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A correlational study between Piagetian concrete reasoning level and academic achievement

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Abstract

Jean Piaget has been identified as one of the great contributors to knowledge in our time. Robinson (1952) lists him in his book, 100 Most Important People in the World Today. During his life he developed the learning theories of genetic epistemology that brought him recognition as the father of modern child psychology. During countless hours of observations performed by him personally, he developed clinical interviewing techniques to reveal the cognitive developmental level of a child. Similarly, all educators are concerned with cognitive development of the learner. The Piagetian clinical interviews glean information on the subject ability to process information which may be related to performance on educati0n measures, such as, achievement and aptitude tests. Both are looking to find out more about the various aspects of the learner's cognitive development. Traditionally standardized tests have been used in measuring academic achievement which is at least one aspect of a learner's level of cognitive reasoning. In light of new knowledge of learning theories, traditional standardized tests may tell educators only part of what they need to know. Teachers are concerned with diagnostic, prescriptive, and analytical tests that can be used both in planning instruction and predicting future academic success in school.

A CORRELATIONAL STUDY BETWEEN
PIAGETIAN CONCRETE REASONING
LEVEL AND ACADEMIC ACHIEVEMENT

A Research Paper
Presented to
Department of Educational Psychology and Foundations
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Introduction

Jean Piaget has been identified as one of the great contributors to knowledge in our time. Robinson (1952) lists him in his book, 100 Most Important People in the World Today. During his life he developed the learning theories of genetic epistemology that brought him recognition as the father of modern child psychology. During countless hours of observations performed by him personally, he developed clinical interviewing techniques to reveal the cognitive developmental level of a child.

Similarily, all educators are concerned with cognitive development of the learner. The Piagetian clinical interviews glean information on the subject's ability to process information which may be related to performance on education measures, such as, achievement and aptitude tests. Both are looking to find out more about the various aspects of the learner's cognitive development. Traditionally standardized tests have been used in measuring academic achievement which is at least one aspect of a learner's level of cognitive reasoning. In light of new knowledge of learning theories, traditional standardized tests may tell educators only part of what they need to know. Teachers are concerned with diagnostic, prescriptive, and analytical tests that can be used both in planning instruction and predicting future academic success in school.

It is the intent and focus of this paper to compare Piagetian test scores to traditional scores on standardized achievement tests. If Piagetian scores do serve as well as, or better than, traditional predictors of academic performance, then one could substitute Piaget's instrument to achieve insight into the problem solving skills required in science classes, skills not effectively measured in the more traditional measures, such as, IQ scores, reading scores, etc.

In the Post-Sputnik era of history, the National Science Foundation initiated several new school science programs that were rooted in learning theories and the work of Jean Piaget. These curriculum changes and Piaget's theories generated a plethora of educational research trying to apply his theories into the educational practices.

Now the mood for innovation has changed. Student achievement scores in science as reported by the National Assesment of Educational Progress have declined, (Funk p.30, 1977). A regressive mood of "back to basics" is upon us in our effort to change trend of declining scores on standardized tests. These test scores present a challenge to curriculum planners and science educators. It is quite possible that elementary science curricula have changed more rapidly than the standardized test, (Funk p.31, 1977). In many cases, science subtests of these traditional standardized tests do not measure what is currently being taught.

If the goal of education is to enhance the reasoning level of the learner and enable them to solve problems, then there is research evidence to support that various program methods will achieve this goal, (Karplus, 1970; Ball and Sayre, 1972). The issue that has yet to be resolved is matching the evaluation of academic achievement to new methods of instruction.

There has been research to show that the "Learning Cycle", (an application of the Piagetian Model), allows the learner to advance to higher levels of intellectual reasoning even though this is not reflected on traditional academic achievement instruments, (Renner, 1975, and Lawson, 1976).

William M. Gray has seriously considered construction of a standardized test based on Piaget's developmental learning theories, (Gray, 1978). He faced difficulties in validation by simply converting the content from Piaget's clinical tasks to a paper and pencil picture format. Many attempts have been made to convert the clinical task interview which requires considerable testing time, special equipment, and trained interviewer to a more efficient paper and pencil version of the test. Most of these instruments show construct and concurrent validity to actual clinical interviews. As reported in Science Education. 1975, 60, (4), (14-15); Raven (1973); Polanski (1974); Joyce and Ankeny (1974), each of these individuals have made attempts to make use of a simplified test to avoid the more time consuming task interview. Of all these efforts, only the Joyce and Ankeny tests, (See Appendix A), used grade school students as subjects to validate their instrument. There still remains a paucity of research efforts using elementary school students to demonstrate relationships between Piagetian levels of cognitive development and elementary school academic achievement.

Piaget's influence on elementary science curriculum has been in the implementation of many activity-centered programs that promote firsthand engagement of the students developing process skills, such as, making hypotheses, experimenting, and interpreting data. This is different from the traditional passive acquisition of content via reading textbooks. Yet standardized tests of achievement have not been changed to reflect these new methods and objectives.

The development of cognitive reasoning skills by using the Piagetian Model provide a teacher with useful insights into the workings of the student's mind not necessarily found in the more traditional measures, like math and reading standard achievement tests. Therefore, two general questions were investigated in this study.

1. How well is elementary school science achievement correlated to the Piagetian level of cognitive development?

2. How well can success on science achievement tests be predicted by the results of a paper and pencil Piagetian test, IQ tests, math, and reading tests?

While searching for evidence that leans on these two questions, the author was aware of possible interaction effects of certain variables. Attempts have been made to isolate and identify these variables and estimate their significance.

