem solving ability was not adequately measured by the ten problems. Analysis reveals that the ten problems were too difficult for one subject (he did not solve any of the ten problems) and not difficult enough for three subjects since they were able to solve all of the ten problems. The four exceptions accounted for only 4.7 percent of the total group used as subjects for the study.

TABLE 5

PROBLEMS SOLVED AND TOTAL NUMBER OF PROBLEMS SOLVED

Lower White			Lower Black			Higher White		
Subject	Problems Solved	Total Solved	Subject	Problems Solved	Total Solved	Subject	Problems Solved	Total Solved
1	1,2,4,7,9	5	26	2,8	2	58	2,3,4,5,6,7,8,9	8
2	2,3,4,5,6,7,8,9	8	27	2,3,4,7,8,9	6	59	1,2,3,4,5,6,7,8,9	9
3	1,2,3,4,6,7,8,9,10	9	28	2,4,5,7,8,9	6	60	1,2,3,4,9	5
4	1,2,4,5,9	5	29	1,2,4,7,8,9	6	61	2,3,4,5,6,7,8,	7
5	1,2,3,4,5,6,7,8,9	9	30	1,2,3,4,5,6,7,8	8	62	1,2,3,4,6	5
6	2,3,4,6	4	31	2,3,4,5,8	5	63		0
7	1,2,3,4,5,6,8	7	32	1,2,3,4,5,6,8,9	8	64	2,4,7,8,9	5
8	2,4,6,8	4	33	1,2,4,5,7,8	6	65	1,2,3,4,5,6,7,9	8
9	1,2,3,4,5,6,7,8,10	9	34	2,4,5,6,7,8,9	7	66	1,2,3,4,5,6,7,8,9	9
10	3,4,5,6,7,8,9	7	35	1,2,4,8,9	5	67	1,2,4,5,8,9	6
11	1,2,3,4,6	5	36	1,2,3,4,5,6,8,10	8	68	1,2,3,4,5,6,8,9	8
12	1,2,3,4,6,9,10	7	37	2,4,5,7,8	5	69	1,2,3,4,5,6,8,9	8
13	1,2,3,4,5,6,7,8,9	9	38	1,2,4,5,7,8,10	7	70	1,2,4,6,8,9,10	7
14	2,3,4,5,6,8	6	39	2,4,6,7,9	5	71	1,2,3,4,5,6,7,8,9,10	10
15	1,2,4,5,7,8,9	7	40	2,4,5	3	72	1,2,4,5,8	5
16	1,2,3,4,5,6,8,10	8	41	2,3,4,5,6,8,9	7	73	2,4	2
17	1,2,3,4,5,6,8,10	8	42	1,2,3,4,5,6,8,9,10	9	74	1,2,4,5,6,7,9	7
18	1,2,4,5,7,8,9	7	43	1,2,3,4,6,7,9	7	75	1,2,3,4,5,6,7,8,9,10	10
19	1,2,4,5,7,8,9	7	44	1,2,3,4,5,6,8,10	8	76	1,2,3,4,6,7	6
20	1,2,3,4,5,7,8,9,10	9	45	1,2,3,4,6,8,10	7	77	1,2,3,4,5,6,8	7
21	1,2,4,5,8,9	6	46	2,4,5,8	4	78	1,2,3,4,5,6,7,8,9	9
22	1,2,3,4,5,6,7,8,9	9	47	2,3,4,5,6,7,9,10	8	79	1,2,3,4,5,6,7,8,9	9
23	1,2,3,4,5,6,7,8,9	9	48	1,2,3,4,5,6,7,8,9,10	10	80	1,2,3,4,5,6,8,9	8
24	1,2,4,6,8	5	49	1,2,3,4,5,7,8,9	8	81	1,2,3,4,5,6,8	7
25	1,2,3,9	4	50	1,2,4,6,9	5	82	1,2,3,4,5,6,8	7

TABLE 5--(Continued)

Lower White			Lower Black			Higher White		
Sub-ject	Problems Solved	Total Solved	Sub-ject	Problems Solved	Total Solved	Sub-ject	Problems Solved	Total Solved
			51	1,2,3,4,5,6,8,9,10	9	83	1,2,3,4,6,8	6
			52	1,2,4,5,6,8,9	7	84	1,2,3,4,5,6,7,8	9
			53	1,2,3,4,6,7	6			
			54	1,2,3,4,5,6,7,8,9	9			
			55	1,2,3,4,5,6,8,9	8			
			56	1,2,4,6,8,9	6			
			57	1,2,3,4,5,6,7,9	8			

TABLE 6

NUMBER OF TRIALS PER PROBLEM USED BY LOWER WHITE, GROUP I SUBJECTS

Subject	Grade	C.A.	M.A.	1	2	3	4	5	6	7	8	9	10	Total Trials	Mean
1	2	88	86	41	15	100	10	100	100	13	100	11	100	590	59
2	2	87	88	100	10	99	10	28	10	46	13	37	100	453	45
3	2	95	94	25	11	57	15	100	60	52	10	57	23	410	41
4	2	93	90	53	11	100	19	12	100	100	100	15	100	610	61
5	2	93	96	12	15	16	2	4	36	57	9	31	100	282	28
6	2	96	102	100	11	14	12	100	36	100	100	100	100	673	67
7	2	91	96	55	10	59	15	13	27	100	13	100	100	492	49
8	2	86	90	100	7	100	10	100	89	100	74	100	100	780	78
9	4	111	108	35	10	32	10	14	20	52	24	100	64	361	36
10	4	111	112	100	100	56	10	21	15	40	25	82	100	549	55
11	4	109	110	58	10	57	10	100	95	100	100	100	100	730	73
12	4	111	112	12	11	61	13	100	13	100	100	18	49	477	48
13	4	124	126	19	11	17	11	10	19	96	17	16	100	316	32
14	4	114	118	100	17	57	10	14	21	100	13	100	100	532	53
15	4	110	116	34	5	100	8	27	100	10	32	17	100	433	43
16	4	109	118	47	10	91	10	16	76	100	20	100	61	531	53
17	6	141	142	12	10	46	10	68	17	100	24	100	16	403	40
18	6	144	144	12	10	100	10	13	100	14	12	15	100	386	39
19	6	138	140	45	10	100	10	52	100	15	13	46	100	471	47
20	6	144	146	26	10	73	14	11	100	31	11	13	100	409	41
21	6	146	148	28	10	100	12	14	100	100	13	36	100	513	51
22	6	155	156	45	10	19	10	12	18	83	11	29	100	337	34
23	6	143	150	12	10	30	10	18	15	31	59	16	100	301	30
24	6	139	148	51	10	100	10	100	42	100	28	100	100	641	64
25	6	144	152	92	10	86	100	100	100	100	100	12	100	800	80

