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GRADUATE COLLEGE

THE INFLUENCE OF AGE, SEX, AND SCHOOL SIZE UPON THE DEVELOPMENT OF FORMAL OPERATIONAL THOUGHT

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the degree of

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BY

WILLIAM ROEDOLPH LEWIS

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THE INFLUENCE OF AGE, SEX, AND SCHOOL SIZE UPON THE DEVELOPMENT OF FORMAL OPERATIONAL THOUGHT

APPROVED BY

DISSERTATION COMMITTEE

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CHAPTER I

THE PROBLEM

Introduction

One of the fundamental forces contributing to the profound changes of today is the expanding role accorded the rational powers of man. The statement has been made that the central purpose of education is the development of the rational powers of man.[1] These rational powers have been defined as "recalling, imagining, classifying, generalizing, comparing, evaluation, analyzing, synthesizing, deducing, and inferring."[2] To conduct educational experiences which will lead to the acquisition of facility with the rational powers, those experiences must be concerned with the process of investigation as opposed to the mastery of the product of investigation.

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[1] Educational Policies Commission, The Central Purpose of American Education (Washington, D.C.: National Education Association, 1961), pp. 1-5.

[2] Ibid., p. 5.

Instruction is not a matter of getting students to commit results to mind. Rather, it is to teach them to participate in the processes that make possible the establishment of knowledge. Knowing is such a process.[3] Involved in the process is the application of logic and empirical evidence to ideas, attitudes, actions, and to pursue better whatever personal goals. " . . . they are the essence of the ability to think . . . "[4]

During the past two decades there has been an unusual amount of emphasis on education for the development of mental processes. Various attempts have been made to break down the processes as well as products of thinking.[5] Intelligence testing is only one way of investigating the development of the ability to think, but such testing is generally concerned with the product of education rather than the process itself. Tests usually present few clues about the ways in which students arrive at the correct solution.

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[3]Jerome S. Bruner, "Some Theorems on Instruction Illustrated with Reference to Mathematics," in Theories of Learning and Instruction, Sixty-third Yearbook, Part I, The National Society for the Study of Education (Chicago: University of Chicago Press, 1964), p. 335.

[4]Educational Policies Commission, op. cit., p. 5.

[5]Jacob W. Getzels, "Creative Thinking, Problem-Solving, and Instruction," in Theories of Learning and Instruction, Sixty-third Yearbook, Part I, The National Society for the Study of Education (Chicago: University of Chicago Press, 1964), pp. 240-67.

Testing procedures that allow a tester to determine how the student arrives at the results obtained is generally called developmental testing. In general, developmental tests indicate what to expect and how to analyze what the student is doing.[6] In order to arrive at an adequate picture of the student's development of thinking abilities, a more in-depth search for clues in the student's motor responses, his play, his language, his behavior in free situations, his activities in social situations, and his response to problem situations should be made.[7]

Piaget divides the development of thinking processes into consecutive periods which he calls stages in the construction of operations.[8] These may be categorized as: (1) the sensorimotor period; (2) the period of symbolic and preconceptual thought, from about one and one-half to four years; (3) the development of intuitive thought, the preoperational period; (4) the development of concrete operations; and (5) the refining of formal thought which appears in adolescence. Piaget indicates the capacity for logical thought is developed between the ages of eleven and fifteen.

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[6]Bruner, op. cit., p. 313.

[7]Michael A. Wallace, "Research on Children's Thinking," in Child Psychology, Sixty-second Yearbook, Part I, The National Society for the Study of Education (Chicago: University of Chicago Press, 1963), pp. 236-76.

[8]Jean Piaget, The Psychology of Intelligence (New York: Harcourt, Brace and World, 1950), pp. 119-150.

Most high school and college students, therefore, should have realized a level of maturation which is sufficient to allow them to demonstrate advanced levels of thought.

Bruner has proposed an alternative set of stages:[9] enactive, a mode of representing events through motoric response; iconic, through images of the perceptual field; and symbolic, through design features involving remoteness and arbitrariness. Bruner states that language provides the means not only for representing experience but also for transforming it.

Vygotsky, with his linguistic approach to thinking, has proposed still another set of stages for concept formation.[10] He labeled the first stage unorganized congeries, by which is meant a vague grouping of individual objects. His second stage is thinking in complexes, where there is a factual connection between the elements included in a single complex. Thinking in concepts is Vygotsky's third stage, which depends on the ability to abstract and view the abstracted elements apart from the totality of the experience on which they are founded.

While development need not take the form of clearly marked steps or stages, much of the analysis of development has used the stage construct. Kessen has suggested that the

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[9]Bruner, op. cit., pp. 306-35.

[10]Lev S. Vygotsky, Thought and Language (New York: John Wiley and Sons, 1962), p. 168.

stage construct is a useful theoretical tool because it yields a highly compressed description of an aspect of behavior at some point in time and it organizes the description in sequential fashion.[11] Piaget, Bruner, and Vygotsky appear to think of the stages as dynamic structures in which certain activities, internal as well as external, produce mental structures or rules of logic by which the student solves problems.

Several studies have been made of the increase in critical thinking students undergo due to exposure to a science course. Yoesting and Renner compared first year college students involved in an elementary physical science class with similar students who had not been involved in such a course,[12] and found there was a significant increase in critical thinking by the physical science students.

Stafford and Renner[13] carried out Piagetian studies with first grade children to determine whether or not the boundary between preoperational and concrete levels of thought

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[11]William Kessen, "Stage and Structure in the Study of Children," Monograph of the Society for Research in Child Development, 1962, 27: 65-82.

[12]John W. Renner and Clarence Yoesting, "Is Critical Thinking an Outcome of a College General Physical Science Course?" School Science and Mathematics, March, 1969, pp. 199-206.

[13]Don G. Stafford and John W. Renner, "SCIS Helps the First Grader to Use Logic in Problem Solving," School Science and Mathematics, February, 1971, pp. 159-164.

could be lowered by means of appropriate educational experiences using the conservation tasks developed by Piaget. McKinnon investigated the effect of a science course in influencing the attainments of logical thought processes in freshman level college students.[14]

Wallace, summarizing the research on students' thinking during the past two decades, finds that the types of development and stages formulated by Piaget are generally supported by other workers. His conclusion that the human's basic cognitive categories for analyzing physical reality are a product of slow and laborious construction,[15] makes it clear that development is not a purely internal process but does represent the individual's interaction over a time with a very complex environment. Thus, the intellectual development of the child is no clockwork sequence of events; it also responds to influences from the environment, notably the school environment.[16]

Piaget's intellectual development model describes how the thinking of a student moves from concrete to abstract. As a student becomes more and more proficient in the

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[14]Joe W. McKinnon, "The Influence of a College Inquiry-Centered Course in Science on Student Entry Into Formal Operational Stage" (unpublished doctoral dissertation, The University of Oklahoma, 1970).

[15]Wallace, op. cit., pp. 236-76.

[16]Jerome S. Bruner, The Process of Education (New York: Vintage Books, 1960), p. 39.

utilization of his rational powers, they too, move from concrete to abstract usage. Therefore, the movement through the Piagetian model and the achievement of the central purpose of education can occur simultaneously, and thus be aided by the schools. Unfortunately, intellectual development as an area of research has been neglected. Thus, in the general area of the development of the ability to think, there is a field for new research of the greatest importance.[17]

McKinnon and Renner[18] found that sixty-six of one hundred thirty-one college freshmen students exhibited characteristics of the concrete operational thinker, while another thirty-two did not meet the criteria for formal operations. The authors concluded that teachers fail to recognize the kinds of experiences incoming freshmen must have to move toward more logical thought.

There are many variables that affect the learning process of children in school. Among these variables are sex, socio-economic level, age, and school size.

The unsuccessful struggle to find the perfect minimum and maximum school size has been going on for many years. There are vast differences in the nature of the operation of school districts and individual schools. Some of these differences are the populations they serve, the services they

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[17] Educational Policies Commission, op. cit., p. 14.

[18] Joe W. McKinnon and John W. Renner, "Are Colleges Concerned with Intellectual Development," The American Journal of Physics, Volume 39, September 1971, pp. 1047-52.

render, and the programs they provide.

Over the years most research has been limited to only one facet of the school size dilemma--establishment of minimum acceptable size for school districts. At the other end of the problem of school district reorganization is the situation where large city school systems have become too big to be manageable and educationally effective. How to decentralize authority and responsibility to smaller units within a large urban area in order to make a central bureaucracy more responsive to local constituencies is one aspect of the intense problem of urban education.[19]

Conant states that high schools with graduating classes of less than one hundred students constitutes one of the serious obstacles to good secondary education throughout most of the United States.[20] When Conant took his second look at the high schools of the country in 1965-66,[21] he recommended four year high schools have an enrollment between 750 and 2,000 students.