Limitation of Study

This author recognized that there were selection and instrumentation problems associated with this study. First, the use of intact classes of students made it impossible to randomize the sample. By comparing the mean scores on the Piagetian test and a series of t-tests revealed no significant difference on the relevant variables of (sex, IQ, achievement test scores, or locations of school). The next limitation was instrumentation. The author had to rely on the school data collected on group administered IQ and achievement tests. In most cases, the Iowa Basic Skills Test was in wide use for the population under consideration.

The sample population was drawn from only two schools. Even though care was taken to use one group of urban students and one group of rural students, both came from similar cultural and geographic backgrounds. The same group IQ tests were not used, the data was incomplete, and the tests were not administered on a regular basis by different schools. It was impossible to administer the same test to both samples of students. Where and whenever possible, the non-verbal IQ score was used. As in any correlational study, no cause-and-effect was assumed in this study.

Assumptions

This study does not replicate Piaget's work but certain assumptions will have to be made to interpret the results.

1. The Concrete Operational Reasoning Test is an appropriate measure of Piagetian level of cognitive development.

2. Performance on the science subtest of the California Tests of Basic Skills is a valid assesment of standard achievement in science.

3. The major variables that are used to predict science achievement were identified and considered in the analysis of the data.

Review of Related Literature

There is such an astronomical number of publications extending and replicating Piaget's studies that in 1970, there was the founding of the Jean Piaget Society. Annual meetings in this country attract authors from all fields of endeavor beyond just education. It has been estimated that Piaget has published close to thirty books and an innumerable number of articles and speeches on the subject of child development. His early works were first translated to English in 1920, and were virtually ignored in this country until about 1950. The best way to begin to understand this work is to examine his personal biographical roots.

Jean Piaget was born on August 9, 1896, in Nerichatel, Switzerland. His father was a medival history scholar and passed on the habit of thinking in details, which was to become apparent in Piaget's writings. His interest in biology was evidenced by his early childhood collections and his work in a natural museum. He published a paper at the age of 10, about an albino sparrow he had observed in a park, this also showing his biological interest. He worked after school hours at the museum. After four years of work, his mentor and director, died. Jean had earned the position of museum director but had to decline because he was still a school boy. He went on to get a doctorate degree in 1918, with a thesis on the subject of malacology, (the branch of zoology dealing with mollusks). His childhood interest in biology would follow him and influence his thinking the rest of his life. He believed that in biology were many explanations to life and even the explanations to working structures of man's mind. Knowledge about how man wants to know what he knows became his epistemological obsession. The answer would not be discovered in pure biology so he became interested in psychology and went on to take another doctorate from Zurich University. Here he learned techniques in clinical interviewing which would be the source of much of his future observations. He then went to Paris where he worked with Alfred Binet, the co-author of the first intellegence test. He returned to Switzerland for the scientific study of the child and for the training of teachers. In 1921, at the age of 25, this young biologist became a psychologist and began a career of research, which was to be his life's work. He married one of his students at the Swiss institute and in time had three children. With his wife's help and thousands of hours of clinical observations of his own children, he wrote books about the cognitive development of children and described his theories about intellegence. He even created his own research institute, the International Center of Genetic Epistomology, and also was co-director of the Institute of Educational Science, (Pulaski,1971).

To the uninitiated reader, his original works are quite voluminous in detail and difficult to follow, so I am suggesting, for ease of understanding, two books that are clear, concise translations and bring into focus possible applications to the educational environment. Understanding Piaget, by Dr. Pulask was the most complete book for background information that this author found. It includes a glossary and appendix of his works in chronological order. Mary Ann Spencer Pulaski stated that the purpose of the book was to serve as a guide. She certainly accomplished this goal.

Another book written by an author active in teacher training, using a "Piagetian Model" for instruciton that specifically exposes the reader to the methods of conducting task interviews and related studies in the field, is Robert Sund's book,Piaget For Teachers. Sund's book is a serious attempt to forge principles of Piaget's cognitive theories into educational practice.

There has been a plethora of publications related to the research of Piaget. Most studies did not use elementary aged subjects as did this study. This author will briefly review only those research efforts that are germaine to this topic.

According to (Ball and Sayre,1972), there was a positive correlation between to number of Piagetian tasks correctly performed by students and their accompanying IQ score. They also discovered that there was a positive significant correlation between scholastic grades and the results of Piagetian interviews. This study included a population of 419 students from grade seven through twelve.

A study similar to this study was performed by Anna Duszynska,(1980), at the Institute of Educational Research,in Warsaw,Poland. It involved grade school aged subjects,age nine to twelve from both Poland and the United States. In this study she developed a multiple choice test called the,(SRLT),Science Reasoning Level Test based on a Piagetian model of the development of thought. The study did reveal the same patterns of thought processes in Polish and American school children. This coincides with Piaget's co-worker's findings that children from different languages and cultures go through similar patterns of cognitive development.

This study also showed a positive correlation between the (SRLT) reasoning test scores and academic achievement. Reading Comprehension and Science Test (both constructed for the purpose of international survey conducted by

International Association for the Evaluation of Educational Achievement) were chosen as external criteria. The correlation coefficients of the (SRLT) to Science and Reading Comprehension was found to be positive and significantly higher with each grade in school. For example, the (SRLT) correlated to science scores in the third grade sample .35, the fourth grade .52, and the fifth grade .58. A similar pattern existed correlating Reading Comprehension to (SRLT) from .32 at the third grade sample level to .51 in the fifth grade level. These results imply that while the subject's standardized test score may not be improving rapidly, the (SRLT) test reveals positive cognitive development is taking place. The results seemed to show that the relationship between reasoning ability and school achievement increase through the grades. With each year spent in school, logical thinking becomes more and more related to school achievement in science, remaining the same through the grades.