TABLE 6--(Continued)

NUMBER OF TRIALS PER PROBLEM USED BY LOWER BLACK, GROUP II SUBJECTS

Subject	Grade	C.A.	M.A.	1	2	3	4	5	6	7	8	9	10	Total Trials	Mean
26	2	89	88	100	39	100	100	100	100	100	55	100	100	894	89
27	2	98	98	100	11	99	10	100	100	43	13	24	100	600	60
28	2	92	92	100	10	100	10	23	100	51	46	39	100	579	58
29	2	88	88	52	10	100	11	100	100	10	34	51	100	568	57
30	2	88	88	46	18	37	10	14	30	11	13	100	100	379	38
31	2	93	94	100	10	51	10	33	100	100	14	100	100	618	62
32	2	98	100	16	10	23	14	99	27	100	35	13	100	437	44
33	2	94	98	39	10	100	19	30	100	34	28	100	100	560	56
34	2	97	104	100	14	100	11	11	60	78	10	11	100	495	50
35	4	117	114	19	10	100	13	100	100	100	16	55	100	613	61
36	4	121	118	42	10	20	10	24	15	100	23	100	29	373	37
37	4	114	114	100	11	100	74	18	100	97	20	100	100	720	72
38	4	114	116	32	10	100	26	93	100	100	22	100	16	599	60
39	4	112	114	100	10	100	14	100	52	61	100	10	100	647	65
40	4	118	112	100	10	100	10	24	100	100	100	100	100	744	74
41	4	111	116	100	10	32	10	13	72	100	13	40	100	490	49
42	4	118	124	37	10	38	12	13	74	100	23	14	25	346	35
43	4	121	128	24	11	65	14	100	32	36	100	43	100	525	53
44	4	112	120	34	10	15	12	25	33	100	11	83	38	361	36
45	4	112	122	71	13	69	14	100	48	100	94	100	24	633	63
46	6	141	136	100	10	100	10	22	100	100	13	100	100	655	66
47	6	142	152	100	10	80	11	13	54	11	100	20	30	429	43
48	6	138	134	12	10	91	20	13	45	12	13	23	45	284	28
49	6	141	138	45	10	92	19	13	100	15	14	12	100	420	42
50	6	136	136	47	10	100	11	100	97	100	100	70	100	735	74
51	6	140	140	12	10	58	10	13	18	100	13	27	69	330	33
52	6	143	146	71	10	100	11	19	40	100	13	70	100	534	53
53	6	142	146	77	10	70	10	100	32	51	100	100	100	650	65
54	6	136	140	76	10	99	10	73	41	100	13	28	100	550	55
55	6	144	148	22	10	32	12	49	34	100	27	32	100	418	42
56	6	140	150	21	4	100	10	100	32	100	8	25	100	500	50
57	6	146	156	16	6	95	10	71	69	28	100	92	100	587	59

TABLE 6--(Continued)

NUMBER OF TRIALS PER PROBLEM USED BY HIGHER WHITE, GROUP III STUDENTS

Subject	Grade	C.A.	M.A.	1	2	3	4	5	6	7	8	9	10	Total Trials	Mean
58	2	91	88	100	12	100	13	59	21	51	28	83	100	567	57
59	2	93	90	92	10	68	10	53	28	56	62	30	100	509	51
60	2	97	94	26	10	43	15	100	100	100	100	17	100	611	61
61	2	93	92	100	11	46	14	52	42	72	20	100	100	557	56
62	2	95	96	18	10	29	10	100	54	100	100	100	100	621	62
63	2	90	90	100	100	100	100	100	100	100	100	100	100	1000	100
64	2	91	92	100	12	100	14	100	100	12	23	25	100	586	59
65	2	94	96	32	10	36	12	51	31	35	100	97	100	504	50
66	2	92	96	52	11	70	12	19	21	72	22	54	100	433	43
67	4	115	114	74	4	100	2	21	100	100	13	60	100	574	57
68	4	114	112	44	10	81	10	20	43	100	24	83	100	515	52
69	4	112	112	16	10	37	10	51	79	100	19	12	100	434	43
70	4	117	118	52	11	100	11	100	39	100	57	64	69	603	60
71	4	114	116	25	10	45	10	25	28	27	14	70	24	278	28
72	4	111	114	100	10	100	10	44	100	100	22	100	100	686	69
73	4	116	120	100	12	100	10	100	100	100	100	100	100	822	82
74	4	114	120	12	10	100	10	67	90	75	100	36	100	600	60
75	4	120	130	18	10	49	15	11	69	14	10	13	63	272	27
76	6	140	134	14	10	43	16	100	80	28	100	100	100	591	59
77	6	138	134	29	10	26	26	13	18	100	46	100	100	468	47
78	6	136	134	16	10	79	12	13	27	40	13	24	100	334	33
79	6	141	140	12	10	22	10	33	24	35	22	80	100	348	35
80	6	144	144	12	10	34	10	18	58	100	24	57	100	423	42
81	6	136	138	13	11	62	10	29	45	100	13	100	100	483	48
82	6	139	142	20	10	58	12	13	28	100	24	100	100	465	46
83	6	145	152	20	10	26	10	100	22	100	100	100	100	588	59
84	6	136	144	8	10	41	16	56	15	45	15	32	100	338	34