Kreiner cites many studies showing that large schools and large school districts excel in comparisons using such

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[19]Warren G. Bennis, "The Coming Death of Bureaucracy," Think Magazine (New York: IBM Company, Nov.-Dec., 1966), p. 32.

[20]James B. Conant, The American High School Today (New York: McGraw-Hill, 1959), p. 81.

[21]James B. Conant, The Comprehensive High School (New York: McGraw-Hill, 1967).

criteria as the range of course offerings, extent of student services, and specialization of administrative services.[22] Light, on the other hand, contends if high communication, identification, involvement, and participation by pupils, teachers, and citizens are acceptable as criteria, disadvantages have been found to accrue very rapidly as school size increases.[23]

These studies indicate it might be possible to secure the management advantages of large districts along with the personal advantages of small individual schools.

This study was undertaken due to the conception or misconception by many who assume school size and quality of education are related.

Renner and Bibens noted the results of McKinnon's study[24] in relation to school size and formal operational thought development. Their suggestion that this might be a fruitful area for further investigation led to the development of this study. The facet of McKinnon's research which stimulated the undertaking of this study dealt with college freshmen students whose high school graduating class sizes

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[22]Leon W. Kreiner, "Changes in Educational Programs in Selected Reorganized Nebraska School Districts" (unpublished doctoral dissertation, University of Nebraska Teachers College, 1966).

[23]Kenneth H. Light, "Community Power Structures and School District Reorganization" (unpublished doctoral dissertation, University of Colorado, 1964).

[24]McKinnon, op. cit., p. 54.

ranged from the under twenty-five category to the more than one thousand category. The class size range was divided into seven categories. The out-of-the-ordinary research findings which serve as the impetus for the study center on the graduating class size categories (51-150), and (501-1,000). This portion of the McKinnon study touched briefly on the idea that school size has significant bearing upon the capacity to think logically. Size of graduating class category (51-150) revealed an F score of 1.25 and category (501-1,000) revealed an F score of 1.00. Based upon this study, students from the small size school (51-150) better handled the logical thought processes, and students from schools whose graduating classes ranged from (501-1,000) seemed to have done the poorest job of moving students toward logical thought processes. Thus, one of the purposes of this study was to explore and research more thoroughly the effect of school size upon the development of formal operational thought.

Statement of the Problem

The problem of this study was to investigate school size, sex, and age as they relate to the scores on the six (6) Piagetian Developmental Thought Processes Tasks. More specifically, when the twenty-five (25) schools involved, from which the population was taken, were divided into small, medium, and large categories, and the students enrolled in the twenty-five (25) schools were divided into eight (8) age-in-month categories by sex, is there an influence that can

be established as statistically significant with the scores on the six (6) tasks?

Statement of Hypotheses

In order to investigate the problem as stated, the following general hypothesis has been developed for testing.

Ho_1 When a factorial analysis of variance is applied on the dependent variables (the attainment of formal operations), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

In addition to the general hypothesis, the following sub-hypotheses were tested:

Ho_2 When a factorial analysis of variance is applied on the dependent variable (ability to conserve solid amount), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

Ho_3 When a factorial analysis of variance is applied on the dependent variable (ability to conserve weight), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

Ho_4 When a factorial analysis of variance is applied on the dependent variable (ability to conserve volume using clay), there is no statistically significant difference of

the independent variables--size of school, age of respondents, and sex of respondents.

Ho_5 When a factorial analysis of variance is applied on the dependent variable (ability to conserve volume using weights), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

Ho_6 When a factorial analysis of variance is applied on the dependent variable (ability to eliminate contradictions), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

Ho_7 When a factorial analysis of variance is applied on the dependent variable (ability to exclude irrelevant variables), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

Origin of the Study

Data for this study were obtained by a research team headed by Dr. John W. Renner and consisting of Dr. Joe McKinnon, Larry McKinney, Dr. Don Stafford, Dr. Donald Kellogg, Jill DeSpain, and Martha Nell Dodson. This research team had as its purpose the establishment of an intellectual profile of the secondary school students of Oklahoma. Because of the interest of this research team on the problem uncovered

by McKinnon (previously mentioned), data for study were offered to the present investigator.

Organization of the Study

This dissertation is organized into four chapters. Chapter I includes the introduction, review of research and related literature, statement of the problem, hypotheses, and the origin of the study. Chapter II contains the design of the study. The analysis and interpretation of the data is reported in Chapter III. Chapter IV contains the summary of the study, findings, conclusions, and implications.

CHAPTER II

DESIGN OF THE STUDY

Methodology

The population of the study included a total of 14,822 students in the twenty-five schools in which the Piagetian Developmental Thought Processes Tasks[1] were administered. The sample included 574 randomly selected students tested with the Piagetian Developmental Thought Processes Tasks. The study encompassed twenty-five public schools in Oklahoma consisting of junior high schools, senior high schools, and junior-senior high schools. The schools selected for the sample were determined by geographic location, major occupational emphasis, and size of cities in which the individual schools were located. From the 7th-12th grade sub-population a stratified random sample of subjects was chosen. Figure 1 shows how the samples were taken.

The schools were broken down into categories based upon size; small schools, middle-sized schools, and large

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[1]For a complete description of the tasks see Appendix A of this study. Of the 588 sample collected by the research team, 14 respondents were not utilized due to incomplete data for some of the categories used in this study. Tables I, II, and III in Appendix B give a complete distribution of students scoring on the six tasks in the total sample.

schools. The three school size categories were determined by logical breaks due to significant differences between the sizes of schools, based on average daily attendance.

FIGURE 1

SCHEMATA OF SELECTION PROCEDURES

	Oklahoma Junior and Senior High Schools					
	Stratified Random Sample of 25 Schools					
Grades Within Each School	7th	8th	9th	10th	11th	12th
TOTAL NUMBER OF SUBJECTS						574

Table I shows the school size categories by school enrollment range and number of schools in each of the three categories.

TABLE I

SCHOOL SIZE CATEGORIES BY SCHOOL ENROLLMENT & NUMBER OF SCHOOLS

School Size	School Enrollment Range	Number of Schools
Small	51 - 273	11
Medium	335 - 713	9
Large	1,124 - 2,382	5
	Total	25

The age-in-months variable was divided into eight categories with the range within each individual category blocked on ten months.

Table II indicates the age-in-month categories corresponding with the age-in-month range, and the total number of respondents within each category.

TABLE II

SCHEMATA OF AGE-IN-MONTH CATEGORY

Category	Age-in-Month Range	Total Number of Respondents
I	145 - 154	56
II	155 - 164	95
III	165 - 174	76
IV	175 - 184	59
V	185 - 194	98
VI	195 - 204	81
VII	205 - 214	75
VIII	215 - 224	34
	Total	574

The other remaining independent variable, sex, was divided by male and female. The scores obtained from the instrument used were a set of performance tasks developed for the purpose of testing the concept of formal operational thought as defined by Piaget.

The Piagetian Developmental Thought Processes Tasks involved six individual tasks. The tasks utilized in this study were selected by the research team composed of Renner, et al. The six performance tasks were selected from a number of Piagetian tasks available. Task number one, conservation of solid amounts, is usually achieved by the middle of the concrete operational stage. Task number two, conservation of weight, is usually the last task achieved during the concrete operational stage. Task number three, conservation of volume using clay, is a task in the transition stage--the very beginning of the formal operational stage. Task number four, conservation of volume using weights, is a task which requires the separation of variables. That task usually appears just after formal operations have occurred. Task number five, elimination of contradictions, is much more complicated than separating variables; factors of displacement, and reasoning beyond the senses must be considered before the task can be completed. Task number six, exclusion of irrelevant variables, involves the isolation of all variables in the task and the elimination of those not relevant to the logical completion of the prescribed task. Tasks five and six require complete formal operational thought.

These tasks illicit different responses from the subjects due to the manipulation of various properties. Briefly, the tasks involved the subjects' reaction to the distortion of clay balls; identical containers of equal amounts of water

and clay balls; two same size metal cylinders and two tubes of exactly the same amount of water, a small container of water and two wooden blocks; and a pendulum whose length could be changed and three different sized weights for the pendulum bob. A more complete description of the tasks used in this operation is given in Appendix A.

The six different task categories were scored as follows. The scoring procedure on the first task, conservation of solid amounts, was recorded with a 0 or 1 determination based upon the subjects' reaction to the task. The second and third tasks, conservation of weight and conservation of volume using clay, illicited responses that were recorded with either a 0, 1, or 2 numerical assignment. The fourth task, conservation of volume using weights, illicited from the subject a numerical assignment of 0, 1, 2, or 3. The fifth and sixth tasks, elimination of contradictions and exclusion, were recorded as 0, 1, 2, 3, or 4. The complete scoring process is outlined in Appendix A.