Traditional standardized achievement tests measure only general notions about intelligence. Reasoning tests go further than this and reveal more about individual differences between tested subjects. These specific diagnostic differences are somewhat obscured by traditional measures. It is very important at an early stage of science education to analyze the cognitive abilities rather than pure factual knowledge prior to his or her entry into laboratory activities.

The results of such testing may help reveal what cognitive skills the learner has, so that instructional materials and methods could be better matched to the abilities of the student. The goal of enhancing the reasoning levels of the students could improve instruction in school science to beyond simple rote-memory or recall of facts type of learning.

In a study (McKimon and Renner, 1971), it was found that fifty percent of the 131 freshman at Oklahoma City University operated completely at the concrete level and twenty-five percent of the remaining subjects never fully attained the formal level of reasoning. It was further found that freshman involved in inquiry-oriented science instruction at the university significantly increased their ability to reason formally. All of these studies utilized clinical interviews as a method of assessing the subject's level of cognitive development then compared those scores to more traditional measures of academic success, like IQ and school grades. These results implied a great need for programs to help measure and develop cognitive reasoning abilities.

Today educators are increasingly being pressed to justify what is being done in schools. Through Piagetian research we are given a new perception of the school's curricula and environment. Many Science Educational programs have been adopted and labeled as being "new" or "modern" because the curriculum has become student-centered, allowing each student opportunity to become actively engaged in the learning process.

In practical educational research,most researchers have attempted to show that methods of teaching, eg. the "Learning Cycle" and"Self regulation", (Lawson p.38,1976),will enhance or accelerate student's development of reasoning abilities. Piaget himself would take issue that this kind of acceleration is not likely or even possible,(Piaget,1964).

This author,after a rather exhaustive search of the literature was not able to find a study that attempted to show that there is a relationship between Piagetian-operational abilitiy and academic achievement, especially at the concrete-operational stage which is thought to equivalent to grades four through six in school. Most research is aimed at the higher "formal level" of reasoning,including subjects from secondary or post-secondary aged sample. Furthermore,no studies have indicated that any predictive model was formed from an analysis of the data. It was the feeling of this author that he was working in a rare area of educational research.

Methods and Procedures

The sample was drawn from two elementary school populations from different locations and backgrounds. The Kingsley Elementary School fourth and sixth graders were part of a large metropolitan school system with upper middle class background. The Allison-Bristow Community School fourth and sixth graders were located in a rural lower middle class, small farming community.

The sixth grade in the city consisted of 19 boys and 20 girls. The fourth grade in the city contained 20 boys and 24 girls. The rural sixth grade had 14 boys and 25 girls. The rural fourth grade had 20 boys and 18 girls. The total of 160 students included 78 sixth graders with 33 boys; 45 girls and 82 fourth graders consising of 40 boys and 42 girls. An individual IQ score for the rural sample subjects was based on the CTMM, (California Test of Mental Maturity, 1963). The non-verbal IQ group administered scores were used. In the city sample, IQ scores were taken from both the Cognitive Abilities Test, (CAT), non-verbal subtest, and the Primary Mental Abilities Test, (PMA). All subjects were given the same level 2 Form S (1973) California Test of Basic Skills Science subtest and raw scores were recorded for each student. The Iowa Test of Basic Skills, (ITBS), Math, and Reading Comprehension tests were given and recorded as grade equivalents based on the national norms. The Math subtest in Problem Solving Abilities was used,excluding computation and concepts. The Concrete-Operational Reasoning Test (CORT) (Joyce-Ankeny,1974), was administered,(see Appendix). The scores and subtest items were recorded as raw scores. The results of this Piagetian(CORT) test were to be considered a reliable measure of the learner's cognitive level of reasoning. The author of this instrument found it to have significant face validity and concurrent validity based on a (r=0.63), significant relationship to actual personal interviews conducted on the pilot sample of 129 students from 8 to 14 years of age in Greeley, Colorado, (Ankeny, 1974). The 20 item multiple choice test has no "hands on" experience but it does have line drawings accompanying each question.

Conservation, a certain characteristic of concrete level of reasoning, in one area, does not mean automatic conservation on other task areas. Therefore, the 30 item test covers ten subtest categories of conservation reasoning. This yields results that show each area that the subject is operating at or beyond the concrete level. The subtest categories include: length, class inclusion, area, Euclidean space, spacial relations, weight, one-to-one correspondence, transitivity, velocity, and volume. A complete item analysis was run on a pilot group by this author. A Reliability (K-R) 20 coefficient of 0.74 was observed. A good (more than 0.40) 57% discrimination index was found.

Since most schools make regular use of group administered IQ and Iowa Tests of Basic Skills, most of the data was available. Many schools did not use any standardized instrument to test science achievement in the elementary school. This meant that the CTBS, California Test of Basic Skills subtest in science was administered and raw scores were collected. This test, level 2 Form S, was used to cover grades six through nine. The instrument had several line drawings which caused the subject to use science reasoning to answer the questions. In the statistical reports about the CTBS, it was reported to have a correlation of 0.63 to the normal sample of 500,000 students taking an IQ test. Likewise, the Concrete-Operational Reasoning Test was given and raw scores collected. These two tests were administered at nearly the same time and took less than an hour of class time.

Analysis of the Data

Basic handling of the data was a twofold process. First, was building a correlations model looking for significant relationship between the variables. Then, focusing on these variables in an attempt to build a prediction model by finding a factor type equation of prediction between the highly correlated variables. It was assumed that the major variables that have prediction value upon success in school science achievement were found.