TABLE 7

SUBJECTS ACHIEVING CORRECT VERBAL GENERALIZATIONS

Lower White			Lower Black			Higher White		
Subject	Problems - Verbal Generalizations Achieved	Total Solved	Subject	Problems - Verbal Generalizations Achieved	Total Solved	Subject	Problems - Verbal Generalizations Achieved	Total Solved
1	1,2,4,7,9	5	26	2,8	2	58	2,3,4,5,6,7,8,9	8
2	2,3,4,5,6,7,8,9	8	27	2,3,4,7,8,9	6	59	1,2,3,4,5,6,7,8,9	9
3	1,2,4,7,8,9	6	28	2,4,5,7,8	5	60	1,2,3,4	4
4	1,2,4,5,9	5	29	1,2,4,7,8,9	6	61	2,3,4,5,6,7,8	7
5	1,2,3,4,5,6,7,8,9	9	30	1,2,4,5,6,7,8	7	62	1,2,4	3
6	2,3,4,6	4	31	2,3,4,5,8	5	63		0
7	1,2,3,4,5,6	6	32	1,2,4,9	4	64	2,4,7,9	4
8	2	1	33	1,2,4,5,7,8	6	65	1,2,3,4,5,6,7,9	8
9	1,2,3,4,5,6,7,8	8	34	2,5,6,7,8,9	6	66	1,2,4,5,6,8	6
10	3,4,5,6,7,8,9	7	35	1,2,4,8,9	5	67	1,2,4,5,8,9	6
11	1,2,3,4,6	5	36	1,2,3,4,5,6,8	7	68	1,2,4,5,6,8,9	7
12	1,2,3,4,6,9	6	37	2,4,5,7,8	5	69	1,2,4,8,9	5
13	1,2,3,4,6,7,8,9	9	38	1,2,4,5,7,8	6	70	2,4	2
14	2,4,5,8	4	39	2,4,7,9	4	71	1,2,4,5,6,7,9	7
15	1,2,4,5,7,8	6	40	2,4	2	72	1,2,4,5,8	5
16	1,2,3,4,5,6,8	7	41	2,3,4,5,6,8,9	7	73	2,4	2
17	1,2,3,4,5,6,8,10	8	42	1,2,3,4,5,6,8,9	8	74	1,2,4,5,7,9	6
18	1,2,4,5,7,8,9	7	43	1,2,3,4,6,7,9	7	75	1,2,3,4,5,6,7,8,9	9
19	1,2,4,5,7,8,9	7	44	1,2,3,4,5,6,8,10	8	76	1,2,3,6,7	5
20	1,2,3,4,5,7,8,9	8	45	4,6,8	3	77	1,2,3,4,5,6,8	7
21	1,2,4,5,8,9	6	46	2,4,5,8	4	78	1,2,3,4,5,6,7,8,9	9
22	1,2,3,4,5,6,7,8,9	9	47	2,4,5,7,9	5	79	1,2,3,4,5,6,7,8,9	9
23	1,2,3,4,5,6,7,8,9	9	48	1,2,3,4,5,7,8,9	8	80	1,2,3,4,5,6,8,9	8
24	1,2,4,8	4	49	1,2,4,5,7,8,9	7	81	1,2,3,4,5,6,8	7
25	1,2,9	3	50	1,2,4	3	82	1,2,3,4,5,6,8	7

TABLE 7--(Continued)

Lower White			Lower Black			Higher White		
Sub-ject	Problems - Verbal Generalizations Achieved	Total Solved	Sub-ject	Problems - Verbal Generalizations Achieved	Total Solved	Sub-ject	Problems - Verbal Generalizations Achieved	Total Solved
			51	1,2,3,4,5,6,8,9	8	83	1,2,3,4,6	5
			52	1,2,4,5,6,8,9	7	84	1,2,3,4,5,6,7,8,9	9
			53	1,2,4,6,7	5			
			54	1,2,4,5,6,7,8,9	8			
			55	1,2,3,4,5,6,8,9	8			
			56	1,2,4,6,8,9	6			
			57	1,2,4,5,7,9	6			

TABLE 8

CHI SQUARE VALUES FOR THE PROPORTION OF EACH GROUP FOR EACH OF THE TEN PROBLEMS PASSED-FAILED

Groups	Problems									
	1	2	3	4	5	6	7	8	9	10
I vs. II	1.1780	.4385*	.7219	1.0025*	.0089	.2055	.0071	.0358	.0133	.0074
I vs. III	.0100*	.05090*	.2340	1.0180*	.0345	.5439	.1828	.0245	.0056	.0156*
II vs. III	1.8627	.4576*	1.4806	.5049*	.0928	1.6159	1.1454	1.356	.0026	1.8552

*Fishers Exact Probability Method was used because Fe was less than 5.

Note: None significant at the .05 level.