The measures recorded and interpreted as measures of formal operational thought were taken from the Piagetian Developmental Thought Process Tasks. Figure 2 shows the variables controlled and the means of controlling each. It can be observed that the independent variables that were related to the dependent variables were controlled in two ways: randomization and blocking or categorization. The dependent variables were measured in the usual manner of assigning a

quantitative value to some record of performance.[2]

FIGURE 2

VARIABLES CONTROLLED AND METHODS EMPLOYED TO CONTROL EACH

Type of Variable	Variable	Method of Control
INDEPENDENT	Age	Blocking Categories--10-month Categories
	Sex	Random Selection of Subjects from Participating Schools
	Educational Environment	Categorization of Schools by Size--Large; Middle-sized; Small
	Extraneous Variables	Random Selection of Subjects
DEPENDENT	Formal Operational Thought Processes	Total response pattern: Six Sub-scores and a Total Score for Each Participant

Certain limitations should be kept in mind while interpreting the results of this study. The most serious limitations are those which are inherent in an ex post facto design. These are the inability to manipulate independent variables and to exercise proper control over the randomization of subject. This study was limited to include only respondents of twenty-five randomly selected public schools in the State of Oklahoma.

[2]W. S. Miles and M. W. Charters, Learning in Social Settings (Boston: Allyn and Bacon, 1970).

Treatment of the Data

Factorial analysis of variance as described by Kerlinger[3] and Winer[4] was used to test the hypotheses of this study. This technique is a statistical method that analyzes the independent and interactive effects of the three independent variables (size of school, sex of respondents, age of respondents) on the dependent variable (performance on the Piagetian Developmental Thought Processes Tasks). This technique allows F ratios to be computed testing the significance of differences recorded in the contingency table. A 3 x 2 x 8 factorial analysis of variance table was used for the copilation of data. The complete study resulted in varying responses per cell. To ensure accuracy of the statistic utilization of a technique described by Winer,[5] the harmonic mean of cell responses for computation of F ratios was used. The computational formula for the harmonic mean is:

$$n_h = \frac{pq}{\Sigma\Sigma(1/n_{ij})}$$

The following formulas were used for the computation of the sum of squares:

$$SS_a = n_h \; p \; q \quad \Sigma(\overline{C}_k - \overline{G})^2$$

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[3]Fred N. Kerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart, and Winston, 1946), p. 213.

[4]B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill, 1962), pp. 241-255.

[5]Winer, op. cit., p. 241.

$$SS_b = n_h\ p\ r \quad \leq(\overline{B}_j - \overline{G})^2$$

$$SS_c = n_h\ q\ r \quad \leq(\overline{A}_i - \overline{G})^2$$

$$SS_{ab} = n_h\ p \quad \leq(\overline{BC}_{jk} - \overline{G})^2 - SS_b - SS_c$$

$$SS_{ac} = n_h\ q \quad \leq(\overline{AC}_{ik} - \overline{G})^2 - SS_a - SS_c$$

$$SS_{bc} = n_h\ r \quad \leq(\overline{AB}_{ij} - \overline{G})^2 - SS_a - SS_b$$

$$SS_{abc} = n_h \quad \leq(\overline{ABC}_{ijk} - \overline{G})^2 - SS_{ab} - SS_{ac} - SS_{bc} - SS_a - SS_b - SS_c$$

Where:

SS = sum of squares

n_h = harmonic mean

p = number of columns

q = row variable of jth row

r = row variable of kth row

$\overline{A}_i$ = total of observations in ith column

$\overline{B}_j$ = total of observations in jth row

$\overline{C}_k$ = total of observations in kth row

$\overline{G}$ = total of all observations

SS_a = independent variable size of school

SS_b = independent variable sex of respondents

SS_c = independent variable age of respondents

SS_{ab} = interaction of independent variables size and sex

SS_{ac} = interaction of independent variables size and age

SS_{bc} = interaction of independent variables sex and age

SS_{abc} = interaction of all independent variables size, sex, age

The statistic used was the F ratio; i.e., the ratio of the mean square of the category to the mean square of the within groups. The mean square is computed by dividing the sum of squares by the degrees of freedom.

The level of significance was selected as $\alpha = 0.05$. This level means that only five percent of the time will the condition studied have occurred by chance. The computed F ratio might have a magnitude greater than the value given in the table of values. If it does, it constitutes the critical region which indicates the significance of the variables studied. To determine the values for the critical region of F refer to Table B.3 in Winer.[6]

One consideration given to the selection of the probability level was to avoid Type I errors. That is to reject the null hypothesis when in fact the two samples were selected from the same population. The writer did not want to set the rejection level at a point that would result in the assumption that the independent variables were not influential when in fact they were. On the other hand, the writer did not want to set the rejection level so high as to increase the possibility of Type II errors. Therefore, the 0.05 level was selected.

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[6] Ibid., pp. 642-647.

CHAPTER III

ANALYSIS AND PRESENTATION OF THE DATA

Introduction

The data of this study were collected from a population of 14,822 students in twenty-five public schools in Oklahoma consisting of junior high schools, senior high schools, and junior-senior high schools. The sample included 574 randomly selected students tested with the Piagetian Developmental Thought Processes Tasks.

The data were arranged so that the statistical treatment could be performed as stated in the section on the treatment of the data in Chapter II. All hypotheses were tested by the use of the F ratio. A 3 x 2 x 8 contingency table was used for the appropriate arrangement of the data.

Testing the Sub-Hypotheses

This portion of the study deals with hypotheses two (2) through seven (7). These provide the basis for dealing with hypothesis one (1), which is the general hypothesis with which the study was concerned.

Sub-hypothesis 2 was: When a factorial analysis of variance is applied on the dependent variable (ability to

conserve solid amount), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

The data in Table III indicate the variables of school size, sex, and age to be significant as related to task number one, which was conservation of solid amount. However, the variables of size and sex were each significant at the 0.001 level of confidence indicating female dominance on task number one. When the interactions of variables were considered, first-order interactions of school size and sex were significant at the 0.001 level of confidence; interactions of size and age were significant at the 0.05 level of confidence; interactions of sex and age were not significant. The second-order interactions, which included all variables, did not prove to be significant.

The F values were of such magnitude that it was possible to reject Hypothesis 2 at the 0.01 level of confidence. The treatment of the data by the factorial analysis of variance design revealed significance of all three independent variables (school size, age, and sex) upon the dependent variable (ability to conserve solid amount). The treatment of the data by the factorial analysis of variance did not reveal direction of influence; therefore, the data had to be examined internally to determine the direction of influence of independent variables, school size, and age of respondents.

TABLE III

MEAN RESPONSES OF TOTAL GROUP AS RELATED TO PIAGETIAN DEVELOPMENTAL THOUGHT PROCESSES TASK NUMBER ONE IN REGARD TO SCHOOL SIZE, SEX, AND AGE

SIZE	Small		Medium		Large	
SEX	Male	Female	Male	Female	Male	Female
AGE						
145-154	1.00	1.00	0.85	0.90	1.00	0.85
155-164	1.00	1.00	0.93	0.92	1.00	0.95
165-174	0.92	1.00	0.75	1.00	0.91	1.00
175-184	0.90	0.94	1.00	0.83	0.90	0.90
185-194	0.95	0.92	0.95	1.00	0.66	1.00
195-204	0.94	0.93	0.85	0.95	1.00	1.00
205-214	0.93	1.00	0.94	0.87	1.00	1.00
215-224	1.00	1.00	1.00	1.00	1.00	1.00

Between Size	d.f. = (2,573)	F = 6.29	Sig. at $P \geq 0.001$
Between Sex	d.f. = (1,573)	F = 12.71	Sig. at $P \geq 0.001$
Between Age	d.f. = (7,573)	F = 3.86	Sig. at $P \geq 0.01$
Interactions:			
Size x Sex	d.f. = (2,573)	F = 6.29	Sig. at $P \geq 0.001$
Size x Age	d.f. = (14,573)	F = 2.00	Sig. at $P \geq 0.05$
Sex x Age	d.f. = (7,573)	F = 1.86	NS
All Variables	d.f. = (14,573)	F = 0.71	NS

In order to determine significant difference between all possible school size category combinations and to determine significant difference between all possible age category combinations, a post-hoc technique of comparing means two at a time, as developed by Scheffe,[1] was used. The data in

[1]George A. Ferguson, Statistical Analysis in Psychology and Education (New York: McGraw-Hill Book Company, 1966), pp. 296-297.

Table IV show the results of this comparison of school size. This technique was employed on each of the six sub-hypotheses and on the general hypothesis. This procedure was necessary since the treatment of the data by the factorial analysis of variance did not provide adequate information required to complete the study.

TABLE IV

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR SCHOOL SIZE--SMALL, MEDIUM, AND LARGE--ON TASK NUMBER ONE

Comparison	F	P
Small versus Medium	8.17	0.001
Medium versus Large	4.50	0.05
Small versus Large	0.13	NS

Significant F ratios resulting from these comparisons were found between small size and medium size schools at the 0.001 level of confidence in favor of small size schools. Comparisons between medium size and large size schools revealed an F ratio at the 0.05 level of confidence in favor of the large size schools. A comparison between small size and large size schools was not significant. Small size schools exerted the greatest influence on task number one.