This procedure began with rostering all the students on a chart, identifying them by a 3 digit student number. Next on the same grid, filled in a code for grade, sex, and school and extended by rostering the IQ, Math, Reading, Science, and Concrete-Operational Reasoning test scores so that this information could be card punched for computer analysis. The SPSS, (Statistical Package for Social Science), was used to calculate correlation coefficients by using the "PEARSON CORR" program, (see figure 1).

Notice in figure 1 the number of variables that correlate very significantly beyond the probability level of 0.05, which is generally accepted as significant in educational research. Note that the Piaget scores from the reasoning test correlates well with all the traditional test measures of IQ, Reading, Math, and Science. All were positive and significant correlations. Of all these correlations, the 0.639 correlation coefficient between Piaget score and Science stand out higher than Reading (0.425) and Science, which is generally regarded as predictor of success in school. The difference between the (0.182) coefficient for Math compared to (0.639) for Science is a good indication that different logical reasoning patterns are needed in both subject areas. This is

Figure 1

PEARSON CORRELATION COEFFICIENTS
FOR 160 FOURTH AND SIXTH GRADE STUDENTS

	PIAGET	IQ	READ	MATH	SCIENCE
PIAGET	1.000 p=0.000	0.391 * p=0.000	0.425 * p=0.000	0.182 * p=0.012	0.639 * p=0.000
IQ		1.000 p=0.016	0.175 p=0.016	0.121 p=0.068	0.466 * p=0.000
READ			1.000 p=0.000	0.229 * p=0.002	0.114 * p=0.000
MATH				1.000 p=0.000	0.183 * p=0.024
SCIENCE					1.000 p=0.000

Note: * means significant correlation

to say that the Piagetian test was probably not measuring the same things that the Math test was. The mental operations measured by the Piagetian test were not highly involved in mathematical skill performances as measured by the standard achievement tests. Note also, the IQ test correlates moderately (0.466) to the (CTBS) Science test. This data supports and reinforces the assumption made in this study that highly correlated variables are most likely the major variables used to predict success in school science and other aöhievement areas. One can clearly see that the Piaget score is the most highly correlated variable in the Science column. One question remained. Was the Piaget score also the best predictor of success in school science? For this, further analysis of the data was needed.

A stepwise regression analysis was used to determine which of the listed variables could be used to predict school achievement in science. This produced a factor-type equation on the printout.

To consider the predictive model in this study via regression analysis, it would be necessary to explain how a linear regression equation had been traditionally used in the educational or guidance setting. If a battery of achievement tests were given and correlated to average grades of a school group, then a regression equation was developed based on that correlation. It follows that probable grades, within the range of a standard error, would be predicted on subsequent school groups by giving the tests and utilizing the test scores and the factor-type regression equation to predict probable grades of the subsequent class in school. Forecasts of this sort have been used in the educational, vocational, and guidance settings. It has been held that entering a given trade or profession can be predicted from a battery of aptitude tests. True, this type of prediction via regression equation is dependent upon other variables not in the equation, however, it has been found to be more reliable than a prediction made merely on subjective judgement. Therefore, these types of predictions would be most probable but not totally reliable.

In contrast to the two variable linear correlation example just mentioned above, this study involved multiple variables, that is to say, there was more than 2 varibles in the equation used as predictors. Therefore, in this study it was designed that an estimated score on the CTBS test, the variable to be used as a measure of successful achievement in school science, could be predicted from a series of obtained scores which made up the multiple regression formula. This formula uses a series of partial r s which were correlation coefficients of each variable in the equation when all others were "partialed out" or held constant. These partial multiple r s gave weight to each score in the predictive model when the sum produced was to be a predicted score (CTBS) as the dependent variable.

The stepwise regression analysis included four steps having entered one at a time, using simple correlations uncovered earlier in the study, (see figure 1). This researcher chose only the most significantly correlated variable to enter into the formula. It was found that spatial reasoning items within the Piagetian Concrete Reasoning Test were significantly correlated to the SCIENCE (CTBS) variable with a coefficient of (0.630). In figure 2, the SPACE referred to just three questions out of the thirty question Piagetian Concrete Reasoning Test. The Reading Comprhension Score from the Iowa Test of Basic Skills is represented on the printout as READ, (see figure 2). This score added little to the predictive model, (see RSQ Change 0.14), which represents approximately how much of the Science score can be attributed to reading comprehension once spatial reasoning skills are already in the formula. This author suspected that this might have also been explained by saying the score on the CTBS SCIENCE TEST was not very dependent upon reading abilities. Notice that once SPACE and READ variables went into the formula on step three, IQ contributed insignificantly 0.04 to further change the Multiple R. Further insignificant contributions were made to the predictive model on step four. When TOTAL, a total raw score on the thirty items Concrete Operational Reasoning Test, was entered into the equation. It was reflected by only a 0.01 change in the Multiple R. On step five, GRADE was entered with very little change, but that was probably attributed to low variability in the sample which consisted of only grades four and six. The (CONSTANT), a number added on to the weighted, was a score to get the predicted probable score.

The final regression formula taken from the data, presented in figure 2 would be the SCIENCE score (CTBS) and would be equal the SPACE score multiplied by 1.707 plus 1.438 times the READ reading score plus the constant.

Several multiple regression analysis runs on the computer were made with sometimes as many as nine steps with always the same results. Each time a reasoning score plus a reading score were entered into the formula, each variable added to the model of prediction made no significant contribution to the overall prediction of CTBS score or the dependent variable used to measure successful achievement in school science.