TABLE 9

STANDARD DEVIATION AND MEAN NUMBER OF TRIALS

		Problem									
		1	2	3	4	5	6	7	8	9	10
Group I	Mean	48.56	14.16	66.8	14.49	45.88	56.36	69.60	40.84	52.60	88.52
	Standard Deviation	31.49	17.67	31.29	17.71	39.34	37.16	34.63	36.30	39.70	24.58
Group II	Mean	59.72	11.1562	77.06	17.12	53.31	65.78	73.06	41.03	57.41	83.62
	Standard Deviation	33.64	5.4262	29.37	18.69	38.30	30.97	35.08	37.03	34.78	23.48
Group III	Mean	44.63	13.48	62.78	15.19	53.63	54.15	72.67	47.04	68.04	94.67
	Standard Deviation	29.50	17.02	28.25	17.08	33.78	31.22	31.67	36.35	32.42	18.70

TABLE 10

t-TEST RATIOS FOR MEAN NUMBER OF TRIALS USED

Comparison	Problems									
	1	2	3	4	5	6	7	8	9	10
I vs. II	-1.2648	0.7979	-1.2388	-0.5442	-0.7029	-1.0016	-0.3658	-0.0694	-0.4697	0.7467
I vs. III	0.4544	0.1380	0.4757	-0.1512	-0.7444	0.2269	-0.3258	-0.6063	-1.4986	-0.9890
II vs. III	1.8041	0.6730	1.8674	0.4090	0.0332	1.4064	0.0447	-0.5685	-1.1925	-1.9757

None significant at the .05 level.

TABLE 11

CHI SQUARE VALUES FOR THE PROPORTION OF EACH GROUP FOR EACH OF THE TEN PROBLEMS PASSED-FAILED THROUGH ACHIEVING THE CORRECT VERBAL GENERALIZATION

Groups	Problems									
	1	2	3	4	5	6	7	8	9	10
I vs. II	2.1259	.5012*	2.6773	.3766*	.5726	.3778	.0221	.7653	.0818	.0300
I vs. III	.0286	.5090*	.0010	.3889*	.1720	.6362	.2962	.4240	4.8288	.0553*
II vs. III	1.6230	.5040*	2.6622	.3825*	.1110	2.1776	.1794	1.4253	4.2078	.0277*

*Fishers Exact Probability Method was used because Fe was less than 5.

TABLE 12

POINT BISERIAL CORRELATION BETWEEN TRIALS USED FOR PROBLEMS SOLVED ALSO VERBALIZED (q) AND TRIALS USED FOR PROBLEMS SOLVED BUT NOT VERBALIZED (p) FOR EACH GROUP

GROUP I

Prob-lems	n	Mean Trials		Proportion		Standard Deviation for Total Group	r_{pb}
		(p)	(q)	(p)	(q)		
1	20	-	36	.00	1.00	-	-
2	24	-	11	.00	1.00	-	-
3	19	67	48	.1764	.8230	26.0242	.2750
4	24	10	11	.0416	.9583	-	-
5	17	-	20	.00	1.00	-	-
6	17	53	31	.2352	.7647	25.2382	.3775
7	13	-	42	.00	1.00	-	-
8	19	44	20	.1052	.8947	20.9927	.3488
9	16	17	29	.0625	.9375	-	-
10	6	59	16	.8333	.1666	-	-

Note: p significant at .05.

TABLE 12--(Continued)

POINT BISERIAL CORRELATION BETWEEN TRIALS USED FOR PROBLEMS SOLVED ALSO VERBALIZED (q) AND TRIALS USED FOR PROBLEMS SOLVED BUT NOT VERBALIZED (p) FOR EACH GROUP

GROUP II

Problems	n	Mean Trials		Proportion		Standard Deviation for Total Group	r_{pb}
		(p)	(q)	(p)	(q)		
1	22	71	35	.0454	.9545	-	-
2	31	13	41	.0322	.9677	-	-
3	18	71	50	.4444	.5555	28.3829	.3590
4	31	11	15	.0322	.9677	-	-
5	22	62	29	.0909	.9090	26.4229	.3522
6	21	57	44	.2857	.7142	22.9477	.2606
7	16	-	41	.00	1.00	-	-
8	25	35	23	.04	.960	-	-
9	19	44	34	.1052	.8947	22.4683	.2864
10	8	34	38	.8750	.1250	-	-

Note: p significant at .05.

TABLE 12--(Continued)

POINT BISERIAL CORRELATION BETWEEN TRIALS USED FOR PROBLEMS SOLVED ALSO VERBALIZED (q) AND TRIALS USED FOR PROBLEMS SOLVED BUT NOT VERBALIZED (p) FOR EACH GROUP

GROUP III

Problems	n	Mean Trials		Proportion		Standard Deviation for Total Group	r_{pb}
		(p)	(q)	(p)	(q)		
1	22	52	31	.0454	.9545	-	-
2	26	-	10	.00	1.00	-	-
3	20	52	49	.25	.75	14.2157	.1078
4	26	16	12	.0384	.9615	-	-
5	19	-	33	.0526	.9473	-	-
6	21	66	35	.1904	.8094	21.9208	.5409*
7	13	74	38	.1538	.8461	18.0600	.7150*
8	20	49	24	.20	.80	21.4347	.4654*
9	17	45	50	.1764	.8235	26.4476	.0740
10	3	52	-	1.00	.00	-	-

*p significant at .05.

CHAPTER III

SUMMARY AND CONCLUSIONS

A comparative study of problem solving ability was made, using 84 public school students in grades two, four and six. Twenty-six subjects were second graders, twenty-eight subjects were fourth graders, and thirty subjects were sixth graders. The second graders varied in chronological age from 7.5 years to 8.5 years, the fourth graders varied from 9.0 years to 10.3 years, and the sixth graders varied in age from 11.5 years to 12.9 years.

The 84 subjects were selected because they were attending one of three types of elementary school in the Oklahoma City Public School System, I-89. School children attending these schools were representative of three types of socio-economic neighborhoods found in most urban centers. Group I subjects were representative of a lower socio-economic white neighborhood, Group II subjects were representative of a lower socio-economic black neighborhood, and Group III subjects were representative of a higher socio-economic white neighborhood. Each of the three types of schools was made up of 95 percent or more white or black student population and have previously been designated as meeting the criteria of differing in socio-economic neighborhoods.