The data in Table V show the results of this comparison of age. The only significant F ratio resulting from these comparisons was found between age categories IV and VIII.

All other age category combination comparisons were not significant.

TABLE V

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR AGE ON TASK NUMBER ONE

Comparison	F	P	Comparison	F	P
I - II	0.72	NS	III - V	0.00	NS
I - III	0.18	NS	III - VI	0.00	NS
I - IV	0.16	NS	III - VII	0.21	NS
I - V	0.20	NS	III - VIII	0.83	NS
I - VI	0.19	NS	IV - V	0.84	NS
I - VII	0.00	NS	IV - VI	0.76	NS
I - VIII	1.48	NS	IV - VII	0.19	NS
II - III	0.23	NS	IV - VIII	2.53	0.05
II - IV	1.89	NS	V - VI	0.00	NS
II - V	0.26	NS	V - VII	0.25	NS
II - VI	0.25	NS	V - VIII	0.89	NS
II - VII	0.94	NS	VI - VII	0.22	NS
II - VIII	0.32	NS	VI - VIII	0.86	NS
III - IV	0.76	NS	VII - VIII	1.63	NS

Sub-hypothesis 3 was: When a factorial analysis of variance is applied on the dependent variable (ability to conserve weight), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents. In reference to

Hypothesis 3, the data in Table VI indicated the variables of school size, sex, and age were significant as related to task number two, which was conservation of weight. Variables school size and sex were significant at the 0.001 level of confidence, and the variable age was significant at the 0.01 level of confidence. Males outperformed females on task number two. When the interactions of variables were considered, first-order interactions of size and sex were significant at the 0.001 level of confidence; interactions of size and age were significant at the 0.05 level of confidence; interactions of sex and age were not significant.

The second-order interactions, which included all variables, was not significant. Thus, it was possible to reject Hypothesis 3 at the 0.01 level of confidence due to the magnitude of the F values.

The data were further analyzed as in the previous hypothesis by comparing the means two at a time. The school size category comparisons are shown in Table VII. Significant F ratios resulting from these comparisons were found between small size and medium size schools at the 0.001 level of confidence in favor of the medium size schools, and between small size and large size schools at the 0.001 level of confidence favoring the large size schools. A comparison between medium size and large size schools was not significant.

TABLE VI

MEAN RESPONSES OF TOTAL GROUP AS RELATED TO PIAGETIAN DEVELOPMENTAL THOUGHT PROCESSES TASK NUMBER TWO IN REGARD TO SCHOOL SIZE, SEX, AND AGE

SIZE	Small		Medium		Large	
SEX	Male	Female	Male	Female	Male	Female
AGE						
145-154	1.71	1.64	1.64	1.80	2.00	2.00
155-164	1.66	1.50	1.86	1.84	1.90	1.86
165-174	1.61	1.64	1.87	1.87	2.00	1.90
175-184	1.70	1.70	2.00	1.50	1.72	1.80
185-194	1.80	1.84	2.00	1.58	1.66	1.78
195-204	1.94	1.86	1.85	1.95	2.00	1.50
205-214	2.00	1.77	2.00	1.91	2.00	2.00
215-224	1.63	2.00	1.57	2.00	2.00	2.00

Between Size	d.f. = (2,573)	F = 5.50	Sig. at $P \geq 0.001$
Between Sex	d.f. = (1,573)	F = 10.97	Sig. at $P \geq 0.001$
Between Age	d.f. = (7,573)	F = 3.37	Sig. at $P \geq 0.01$
Interactions:			
Size x Sex	d.f. = (2,573)	F = 5.50	Sig. at $P \geq 0.001$
Size x Age	d.f. = (14,573)	F = 1.70	Sig. at $P \geq 0.05$
Sex x Age	d.f. = (7,573)	F = 1.57	NS
All Variables	d.f. = (14,573)	F = 0.80	NS

Large size schools exerted the greatest influence on task number two.

TABLE VII

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR SCHOOL SIZE--SMALL, MEDIUM, AND LARGE--ON TASK NUMBER TWO

Comparison	F	P
Small versus Medium	10.71	0.001
Medium versus Large	0.71	NS
Small versus Large	11.11	0.001

The data in Table VIII show the results of the comparison of the age categories. Significant F ratios resulting from these comparisons were found between age categories I-VI, III-VII, and V-VII at the 0.05 level of confidence; between age categories I-VII and IV-VI at the 0.01 level of confidence; and between age categories II-VII and IV-VII at the 0.001 level of confidence. All other age category combination comparisons were not significant.

Sub-hypothesis 4 was: When a factorial analysis of variance is applied on the dependent variable (ability to conserve volume using clay), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents. There was a statistically significant difference between the dependent variable and each of the independent variables.

TABLE VIII

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR AGE ON TASK NUMBER TWO

Comparison	F	P	Comparison	F	P
I - II	0.95	NS	III - V	0.01	NS
I - III	0.02	NS	III - VI	1.05	NS
I - IV	0.03	NS	III - VII	2.48	0.05
I - V	0.42	NS	III - VIII	0.00	NS
I - VI	2.15	0.05	IV - V	0.79	NS
I - VII	3.84	0.01	IV - VI	2.90	0.01
I - VIII	0.11	NS	IV - VII	4.84	0.001
II - III	0.22	NS	IV - VIII	0.25	NS
II - IV	1.47	NS	V - VI	0.72	NS
II - V	0.14	NS	V - VII	2.38	0.05
II - VI	0.36	NS	V - VIII	0.03	NS
II - VII	14.28	0.001	VI - VII	0.32	NS
II - VIII	0.20	NS	VI - VIII	0.80	NS
III - IV	0.54	NS	VII - VIII	1.75	NS

The data in Table IX indicated the variables of school size, and sex, were each significant at the 0.001 level of confidence, and the variable of age was significant at the 0.01 level of confidence. When the interactions of variables were considered, first-order interactions of size and sex were significant at the 0.001 level of confidence; interactions of size and age were significant at the 0.05 level of confidence; interactions of sex and age were not significant. The second-order interactions, which included all variables, did not prove to be significant. Thus, it was possible to reject Hypothesis 4 at the 0.01 level of confidence due to the magnitude of the F values.

TABLE IX

MEAN RESPONSES OF TOTAL GROUP AS RELATED TO PIAGETIAN DEVELOPMENTAL THOUGHT PROCESSES TASK NUMBER THREE IN REGARD TO SCHOOL SIZE, SEX, AND AGE

SIZE	Small		Medium		Large	
SEX	Male	Female	Male	Female	Male	Female
AGE						
145-154	1.42	1.64	1.50	1.50	1.50	1.42
155-164	2.00	1.75	1.73	1.46	1.62	1.27
165-174	1.38	1.64	1.75	1.50	1.66	1.50
175-184	1.80	1.47	1.60	1.50	1.63	1.40
185-194	1.52	1.53	1.69	1.35	1.66	1.50
195-204	1.41	1.60	1.45	1.56	2.00	1.50
205-214	1.66	1.66	1.89	1.70	1.33	1.20
215-224	1.36	1.80	1.57	2.00	2.00	1.80

Between Size	d.f. = (2,573)	F = 5.48	Sig. at $P \geq 0.001$
Between Sex	d.f. = (1,573)	F = 11.00	Sig. at $P \geq 0.001$
Between Age	d.f. = (7,573)	F = 3.35	Sig. at $P \geq 0.01$
Interactions:			
Size x Sex	d.f. = (2,573)	F = 5.43	Sig. at $P \geq 0.001$
Size x Age	d.f. = (14,573)	F = 1.70	Sig. at $P \geq 0.05$
Sex x Age	d.f. = (7,573)	F = 1.57	NS
All Variables	d.f. = (14,573)	F = 0.83	NS

Since treatment of the data revealed significance of all three independent variables, the data were further analyzed as in the previous hypothesis by comparing the means two at a time. The data in Table X show the results of these comparisons of school size. Results of these comparisons revealed F ratios between medium size and large size schools and between small size and large size schools at the 0.001

level of confidence. The medium size-large size school comparisons favored the medium size schools. Comparisons between small size and large size schools favored small size schools. A comparison between small size and medium size schools was not significant. Medium size schools exerted the greatest influence on task number three.

TABLE X

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR SCHOOL SIZE--SMALL, MEDIUM, AND LARGE--ON TASK NUMBER THREE

Comparison	F	P
Small versus Medium	1.19	NS
Medium versus Large	11.11	0.001
Small versus Large	7.41	0.001

Table XI contains data that show the results of the age category combination comparisons. Significant F ratios resulting from these comparisons were found between age categories II-VII and IV-VII at the 0.05 level of confidence; between age categories I-VII, III-VII, and V-VII at the 0.01 level of confidence; and between age categories VI-VII at the 0.001 level of confidence. All other age category combination comparisons were not significant.