Figure 2

MULTIPLE REGRESSION

DEPENDENT VARIABLE...CTBS

Summary Table

VARIABLE	MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R
SPACE	0.630	0.397	0.397	0.630
READ	0.739	0.546	0.148	0.614
IQ	0.768	0.590	0.044	0.458
TOTAL	0.780	0.609	0.018	0.622
GRADE	0.785	0.617	0.007	0.264
(CONSTANT)				

Variables in the Equation

VARIABLE	B	STD ERROR B	F
SPACE	1.707	0.265	41.2
READ	1.438	0.238	36.3
(CONSTANT)	7.913		

Conclusions and Implications

The author is an elementary school science instructor and in this study has examined the relationships between Piagetian level of cognitive development and successful achievement in school science. If the assumption that the (CTBS) California Test of Basic Skills is a valid assessment of achievement in school science, the Piagetian measures, not only,correlate(r=0.63), nicely,but they also have a higher coefficient than Reading,IQ,Math, or any other variables considered in this study,(see figure 1). One could conclude from this study that Piagetian measures may have provided insightful aspects of the learner's cognitive operations in science class that are otherwise overlooked if one relied solely on Reading ,Math,orIQ and other traditional measures. The data suggests that there are many cognitive operations in science that are beyond pure reading comprehension. This author concluded more inclusion of Piagetian testing should be incorporated into the instructional and evaluation strategies to enhance the knowledge of what cognitive abilities successful students in elementary school science possess. If a teacher,administrator, or curriculum planner relied solely on the traditional achievement measures of Reading,Math,and IQ, some important cognitive abilities could be overlooked. It would seem that more controlled studies would be in order to isolate and clarify what cognitive abilities were not being measured by the standardized achievement tests. With further Piagetian related research,deeper understanding of what reasoning abilities were possessed by those learners observed to have success in science achievement could be revealed.

The discovery of these things would serve as a good guide for instruction to the rest of the class.

The results of the regression analysis showed that certain variables from this study could indeed be used to predict success in school science achievement, by the simple to administer, paper-and-pencil reasoning test. There was little data to support that achievement in science was heavily related to reading comprehension skills. The implication that science in elementary school should be textbook oriented with emphasis on reading comprehension could not be supported by data collected in this study. On the contrary, spatial reasoning exercises, like activities in astronomy, would make more sense in view of the data in figure 2.

It was concluded that Piagetian measures have useful predictive validity, particularly when used in combination with reading abilities. The ability to reason spatially was the most prominent predictor in the formula. It would follow that more work in science classes were needed to develop these potent abilities as prerequisites to more complex scientific reasoning abilities.

All empirical data in this study seemed to imply the need to teach towards objectives that would enhance the reasoning level of the student, particularly the spatial reasoning type skills. This author, an elementary school teacher, can find support for continued work in the classroom teaching towards these types of objectives.

I have found certain topics and activities in astronomy, like phases of the moon, help to promote spatial reasoning skills, as well as, learning content knowledge.

This study also implies the need for more Piagetian-based research particularly using elementary school subjects. The cognitive reason type tests are available but rarely used. If put to use more widely, teachers could gain much deeper perceptions about their students,compared to those guided through the traditional IQ and achievement type tests. Hopefully, the day will come when teachers' knowledge and use of cognitive reasoning abilities will be raised to the level of popularity and importance now given scores on a standardized achievement test.

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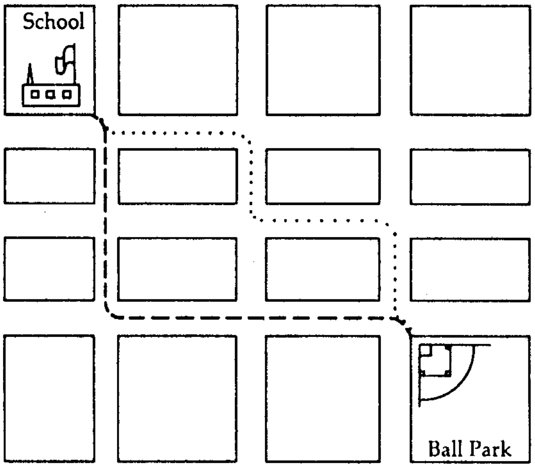
Appendix A
Concrete-Operational Reasoning Test

Directions: This test consists of thirty problems. Read each problem carefully before trying to answer it. Pick out the best answer from the choices given and write the number of your choice on a separate answer sheet. (See p. 172.)

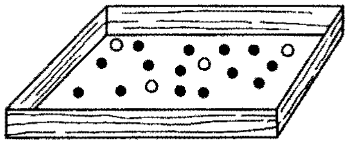
1. Henry and Bobby decide to go to the ball park after school. They can't agree on which way to go, so Bobby goes one way (shown by the dotted line . . .)and Henry goes another way (shown by the dashed line - - -).



Which of these statements is true?

1. Henry and Bobby will walk the same distance.
2. Bobby will walk farther.
3. Henry will walk farther.
4. Impossible to say.

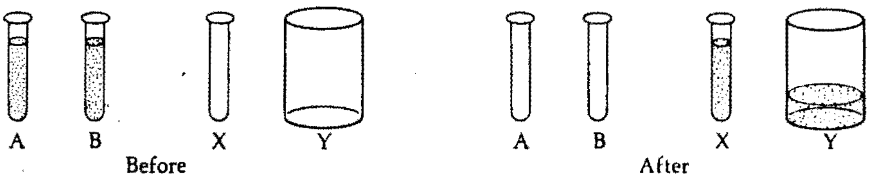
2. The following box contains wooden beads. Fourteen beads are black and four are white.