Comparisons were made and statistical hypotheses tested of the problem solving ability for three groups of children, whose I.Q.'s were within the average range of 95-105 and who had differences in their socio-econcmic backgrounds. The results of testing for differences in problem solving ability with the Problem Box, built and used in this study, necessitated the acceptance of the null hypotheses 1 through 9. Hypotheses one, two and three stated that no statistically significant difference in problem solving ability was expected and when the three groups were compared, differences were not found to exist in the problem solving ability on any of the ten problems between any of the three groups. The proportion of subjects passing or failing any problem for any one group did not exceed significantly the proportion of either of the other groups passing or failing any one of the ten possible problems.

Hypotheses four, five and six were also accepted. This study revealed that no significant difference in problem solving ability was found between any one of the three groups tested as to the number of trials used to solve each of the ten problems. Hypotheses seven, eight and nine were also accepted as true statements. Significant differences were not found in problem solving ability between any one of the three groups as to the proportion of subjects in any one group exceeding the proportion of either of the other groups for any of the ten possible problems passed or failed as to achieving a correct verbal generalization to the criteria for each problem.

Hypothesis ten, that zero correlation exists between the mean number of trials and achieving verbal generalizations for subjects in Group I and II respectively, was accepted. Hypothesis 10 was also accepted for Group III on all problems except problems 6, 7, and 8 and for these problems hypothesis 10 was rejected.

Subjects from Group I and II who solved any of the ten problems with a correct verbal generalization, did so with fewer mean trials than subjects solving the problem by lighting ten reward lights in succession but could not give the correct verbal generalization. The same was found for 70 percent of the ten problems solved by Group III subjects. Three out of the ten problems tended to be solved by Group III subjects with fewer trials when they could not give the correct verbal generalization for the solution than when subjects could verbalize the correct generalization.

Comparisons of problem solving ability, when subjects were compared by chronological and mental age, revealed that problem solving, as measured by all three criteria tested, increased as mental age and chronological age increased. Increases in I.Q. scores (95-105) proved to be an unreliable indicator that an increase in problem solving, as measured by the three criteria used in this study, would result. Increases were observed in the average number of problems solved at each successive age level for all three groups. Decreases in the mean trials used to solve the problems were observed at each successive grade level for all three groups.

The study showed that no significant differences exist in the problem solving ability on the Problem Box. If noticeable differences in school achievement of differing socio-economic groups of children are found, it may be the result of the way or ways different children perceive problems and the way different children cope with the frustration that seems to be aroused in problem situations. More research will be required to investigate this aspect of problem solving. Special problems could be devised for further research using the Problem Box built for this study.

Discussion of Problem Solving

The human behavior involved in problem solving begins with the individual's awareness of the problem. Though individuals apparently respond somewhat differently, there appears to be factors that will stimulate and encourage the process of problem solving among children. The specific factors probably vary with individuals but at least two ways to encourage problem solving behavior among individuals seem worth noting as it relates to school related problem solving behavior.

Problem solving behavior may be encouraged by utilizing as a means those learning experiences of children which arise from each student's own needs, goals, interests and curiosities. Another way to encourage problem solving behavior may be, by stimulating student's interest in problem solving situations that are relevant problems for the student. Educators may encourage students to become effective problem solvers by the educators creating problems that arouse the student's curiosity, provoke their interest, and require them to expend effort toward the attainment of the desired goal. Problem solving behavior provides its reward when goal attainment is encouraged and rewarded by people who are important to the student. It may be that a person thinks that a particular reward will be appropriate to encourage problem solving behavior when the reward may be inappropriate for that individual. Students who achieve at problem solving do so as a result of adequate analysis of the goal and this provides part of the justification for the school to provide the necessary background of information and knowledge that offers students ways to seek relevant information and to acquire ways to test proposed hypotheses.

Education that rewards problem solving behavior probably contributes to the development of students hypothesis-testing which allows for deductive reasoning with its "if then" kinds of relationships. If school personnel are to be effective in assisting students to become more efficient problem solvers, they might start by identifying some of the schools "relevant" problems. Thorndike[19] helped educators by providing some "data" for consideration when he summarized what schools could contribute toward assisting students to become problem solvers.

> A wide range of interests and experiences, an organized and functional stock of background information, efficient skills for locating and organizing needed information, perseverance yet flexibility in attacking problem situations, a willingness to suspend judgment until the evidence is in, habits of testing critically any proposed solution, attitudes of critical appraisal of the reliability and bias of sources, skill in "if-then" thinking--these and many more are the qualities which a school must try to develop if it is to improve problem solving abilities in its pupils.

The Problem Box used for this study was deliberately built with flexibility and various characteristics which allow further experimentation of problem solving. Any further investigators using the Problem Box will be able to vary (1) the problems used, (2) the arrangement, shapes, size, and colors of images that can be projected onto the screen, (3) reward and reinforcement times are variable and (4) electric equipment

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[19] R. L. Thorndike, "How Children Learn the Principles and Techniques of Problem Solving," Forty-ninth Yearbook of the National Society for the Study of Education, Part 1, Learning and Instruction, Chicago, University of Chicago Press, 1950, pp. 192-216.

such as timers, recorders, electric shock devises can be easily devised and connected to the Problem Box.

It may be possible to use the Problem Box as a teaching device that might be used to reinforce subjects problem solving behavior. Additional investigation would need to be made if any of these ideas warrant consideration.