Sub-hypothesis 5 was: When a factorial analysis of variance is applied on the dependent variable (ability to conserve volume using weights), there is no statistically

significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

TABLE XI

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR AGE ON TASK NUMBER THREE

Comparison	F	P	Comparison	F	P
I - II	0.55	NS	III - V	0.07	NS
I - III	0.22	NS	III - VI	0.27	NS
I - IV	0.20	NS	III - VII	2.77	0.01
I - V	0.06	NS	III - VIII	0.82	NS
I - VI	0.00	NS	IV - V	0.06	NS
I - VII	4.01	0.01	IV - VI	0.23	NS
I - VIII	1.55	NS	IV - VII	2.41	0.05
II - III	0.07	NS	IV - VIII	0.01	NS
II - IV	0.06	NS	V - VI	0.07	NS
II - V	0.33	NS	V - VII	4.16	0.01
II - VI	0.67	NS	V - VIII	1.32	NS
II - VII	2.20	0.05	VI - VII	4.89	0.001
II - VIII	0.53	NS	VI - VIII	1.76	NS
III - IV	0.00	NS	VII - VIII	0.16	NS

In reference to Hypothesis 5, the data in Table XII indicated that the variables of school size, and sex, were significant at the 0.001 level of confidence. The variable age was significant at the 0.01 level of confidence. Thus, the data in Table XII indicated the variables of school size,

TABLE XII

MEAN RESPONSES OF TOTAL GROUP AS RELATED TO PIAGETIAN DEVELOPMENTAL THOUGHT PROCESSES TASK NUMBER FOUR IN REGARD TO SCHOOL SIZE, SEX, AND AGE

SIZE	Small		Medium		Large	
SEX	Male	Female	Male	Female	Male	Female
AGE						
145-154	2.28	1.28	2.50	1.70	2.00	1.71
155-164	2.88	1.50	2.06	1.69	2.03	1.72
165-174	2.07	1.76	2.37	1.68	2.33	1.80
175-184	2.50	1.82	2.20	1.66	2.54	2.30
185-194	2.38	2.11	2.26	1.88	2.00	1.62
195-204	2.58	2.26	2.60	2.00	2.50	1.75
205-214	2.26	2.00	2.63	1.87	2.33	2.40
215-224	2.27	2.00	2.14	2.00	3.00	2.00

Between Size	d.f. = (2,573)	F = 5.39	Sig. at $P \geq 0.001$
Between Sex	d.f. = (1,573)	F = 11.59	Sig. at $P \geq 0.001$
Between Age	d.f. = (7,573)	F = 3.29	Sig. at $P \geq 0.01$
Interactions:			
Size x Sex	d.f. = (2,573)	F = 5.39	Sig. at $P \geq 0.001$
Size x Age	d.f. = (14,573)	F = 1.68	Sig. at $P \geq 0.05$
Sex x Age	d.f. = (7,573)	F = 1.61	NS
All Variables	d.f. = (14,573)	F = 0.83	NS

sex, and age were significant as related to task number four, which was conservation of volume using weights. Males outperformed females on task number four. When the interactions of variables were considered, first-order interactions of size and sex were significant at the 0.001 level of confidence; interactions of size and age were significant at the

0.05 level of confidence; interactions of sex and age were not significant. The second-order interactions, which included all variables, was not significant.

There was a statistically significant difference between the dependent variable and each of the independent variables. The F values were of such magnitude that it was possible to reject Hypothesis 5 at the 0.01 level of confidence.

Since treatment of the data by the factorial analysis of variance design revealed significance of all three dependent variables, it was again necessary to further analyze the data by comparing the means two at a time as in the previously treated hypotheses.

These school size category comparisons on task number four are shown in Table XIII. A significant F ratio resulting from these comparisons was found between small size and large size schools at the 0.001 level of confidence in favor of small size schools. Comparisons between medium size and large size schools revealed an F ratio at the 0.05 level of confidence in favor of medium size schools. A comparison between small size and medium size schools was not significant. Small size schools exerted the greatest influence on task number four.

TABLE XIII

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR SCHOOL SIZE--SMALL, MEDIUM, AND LARGE--ON TASK NUMBER FOUR

Comparison	F	P
Small versus Medium	0.23	NS
Medium versus Large	6.38	0.05
Small versus Large	10.20	0.001

The data in Table XIV show the results of the comparisons of the age categories. Age category comparisons revealing a significant F ratio at the 0.001 level of confidence were I-IV, I-V, I-VI, I-VII, I-VIII, II-VI, II-VII, III-VI, and III-VII. Those age category comparisons showing a significant F ratio at the 0.01 level of confidence were II-IV, II-V, II-VIII, III-IV, III-V, III-VIII, and V-VI. All other age category combination comparisons were not significant.

Sub-hypothesis 6 was: When a factorial analysis of variance is applied on the dependent variable (ability to eliminate contradictions), there is no statistically significant difference of the independent variables--size of schools, age of respondents, and sex of respondents. The data in Table XV indicated there was a statistically significant difference between the dependent variable and each of the independent variables. The independent variables of school size, and sex, were each significant at the 0.001 level of

confidence, and the variable of age was significant at the 0.01 level of confidence. When the interactions of variables were considered, first-order interactions of size and sex were significant at the 0.001 level of confidence; interactions of size and age and sex and age were not significant.

TABLE XIV

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR AGE ON TASK NUMBER FOUR

Comparison	F	P	Comparison	F	P
I - II	1.04	NS	III - V	2.66	0.01
I - III	0.78	NS	III - VI	12.34	0.001
I - IV	6.72	0.001	III - VII	5.73	0.001
I - V	5.87	0.001	III - VIII	3.29	0.01
I - VI	17.06	0.001	IV - V	0.22	NS
I - VII	9.57	0.001	IV - VI	1.87	NS
I - VIII	5.95	0.001	IV - VII	0.12	NS
II - III	0.04	NS	IV - VIII	0.04	NS
II - IV	3.53	0.01	V - VI	4.34	0.01
II - V	3.01	0.01	V - VII	0.83	NS
II - VI	13.03	0.001	V - VIII	0.39	NS
II - VII	5.87	0.001	VI - VII	1.15	NS
II - VIII	3.22	0.01	VI - VIII	0.84	NS
III - IV	3.58	0.01	VII - VIII	0.00	NS

TABLE XV

MEAN RESPONSES OF TOTAL GROUP AS RELATED TO PIAGETIAN DEVELOPMENTAL THOUGHT PROCESSES TASK NUMBER FIVE IN REGARD TO SCHOOL SIZE, SEX, AND AGE

SIZE	Small		Medium		Large	
SEX	Male	Female	Male	Female	Male	Female
AGE						
145-154	0.71	1.07	1.35	0.90	1.25	1.14
155-164	2.11	0.50	1.73	1.23	1.59	1.40
165-174	1.07	1.17	1.37	1.18	1.66	1.10
175-184	1.60	1.29	1.40	1.66	1.18	1.40
185-194	1.47	1.34	1.95	1.23	2.00	1.25
195-204	1.64	1.46	1.90	1.47	4.00	1.75
205-214	2.13	1.33	1.73	1.37	1.00	1.40
215-224	1.54	1.20	1.42	1.33	3.66	1.40

Between Size	d.f. = (2,573)	F = 5.62	Sig. at $P \geq 0.001$
Between Sex	d.f. = (1,573)	F = 11.95	Sig. at $P \geq 0.001$
Between Age	d.f. = (7,573)	F = 3.19	Sig. at $P \geq 0.01$
Interactions:			
Size x Sex	d.f. = (2,573)	F = 5.29	Sig. at $P \geq 0.001$
Size x Age	d.f. = (14,573)	F = 1.24	NS
Sex x Age	d.f. = (7,573)	F = 1.62	NS
All Variables	d.f. = (14,573)	F = 4.10	Sig. at $P \geq 0.001$

The second-order interactions, which included all variables, proved to be significant at the 0.001 level of confidence. Since treatment of the data revealed significance of all three independent variables, the data were further analyzed as in the previous hypotheses by comparing the means two at a time.

The data in Table XVI show the results of these comparisons of school size. These comparisons revealed an F ratio at the 0.001 level of confidence between small size and medium size schools in favor of medium size schools, and between small size and large size schools in favor of large size schools. A comparison between medium size and large size schools revealed an F ratio at the 0.05 level of confidence in favor of large size schools. Large size schools exerted the greatest influence on task number five.

TABLE XVI

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR SCHOOL SIZE--SMALL, MEDIUM, AND LARGE--ON TASK NUMBER FIVE

Comparison	F	P
Small versus Medium	31.57	0.001
Medium versus Large	4.17	0.05
Small versus Large	44.00	0.001

Table XVII shows the results of the age category combination comparisons. Significant F ratios resulting from these comparisons were found between age categories I-II, I-IV, I-V, I-VI, I-VII, I-VIII, II-III, II-VI, III-V, III-VI, III-VII, III-VIII, IV-VI, IV-VII, IV-VIII, and V-VI at the 0.001 level of confidence; between age categories I-III, II-IV, and III-IV at the 0.01 level of confidence; and between age categories IV-V and V-VII at the 0.05 level of confidence.