Are there more black beads than wooden beads?

1. more black beads
2. more wooden beads
3. same number of black beads as wooden beads
4. Impossible to say.

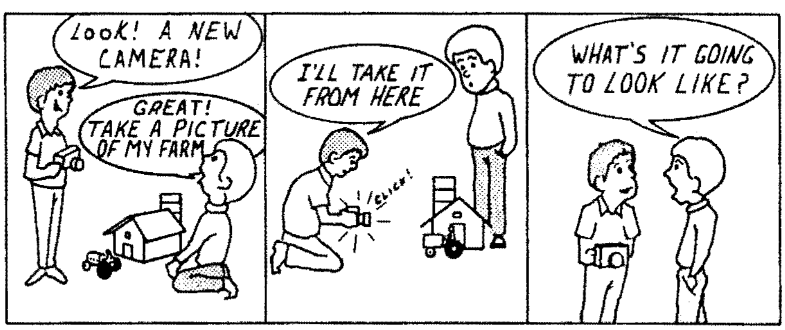
3. Two test tubes are filled with water. The water from tube *A* is poured into tube *X*. And the water from tube *B* is poured into glass Y, as shown following.



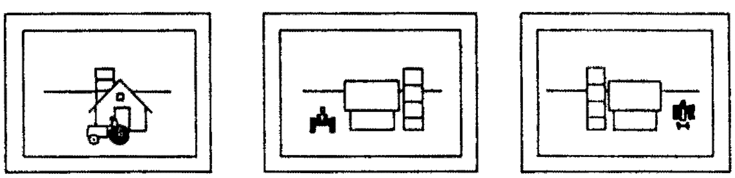
Which of these statements is true?

1. *X* and Y both have the same amount of water.
2. *X* has more water than Y.
3. Y has more water than *X*.
4. Impossible to say.

4.

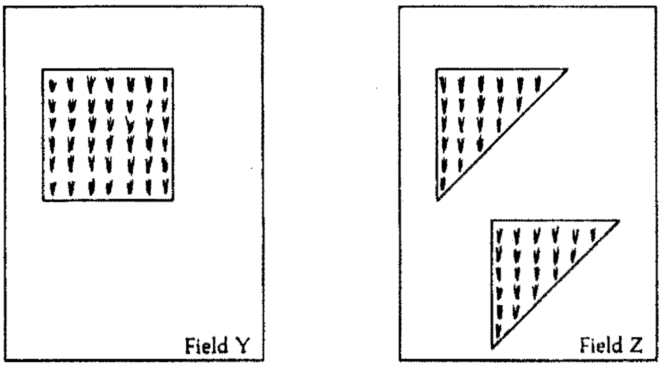


What will the picture look like?



1 2 3

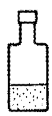
5. A farmer has two fields of the same size in which he wants to grow equal amounts of wheat. He plants wheat in a square plot in one field. In the other field this square has been divided into two parts, as shown below.



Which of these statements is true?

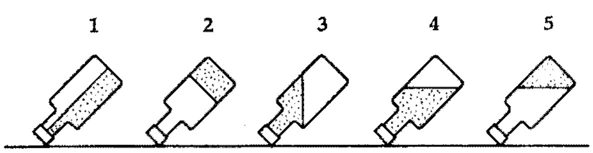
1. More wheat has been planted in field Y.
2. More wheat has been planted in field Z.
3. Field Y and Z are equal in the amount of wheat planted.
4. Impossible to say.

6.



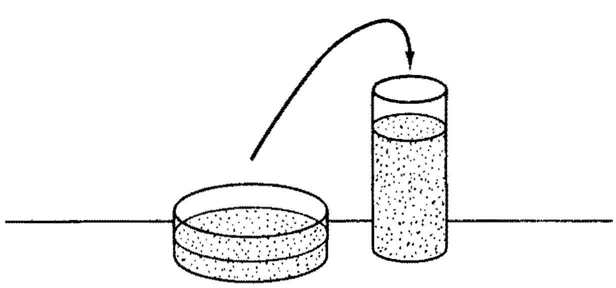
Water bottle with cap screwed on.

If the bottle is tipped as shown, which figure shows the correct water line?



1. bottle 1
2. bottle 2
3. bottle 3
4. bottle 4
5. bottle 5

7. All the water from the short, fat bowl is poured into the tall, narrow glass.

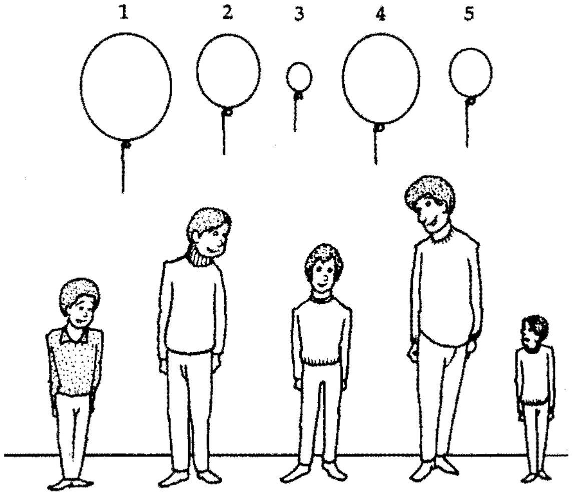


Which of these statements is true?