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A P P E N D I X

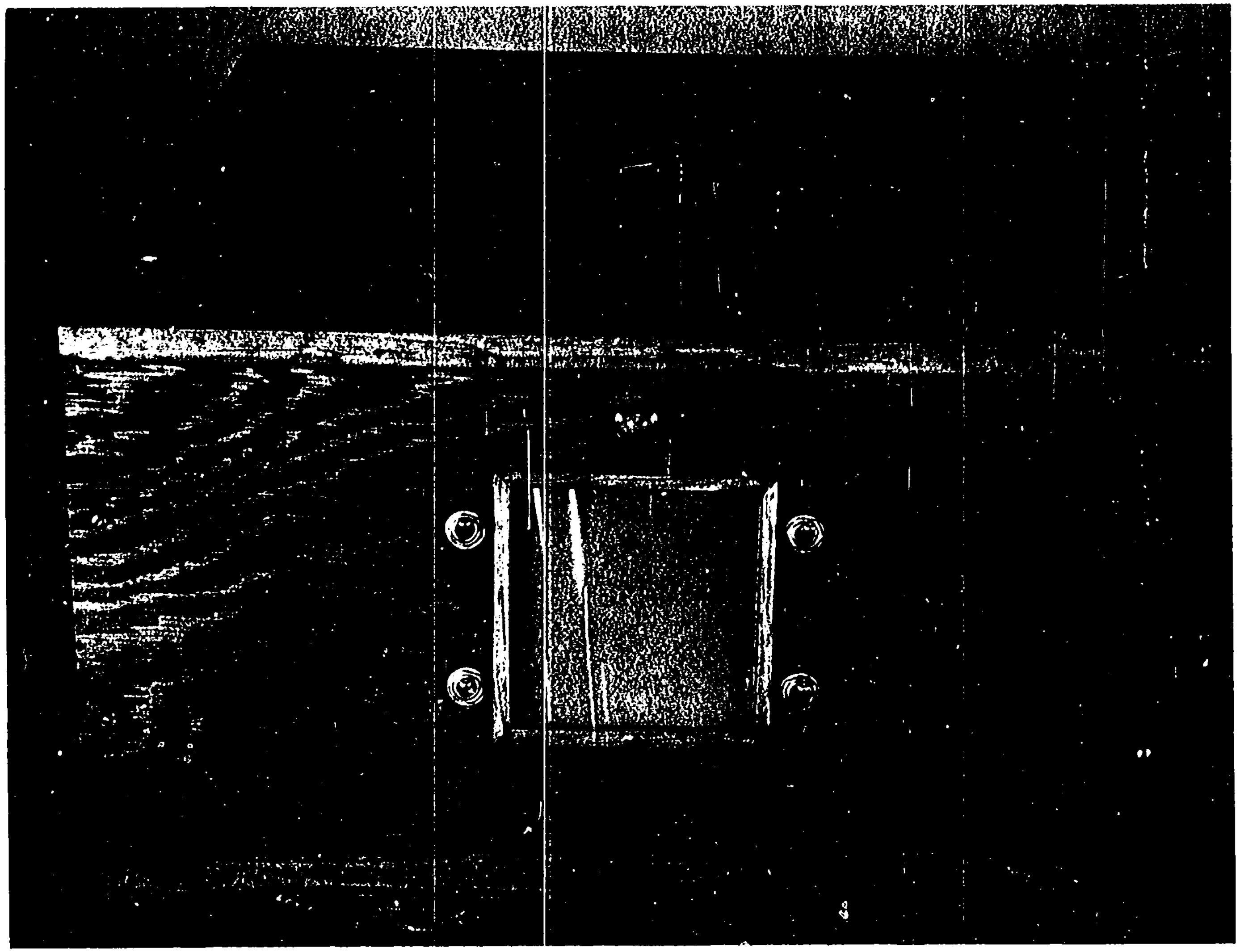


Illustration 1. Front view of Heath Problem Box

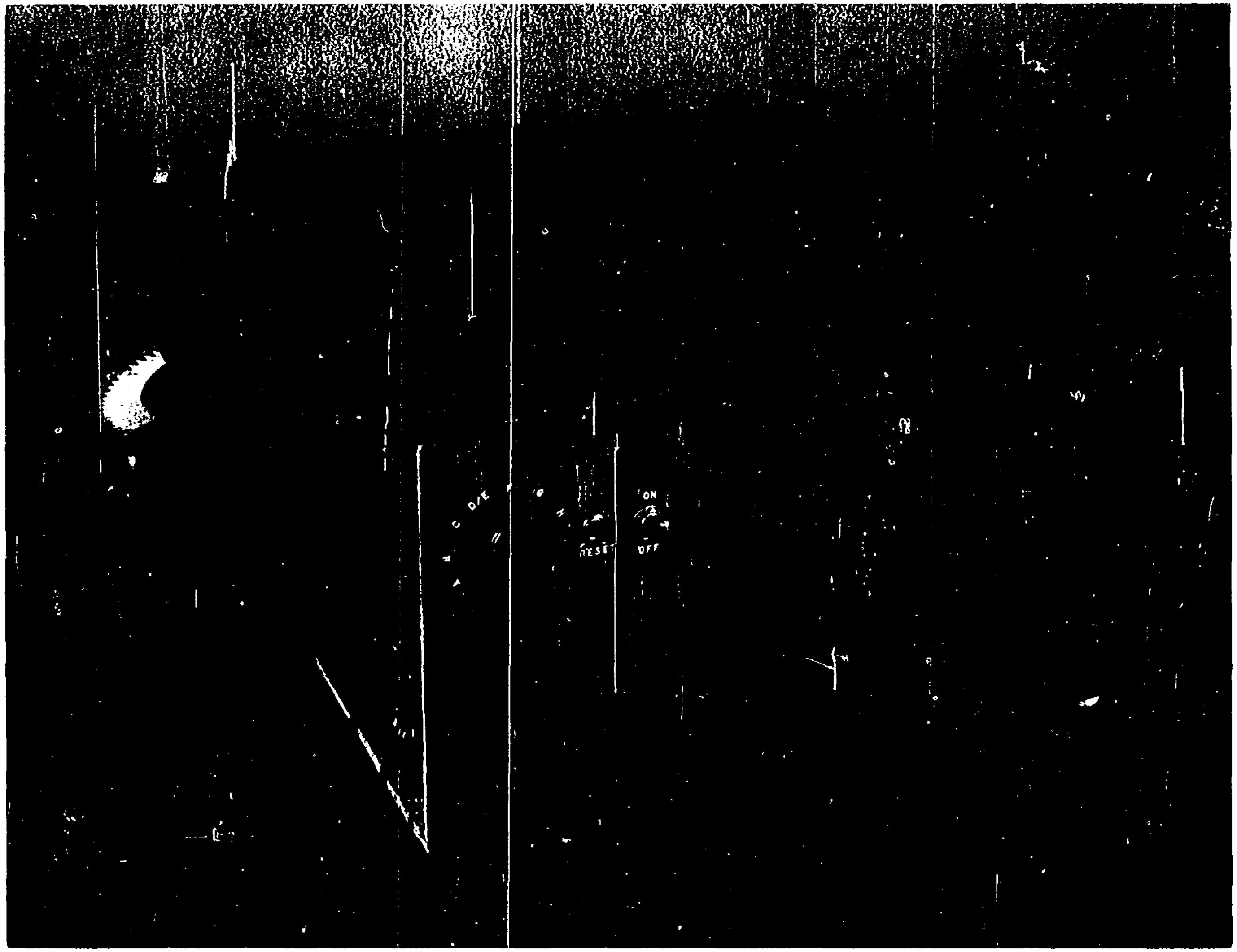


Illustration 2. Side view of Heath Problem Box