All other age category combination comparisons were not significant.

TABLE XVII

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR AGE ON TASK NUMBER FIVE

Comparison	F	P	Comparison	F	P
I - II	30.81	0.001	III - V	13.79	0.001
I - III	3.46	0.01	III - VI	37.50	0.001
I - IV	12.32	0.001	III - VII	23.14	0.001
I - V	28.49	0.001	III - VIII	15.38	0.001
I - VI	57.14	0.001	IV - V	2.12	0.05
I - VII	39.40	0.001	IV - VI	14.51	0.001
I - VIII	27.31	0.001	IV - VII	6.89	0.001
II - III	15.68	0.001	IV - VIII	4.98	0.001
II - IV	2.91	0.01	V - VI	5.44	0.001
II - V	0.09	NS	V - VII	2.04	0.05
II - VI	6.02	0.001	V - VIII	1.45	NS
II - VII	1.28	NS	VI - VII	1.50	NS
II - VIII	0.96	NS	VI - VIII	0.72	NS
III - IV	3.57	0.01	VII - VIII	0.01	NS

Sub-hypothesis 7 was: When a factorial analysis of variance is applied on the dependent variable (ability to exclude irrelevant variables), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents.

The data in Table XVIII indicated there was a statistically significant difference between the dependent variable and each of the independent variables. The F values were of such magnitude that it was possible to reject Hypothesis 7 at the 0.01 level of confidence. The data revealed the variables of school size, and sex, were significant at the 0.001 level of confidence. The variable age was significant at the 0.01 level of confidence. When the interactions of variables were considered, first-order interactions of size and sex were significant at the 0.001 level of confidence; interactions of size and age were significant at the 0.05 level of confidence; interactions of sex and age were not significant. The second-order interactions, which included all variables, was not significant.

The data were further analyzed as in the previous hypotheses by comparing the means two at a time. These school size category comparisons on task number six are shown in Table XIX. Significant F ratios resulting from these comparisons were found between medium size and large size schools at the 0.001 level of confidence in favor of the large size schools, and between small size and large size schools at the 0.001 level of confidence favoring the large size schools. A comparison between small size and medium size schools was not significant. Large size schools exerted the greatest influence on task number six.

TABLE XVIII

MEAN RESPONSES OF TOTAL GROUP AS RELATED TO PIAGETIAN DEVELOPMENTAL THOUGHT PROCESSES TASK NUMBER SIX IN REGARD TO SCHOOL SIZE, SEX, AND AGE

SIZE	Small		Medium		Large	
SEX	Male	Female	Male	Female	Male	Female
AGE						
145-154	1.71	1.57	1.64	1.60	2.25	1.42
155-164	2.22	2.00	1.20	1.38	1.68	1.63
165-174	1.38	1.29	1.75	1.12	1.83	1.60
175-184	1.20	2.23	1.80	1.66	1.90	2.50
185-194	2.14	1.46	2.00	1.94	1.66	1.37
195-204	2.64	1.53	2.05	1.82	4.00	2.50
205-214	2.13	1.33	2.26	2.00	3.00	2.20
215-224	1.45	1.60	2.14	1.00	4.00	2.80

Between Size	d.f. = (2,573)	F = 5.47	Sig. at $P \geq 0.001$
Between Sex	d.f. = (1,573)	F = 10.50	Sig. at $P \geq 0.001$
Between Age	d.f. = (7,573)	F = 3.03	Sig. at $P \geq 0.01$
Interactions:			
Size x Sex	d.f. = (2,573)	F = 5.00	Sig. at $P \geq 0.001$
Size x Age	d.f. = (14,573)	F = 1.83	Sig. at $P \geq 0.05$
Sex x Age	d.f. = (7,573)	F = 1.44	NS
All Variables	d.f. = (14,573)	F = 0.69	NS

TABLE XIX

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR SCHOOL SIZE--SMALL, MEDIUM, AND LARGE--ON TASK NUMBER SIX

Comparison	F	P
Small versus Medium	3.23	NS
Medium versus Large	33.33	0.001
Small versus Large	48.84	0.001

The data in Table XX show the results of the comparisons of the age categories. Age category comparisons revealing a significant F ratio at the 0.001 level of confidence were I-IV, I-VI, I-VII, I-VIII, II-IV, II-VI, II-VII, II-VIII, III-IV, III-V, III-VI, III-VII, III-VIII, V-VI, and V-VII. Those age category comparisons showing a significant F ratio at the 0.01 level of confidence were I-III, I-V, II-III, and II-V. The age category comparisons showing a significant F ratio at the 0.05 level of confidence were V-VIII. All other age category combination comparisons were not significant.

Testing the General Hypothesis

Hypothesis 1 was: When a factorial analysis of variance is applied on the dependent variable (the attainment of formal operations), there is no statistically significant difference of the independent variables--size of school, age of respondents, and sex of respondents. This hypothesis

TABLE XX

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR AGE ON TASK NUMBER SIX

Comparison	F	P	Comparison	F	P
I - II	0.03	NS	III - V	16.29	0.001
I - III	3.57	0.01	III - VI	44.52	0.001
I - IV	7.68	0.001	III - VII	40.46	0.001
I - V	2.86	0.01	III - VIII	20.49	0.001
I - VI	17.76	0.001	IV - V	2.00	NS
I - VII	15.75	0.001	IV - VI	1.60	NS
I - VIII	7.62	0.001	IV - VII	1.11	NS
II - III	3.81	0.01	IV - VIII	0.14	NS
II - IV	11.00	0.001	V - VI	9.00	0.001
II - V	4.81	0.01	V - VII	7.35	0.001
II - VI	25.80	0.001	V - VIII	2.52	0.05
II - VII	22.51	0.001	VI - VII	0.04	NS
II - VIII	10.02	0.001	VI - VIII	0.42	NS
III - IV	24.08	0.001	VII - VIII	0.88	NS

differs from the other hypotheses in that the dependent variable (the attainment of formal operations) was a combined total of scores on the six Piagetian Developmental Thought Processes Tasks.

The data in Table XXI indicated there was a statistically significant difference between the dependent variable and each of the independent variables. The F values were of such magnitude that it was possible to reject Hypothesis 1 at the 0.01 level of confidence. The data further revealed the variables of school size, and sex, were significant at the 0.001 level of confidence. The variable age was significant at the 0.01 level of confidence. When the interactions of variables were considered, first-order interactions of size and sex, and size and age, were significant at the 0.05 level of confidence; interactions of sex and age were not significant. The second-order interactions, which included all variables, did not prove to be significant.

The data were further analyzed as in the previous hypotheses by comparing the means two at a time. The school size category comparisons on the combined six task totals are shown in Table XXII. The data did not indicate any statistically significant differences of school size comparisons on the attainment of formal operations.

TABLE XXI

MEAN RESPONSES OF TOTAL GROUPS AS RELATED TO THE COMBINED SIX PIAGETIAN DEVELOPMENTAL THOUGHT PROCESSES TASKS IN REGARD TO SCHOOL SIZE, SEX, AND AGE

SIZE	Small		Medium		Large	
SEX	Male	Female	Male	Female	Male	Female
AGE						
145-154	8.85	8.21	9.50	8.40	10.00	8.57
155-164	11.88	8.25	9.53	8.53	9.90	8.68
165-174	8.46	8.52	9.87	8.37	10.41	8.70
175-184	9.70	9.47	10.00	8.83	9.72	10.30
185-194	10.28	9.23	10.86	9.00	9.66	8.75
195-204	11.17	9.86	10.70	9.69	15.50	10.00
205-214	11.13	9.11	11.68	9.75	10.66	10.20
215-224	8.36	9.60	9.85	9.33	15.66	11.00

Between Size	d.f. =	(2,573)	F = 5.48	Sig. at $P \leq 0.001$
Between Sex	d.f. =	(1,573)	F = 11.11	Sig. at $P \geq 0.001$
Between Age	d.f. =	(7,573)	F = 3.31	Sig. at $P \geq 0.01$
Interactions:				
Size x Sex	d.f. =	(2,573)	F = 4.01	Sig. at $P \geq 0.05$
Size x Age	d.f. =	(14,573)	F = 1.70	Sig. at $P \geq 0.05$
Sex x Age	d.f. =	(7,573)	F = 1.57	NS
All Variables	d.f. =	(14,573)	F = 0.61	NS

TABLE XXII

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR SCHOOL SIZE--SMALL, MEDIUM, AND LARGE--ON THE SIX TASK TOTALS (THE ATTAINMENT OF FORMAL OPERATIONS)

Comparison	F	P
Small versus Medium	2.88	NS
Medium versus Large	0.30	NS
Small versus Large	0.11	NS

Figure 3 summarizes an internal comparison of each task and the three categories of school size--small, medium, and large. The data do not generally favor either small, medium, or large school size on tasks one through four. However, on tasks five and six the data consistently favor the large school size.