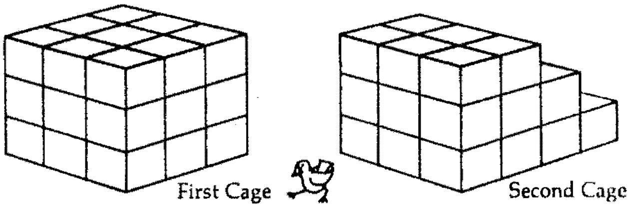
1. The water takes up less space now than it did in the bowl.
2. The water takes up more space now than it did in the bowl.
3. The water takes up the same amount of space in the glass as in the bowl.
4. Impossible to say.

8. Each man in this picture will be given the balloon most similar to himself in size. The largest balloon will go to the tallest man, and so on. Therefore, the man at the far left with the dark shirt will be given which balloon?

   1. balloon 1
   2. balloon 2
   3. balloon 3
   4. balloon 4
   5. balloon 5



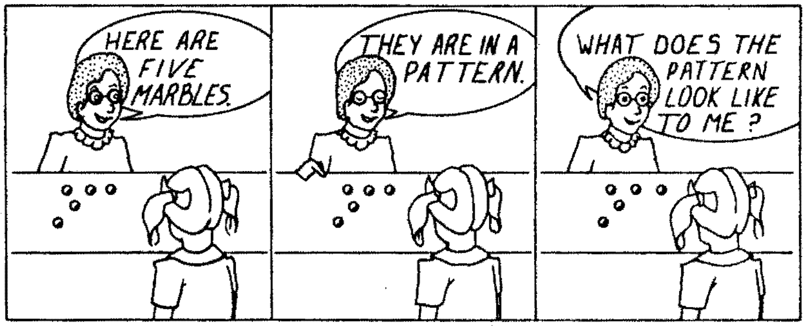
9. Playing with blocks, a girl builds a make-believe bird cage for a canary. Using all of the same blocks, she later makes a second cage.

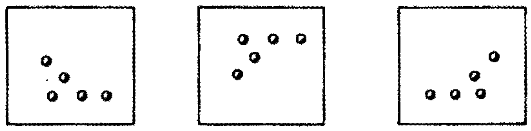


Which of these statements is true about the amount of room that the canary will have for walking and flying?

1. The first cage has more space.
2. The second cage has more space.
3. The amount of room is the same in both cages.
4. Impossible to say.

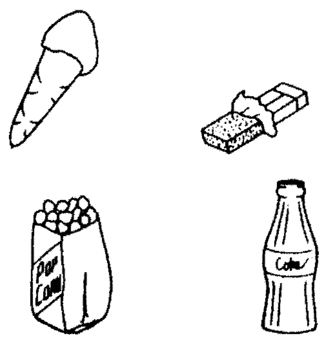
10.





1 2 3

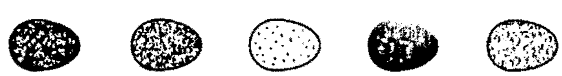
11. Sue likes candy better than ice cream. She likes ice cream better than soda pop. And she likes soda pop better than popcorn.



Which of these statements is true?

1. Sue likes popcorn better than candy.
2. Sue likes candy better than popcorn.
3. Sue likes popcorn and candy equally well.
4. Impossible to say.

12. Below are five Easter eggs. The youngest person gets the darkest colored egg, and so on.

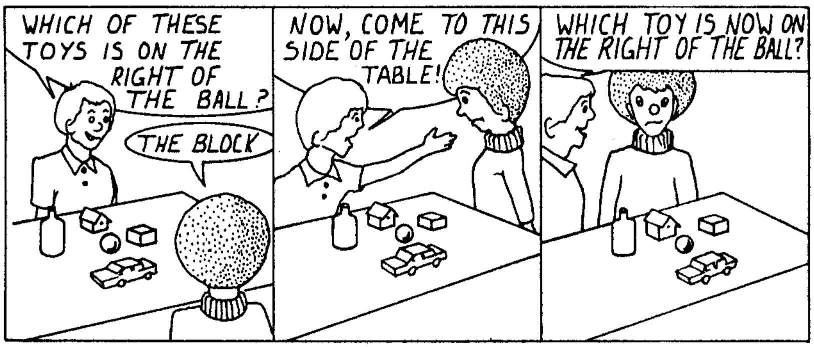


1	2	3	4	5
Sally	John	Tim	Mary	Susan
14 years	11 years	7 years	13 years	9 years

Which child would receive egg 1?

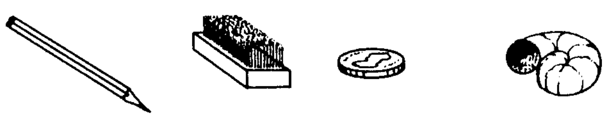
1. Sally
2. John
3. Tim
4. Mary
5. Susan

13. Along the coast, are sea gulls more abundant than sea birds?
    1. There are more sea gulls.
    2. There are more sea birds.
    3. There are the same number of sea gulls as sea birds.
    4. Impossible to say.

14. 

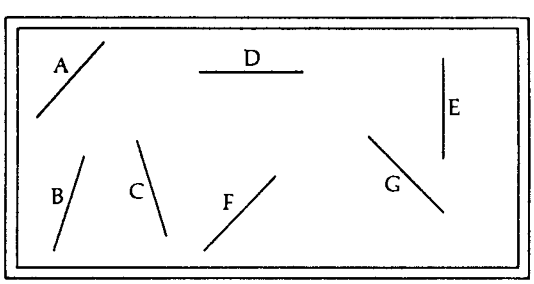
    1. car
    2. bottle
    3. block
    4. house

15. Look at the objects following. The pencil weighs less than the brush. The brush and the coin weigh the same. The coin weighs less than the shell.