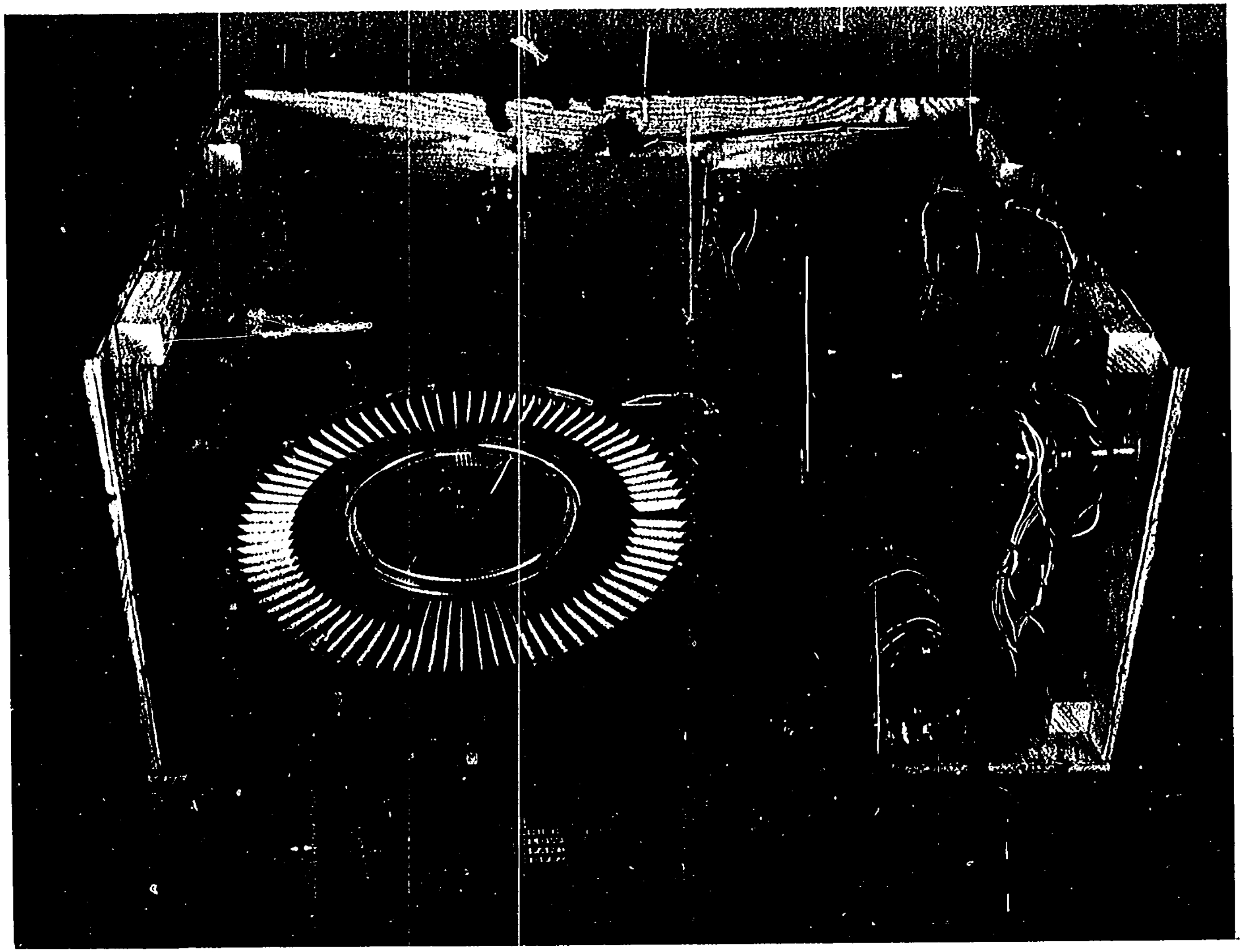


Illustration 3. Inside mechanism of Heath Problem Box

Problems 1,2,3

		ws	wt
ws	wt		
wt			
	ws	ws	wt
	ws	wt	
wt			ws
ws	wt	wt	ws
wt	ws		ws
		wt	
		ws	
wt	ws		wt
ws			wt
	wt	ws	
ws	wt	wt	ws
	wt		wt
ws		ws	
	ws	wt	ws
wt			