FIGURE 3

SCHOOL SIZE COMPARISONS ON EACH OF THE SIX TASKS*

Task	1	2	3	4	5	6
	M < L	M = L	M > L	M > L	M < L	M < L
	S > M	S < M	S = M	S = M	S < M	S = M
	S = L	S < L	S > L	S > L	S < L	S < L

S = Small
M = Medium
L = Large

*The greater than symbol and the lesser than symbol indicate direction of statistical significance.

Table XXIII revealed the results of the comparisons of the age categories on the attainment of formal operations. Age category comparisons revealing a significant F ratio at the 0.001 level of confidence were I-VI, I-VII, III-VI, and III-VII. Those age category comparisons showing a significant F ratio at the 0.01 level of confidence were I-V, I-VIII, II-VI, II-VII, III-V, and III-VIII. The age category comparisons showing a significant F ratio at the 0.05 level of confidence were I-IV, III-IV, IV-VI, IV-VII, V-VI, and V-VII. All other age category combination comparisons were not significant.

TABLE XXIII

COMPARISON OF MEANS TWO AT A TIME FOLLOWING AN F TEST FOR AGE ON THE SIX TASK TOTALS (THE ATTAINMENT OF FORMAL OPERATIONS)

Comparison	F	P	Comparison	F	P
I - II	1.77	NS	III - V	3.30	0.01
I - III	0.05	NS	III - VI	9.89	0.001
I - IV	2.38	0.05	III - VII	10.28	0.001
I - V	3.60	0.01	III - VIII	2.79	0.01
I - VI	9.72	0.001	IV - V	0.03	NS
I - VII	10.13	0.001	IV - VI	2.21	0.05
I - VIII	3.13	0.01	IV - VII	2.48	0.05
II - III	1.43	NS	IV - VIII	0.20	NS
II - IV	0.14	NS	V - VI	2.23	0.05
II - V	0.42	NS	V - VII	2.53	0.05
II - VI	4.42	0.01	V - VIII	0.00	NS
II - VII	4.79	0.01	VI - VII	0.01	NS
II - VIII	0.64	NS	VI - VIII	0.59	NS
III - IV	2.03	0.05	VII - VIII	0.73	NS

The General Hypothesis (Hypothesis 1) was rejected on the basis of the factorial analysis of variance treatment. Further analysis using the Scheffe technique did not indicate any statistically significant differences of school size comparisons on the attainment of formal operations. This technique revealed specific differences of age on the attainment of formal operations. Males outperformed females on the attainment of formal operations. The sub-hypotheses (2 through 7) were rejected on the basis of the factorial analysis of variance treatment. Further analysis using the Scheffe technique revealed specific differences among the hypotheses. On task number 1 (sub-hypothesis 2) females outperformed males. Males were more successful than females on all other sub-hypotheses (3-7).

CHAPTER IV

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to determine whether the differences in school size, age of respondents, and sex of respondents influence the development of formal operational thought. In addition, the interactions of the independent variables with each other were examined to determine the extent to which they influence the development of formal operational thought.

The Problem

The problem of the study was to investigate school size, sex, and age as they relate to the scores on the six (6) Piagetian Developmental Thought Processes Tasks. More specifically, when the twenty-five (25) schools involved from which the population was taken were divided into small, medium, and large categories, and the students enrolled in the twenty-five (25) schools were divided into eight (8) age-in-month categories by sex, is there an influence that can be established as statistically significant with the scores on the six (6) tasks?

Design of Study

The study included a total population of 14,822 students in the twenty-five schools in which the Piagetian Developmental Thought Processes Tasks were administered. From the seventh through the twelfth grade population a stratified random sample of subjects was chosen. This sample included five hundred seventy-four randomly selected students tested with the Piagetian Developmental Thought Processes Tasks. The schools were broken down into three size categories, small, medium, and large. The small school category contained a total of eleven schools; the medium school category entailed a total of nine schools, and the large school category was composed of a total of five schools. (See Table I.)

The age variable was divided into eight age-in-month categories with the range within each category blocked on ten months. The breakdown of the total number of respondents within each category was: Category I-56, II-95, III-76, IV-59, V-98, VI-81, VII-75, and VIII-34, for a total of 574 respondents. (See Table II.)

The six individual performance tasks utilized in the study were selected from a number of Piagetian tasks available, by the previously mentioned research team.

The treatment of the data for the study was tnrough the employment of the factorial analysis of variance design and further through the use of the Scheffe technique of

comparing means two at a time. The accepted level of significance was at the 0.05.

Findings

The General Hypothesis (Hypothesis I) was rejected using the 0.05 level of confidence as a minimum. Some of the sub-hypotheses reached 0.01 or better. The higher confidence levels were reported. Further analysis, using the Scheffe technique, did not indicate any statistically significant differences of school size comparisons, but did reveal specific differences of age on the attainment of formal operations. The significance of the age variable occurred between categories I-VI, I-VII, III-VI, and III-VII at the 0.001 level of confidence; and between categories I-IV, III-IV, IV-VI, IV-VII, V-VI, and V-VII at the 0.05 level of confidence. The sub-hypotheses (2 through 7) were rejected on the basis of the factorial analysis of variance treatment. Further analysis, using the Scheffe technique, revealed specific differences among the hypotheses.

Sub-hypothesis 2: This hypothesis, dealing with Task Number One, was rejected.

In the comparison of school size, those in the small schools did better on this task to the extent that in relation to medium sized schools, rejection was at the 0.001 level of confidence. When medium sized schools were compared with large sized schools, the confidence level was at the required 0.05 in favor of the large size schools. The

greatest influence on task number one was from the small size school. The influence of age upon task number one was significant between categories IV and VIII only. Females outperformed males on task number one.

Sub-hypothesis 3: This hypothesis, dealing with Task Number Two, was rejected.

Significant F ratios resulting from mean comparisons were found between small size and medium size schools at the 0.001 level of confidence, in favor of the medium size schools, and between small size and large size schools at the 0.001 level of confidence favoring the large size schools. The greatest influence on task number two was from the large size school.

The influence of age upon task number two was significant between age categories II-VII and IV-VII at the 0.001 level of confidence, between age categories I-VII and IV-VI at the 0.01 level of confidence, and between age categories I-VI, III-VII, and V-VII at the 0.05 level of confidence. Males performed better than females on task number two.

Sub-hypothesis 4: This hypothesis, dealing with Task Number Three, was rejected.

In the comparison of school size, those in medium size schools did better than those in large size schools, and those in small size schools did better than those in large size schools on this task. These comparisons were rejected

at the 0.001 level of confidence. The greatest influence on task number three was from the medium size school.

The influence of age upon task number three was significant between age categories VI-VII at the 0.001 level of confidence, between age categories I-VII, III-VII, and V-VII at the 0.01 level of confidence, and between age categories II-VII and IV-VII at the 0.05 level of confidence. Males were more successful than females on task number three.

Sub-hypothesis 5: This hypothesis, dealing with Task Number Four, was rejected.

In the comparison of school size, those in the small schools did better on this task to the extent that in relation to large sized schools, rejection was at the 0.001 level of confidence. When medium sized schools were compared with large sized schools, the confidence level was at the required 0.05 in favor of the medium sized schools. The greatest influence on task number four was from the small size school.

The influence of age upon task number four was significant between age categories I-IV, I-V, I-VI, I-VII, I-VIII, II-VI, II-VII, III-VI, and III-VII at the 0.001 level of confidence, and between age categories II-IV, II-V, II-VIII, III-IV, III-VIII, and V-VI at the 0.01 level of confidence. Males outperformed females on task number four.

Sub-hypothesis 6: This hypothesis, dealing with Task Number Five, was rejected.

In the comparison of school size, those in the large size schools did better on this task to the extent that in relation to small size schools, rejection was at the 0.001 level of confidence. When small size schools were compared with medium size schools, rejection was at the 0.001 level of confidence in favor of the medium size schools. Comparison of medium size schools with large size schools revealed rejection was at the required 0.05 level of confidence in favor of the large size schools. The greatest influence on task number five was from the large size school.

The influence of age upon task number five was significant between age categories I-II, I-IV, I-V, I-VI, I-VII, I-VIII, II-III, II-VI, III-V, III-VI, III-VII, III-VIII, IV-VI, IV-VII, IV-VIII, and V-VI at the 0.001 level of confidence, between age categories I-III, II-IV, and III-IV at the 0.01 level of confidence, and between age categories IV-V and V-VII at the 0.05 level of confidence. Males were more successful than females on task number five.

Sub-hypothesis 7: This hypothesis, dealing with Task Number Six, was rejected.