Problem 4

wt	gs		
		wt	gs
	wt		gt
gs		ws	
wt	gs		
		ws	gt
			gt
ws	gt	ws	
	ws		ws
gt		gt	
gs	wt		gs
		wt	
	wt		
gs		wt	gs
gs			ws
	wt	gt	
ws	gt		
		gs	gt
gt	ws		gs
		wt	

Problems 5,8,9,10

rs	rt	gt	
			gs
	rs	gt	gs
rt			
gt	gs	rs	
			rt
gt			gs
	gs	gt	
rt	rs	gs	gt
gs			rt
	gt	rs	
rt	rs	rs	rt
gs	gt		rs
		gt	
	rt		
rs		gs	gt
rt	rs		rt
		rs	

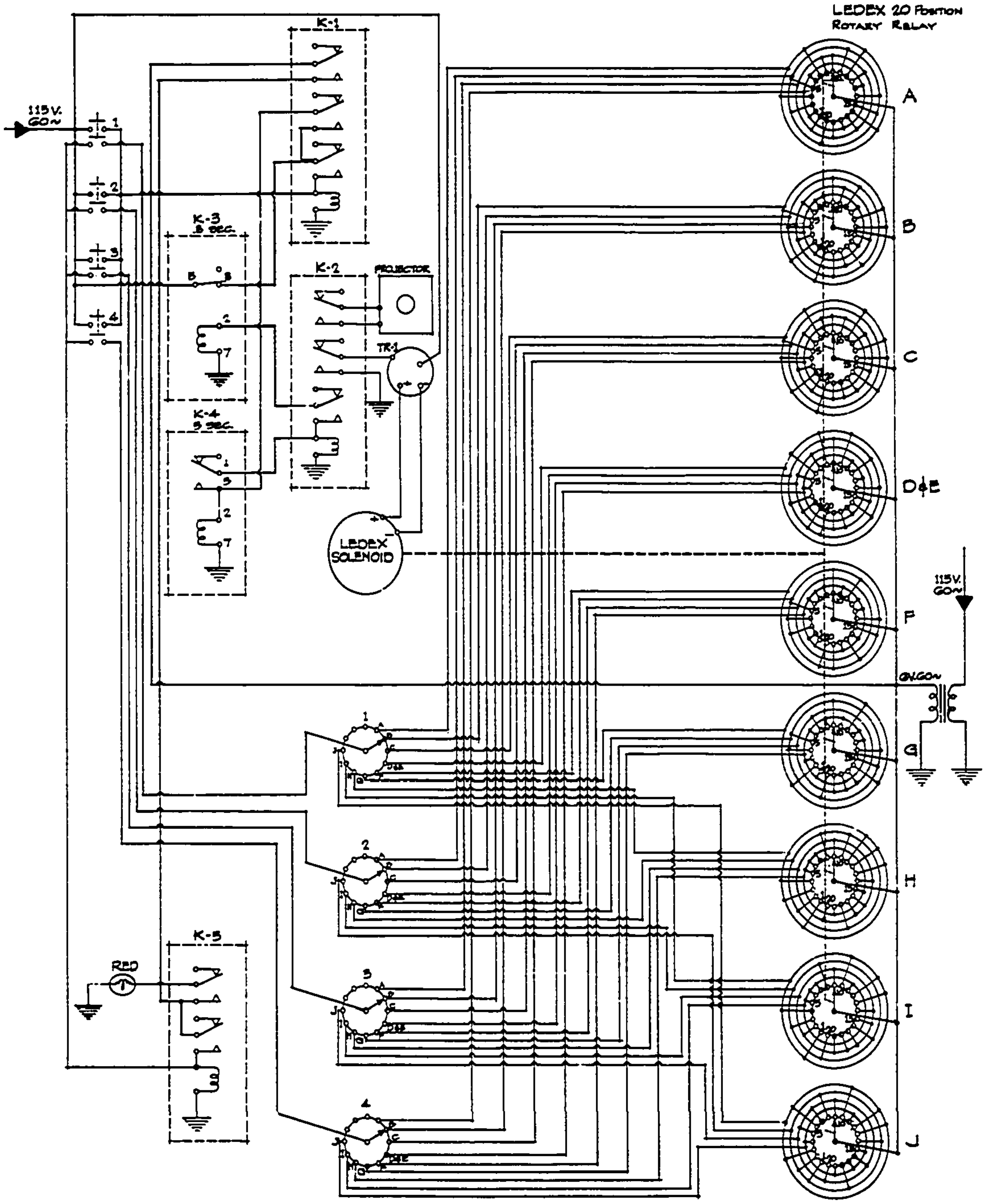
Problems 6,7

		rs	gt
gs	rt		
gt			
	rs	rs	gt
	gs	gt	
rt			rs
rs	gt	rt	gs
gt	rs		rs
		gt	
		gs	
rt	gs		rt
gs			gt
	rt	rs	
rs	gt	gt	rs
	rt		gt
gs		rs	
rt		rt	gs
	gs		

<u>Code for colors of Geometric figures</u>
w equals white
g equals green
r equals red

<u>Code for shapes of Geometric figures</u>
t equals triangle
s equals square

Figure 1. Order of Presentation of the Slides for the Ten Problems



SCHEMATIC DIAGRAM OF HEATH PROBLEM BOX

Figure 2