In the comparison of school size, those in the large size schools did better on this task to the extent that in relation to small size schools and medium size schools, rejection was at the 0.001 level of confidence. The greatest influence on task number six was from the large size school.

The influence of age upon task number six was significant between age categories I-IV, I-VI, I-VII, I-VIII, II-IV, II-VI, II-VII, II-VIII, III-IV, III-V, III-VI, III-VII, III-VIII, V-VI, and V-VII at the 0.001 level of confidence, between age categories I-III, I-V, II-III, and II-V at the 0.01 level of confidence, and between age categories V-VIII at the 0.05 level of confidence. Males outperformed females on task number six.

Conclusions

Based upon the findings of this study, the following conclusions seemed appropriate.

1. The higher the chronological age of pupils, the more successful the development of the attainment of formal operational thought.

2. Males make more rapid progress toward the development of formal operational thought.

3. The school size influence on the less complicated tasks came from the smaller schools, and the large schools were more influential on the more complicated tasks.

4. In regard to the attainment of formal operational thought, the age variable was the most significant influence, the sex variable the next most significant influence, and the school size variable the least significant influence.

5. Tne transition from concrete operation to formal operation is gradual with age and there are no distinct

plateaus at which all students are either concrete operational or formal operational.

Implications and Recommendations

1. Since formal operations are required for many of the tasks of high school courses as they are presently taught, these courses need to be reorganized to the level of the student.

2. Since all students at a given age level are not at the same level of operations, more than one course might be needed (for example, one for concrete operational fifteen year olds; one course for formal operational fifteen year olds).

3. This study might be repeated with a different set of tasks to determine if the performance of males and females is influenced by the tasks themselves. If the suggested study results coincide with the results of this study, curriculum developers might want to examine the total educational program to determine what experiences in the school program allows males to perform better than females.

4. Since females generally outperform males on standardized achievement tests and this study shows the opposite with respect to the Piaget Developmental Tasks, perhaps a combination of academic oriented achievement tests and developmental type tests might give a more accurate evaluation of students.

5. The data are somewhat inclusive on school size and performance on concrete operational and early formal operational tasks. They speak quite clearly in favor of the large schools on the advanced formal operational tasks. Thus, the consolidation of schools of the medium size and small size range might prove to be fruitful in the achievement of formal operational thought.

6. Teachers should be more concerned about the level of intellectual development and the selection of activities that might enhance that level, rather than being overly concerned about maintaining a highly sophisticated course of study.

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APPENDIX A

DESCRIPTION OF THE PIAGETIAN DEVELOPMENTAL THOUGHT PROCESSES TASKS

APPENDIX A

UNIVERSITY OF OKLAHOMA

Science Education Center
College of Education
Norman, Oklahoma

March, 1971

Participating Institutions: Oklahoma City University, East Central State College, (Ada) and the Oklahoma City Public School System.

Between September 1, 1970, and March 1, 1971, 588 students in grades 7 through 12 each completed six logical thinking tasks designed by Jean Piaget and Barbel Inhelder. A description of each of the tests and the administration and scoring procedures used follows. The students were randomly selected from all sizes of schools from all parts of Oklahoma.

1. The Conservation of Solid Amounts

The student was allowed to work with two balls of clay until he was convinced each ball contained the same amount. The examiner then distorted one of the balls. The student was then asked if the distorted clay or the clay-ball contained more or if each contained the same amount. This task was administered to establish if the student was concrete operational. If he successfully completed the task, he was rated IIA and given one point. Piaget has stated that the child learns to

solve this problem at about seven or eight[1] years of age.

2. The Conservation of Weight

Piaget believes that this ability is developed at nine[2] or ten years. The student is given two balls of clay and allowed to work with them until he believes their weights are the same. The examiner then distorts one of the balls. He then asks the student to tell him (without picking up the clay) which portion of clay weighs more or if they weigh the same. A correct response placed the student in class IIB and yielded him two points.

3. The Conservation of Volume Using the Clay Just Worked With

Piaget has stated that this ability is developed at eleven or twelve years of age.[3] The student was presented two identical containers which contained equal amounts of water and allowed to work with the volumes until he had convinced himself the amounts were equal. He was then asked if the distorted ball of clay (from task #2) would push the water level up more, if the non-distorted ball would push the level up more, or if the two amounts of clay would push the levels up equally. Successful completion of the task confirmed the student's level at IIB and he was given two points.

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[1] Jean Piaget and Barbel Inhelder, The Psychology of the Child, Basic Books, Inc., New York, 1969, p. 99.

[2] Ibid.

[3] Ibid.

4. Conservation of Volume Using Two Identically Shaped Cylinders of Different Weights

Task number three used objects of equal weights and different shapes. This task appeals to the non-volume conserver who successfully completed task two by centering his attention on weight and believing that the levels of the liquid would rise equally because the objects weighed the same. In this task the student was given two metal cylinders of exactly the same size but with marked differences in their weights. All the foregoing properties of the cylinders were pointed out to the student. He was next presented two identical cylinders partially filled with water and allowed to adjust the levels until he was convinced that each tube contained exactly the same amount of water. The student was then asked if the heavy cylinder would push the water level up more, if the lighter cylinder would push the level up more, or if the cylinder would push the levels up the same. Successful completion of the task placed the student in class IIIA, and he was awarded three points. If he predicted incorrectly and then explained the event after he saw it, he was classified as IIB and awarded two points.

5. The Elimination of Contradictions[4]

The student was presented with a small container of water and two wooden blocks. One block was large and heavy and

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[4]Barbel Inhelder and Jean Piaget, The Growth of Logical Thinking, Basic Books, New York, 1958, pp. 20-45.

would float, the other block was small and light but sunk. The student was asked to predict which block would sink and which one would float, or if the blocks would both sink or both float. The prediction was merely a device to involve the examinee in the problem and no points were awarded for a correct prediction. If the student recognized that a rule probably existed to explain what he saw and that the explanation involved both the weight of the blocks and their volumes, he was ranked IIB and awarded two points. If the student recognized that the explanation involved the relationship of the volume and weight of the block to an equivalent volume and weight of water, he was rated IIA and given three points. When the examinee could identify all the variables, order them, derive an hypothesis, test it, and state the results in a logical fashion, he was rated as completely formal operational, i.e., IIIB, and awarded four points.

6. The Exclusion of Irrelevant Variables[5]

The examinee was presented a pendulum whose length could be easily changed and three different sized weights which would be used for the pendulum bob. He was told to do as many experiments as he needed to, using many different lengths of string and all the various sized weights, until he could explain what he needed to do to make the pendulums go fast or slowly. The variables of string, angle, and push were also usually pointed out to the student. If the examinee recognized that

[5] Ibid., pp. 67-79.

length was the only relevant variable, i.e., if he excluded length, push, and angle, he was rated IIB and awarded two points. If he not only excluded the irrelevant variables, but hypothesized a solution to the problem and demonstrated his solution, he was rated IIIA and given three points. If the student could state a general rule about pendula in such a way that it could be tested, he was scored IIIB and awarded four points.

John W. Renner, Ph.D.
Professor of Science Education
University of Oklahoma

Sample size by grades:

Grade 7	= 96
Grade 8	= 108
Grade 9	= 94
Grade 10	= 94
Grade 11	= 99
Grade 12	= 97

APPENDIX B

TABLES INDICATING THE SCORING DISTRIBUTION OF THE 588 RESPONDENTS ON THE SIX TASKS

APPENDIX B

Taken from John W. Renner, Donald G. Stafford, and William B. Ragan, Teaching Science in the Elementary School, Harper and Row, In Press.

The following tables summarize the data as follows: Table I indicates complete combined score distribution of the 588 respondents on the six tasks by grade level.

TABLE I

Grade Score	7 N=96	8 N=108	9 N=94	10 N=94	11 N=99	12 N=97	Totals N=588
0-5	5	3	4	4	3	1	20
6	8	5	5	6	5	3	32
7	11	20	10	9	6	10	66
8	23	16	12	19	16	3	89
9	13	13	12	9	14	15	76
10	15	20	19	11	13	19	97
11	5	7	16	11	11	13	63
12	8	9	4	10	13	6	50
13	5	9	3	5	6	9	37
14	2	3	6	5	4	6	26
15	0	1	1	3	5	8	18
16	1	2	2	2	3	4	14

Table II shows the total sample distribution into the four classification categories.

TABLE II

Score	Classification	No. of Students
0-5	Pre-Operational	20
6-11	Concrete Operational	423
12-13	Post-Concrete Operational	87
14-16	Formal Operational	58

Table III gives a distribution of students recording combined scores of 11 or less on the six tasks, and the percentage of the sample within each grade level category.

TABLE III

Grade	Sample Size	No. Scoring 11 or Less	Percentage of the Sample
7	96	80	83
8	108	83	77
9	94	77	82
10	94	68	73
11	99	70	71
12	97	64	66