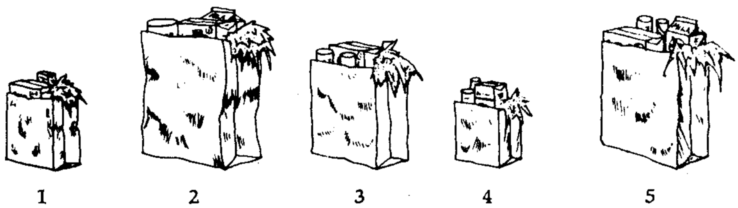


Which of these statements is true?
    1. The pencil weighs *more* than the shell.
    2. The pencil weighs *less* than the shell.
    3. The pencil and the shell weigh the same.
    4. Impossible to say.

16. Which two lines in the box below run in the same direction and would never meet if they were drawn longer?
    1. *B* and *G*.
    2. *A* and *F*
    3. *E* and *F*
    4. Impossible to say.



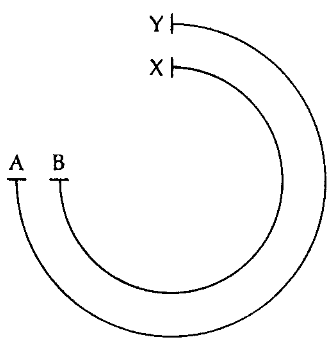
17. Mary and her friends went to the store and bought sacks of groceries as shown below. Each sack cost a different amount. The amounts were \$5.50, \$2.00, \$9.00, \$3.50, and \$13.00.



Which sack of groceries would probably have cost \$9.00?

1. sack 1
2. sack 2
3. sack 3
4. sack 4
5. sack 5

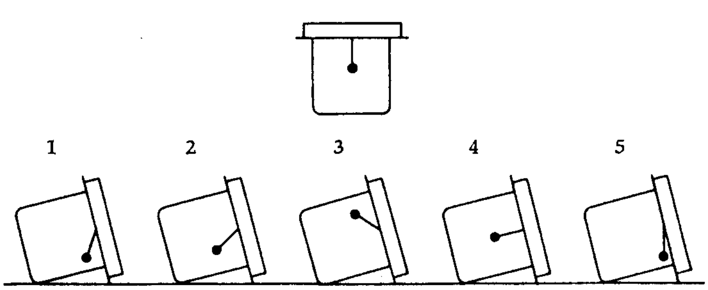
18. Two joggers run around the paths shown below. They start together at *A* and *B*. Each runs for four minutes. They stop together at *X* and *Y*.



Which of these statements is true?

1. The runner who started at *A* ran faster and had higher speed.
2. The runner who started at *B* ran faster and had higher speed.
3. The two runners had the same speed.
4. Impossible to say.

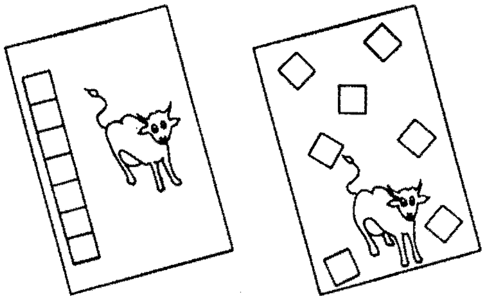
19. The jar alone has a screw-on cover. A marble is suspended from the center of the cover, and then the cover is put on the jar as shown.



If the jar is tipped as shown, which figure shows the correct position of the string and marble?

1. jar 1
2. jar 2
3. jar 3
4. jar 4
5. jar 5

20. Farmyards are constructed on two fields of the same size as shown below. Similar barns are placed on each field, but are arranged differently.



Field X Field Y

Compare the amount of grass that the cows will have to eat. Which of these statements is true?

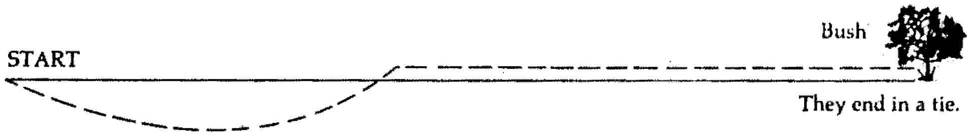
1. The cow in field *X* has more grass.
2. The cow in field *Y* has more grass.
3. Both cows have the same amount of grass.
4. Impossible to say.

21. In the picture below, there are dark and light wild flowers.

Are there more wild flowers than dark flowers?

1. more wild flowers
2. more dark flowers
3. same number of wild flowers as dark flowers
4. Impossible to say.

22. Two motorcycle riders are racing each other in a field toward a small bush. They start at the same time and arrive at the bush at the same time. The rider on the first cycle followed the path shown by the solid line, while the second cycle moved along the path shown by the dashes.



Compare the speeds of the two riders.

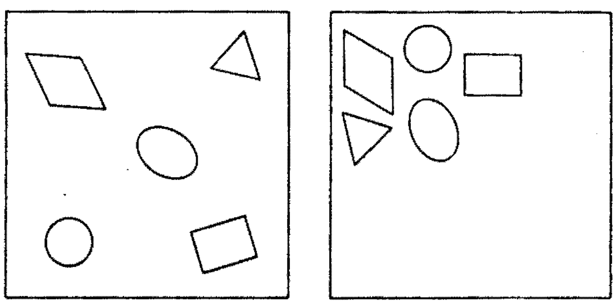
1. The rider on the path shown by the solid line had a higher speed.
2. The rider on the path shown by the dashes had a higher speed.
3. The two riders had equal speeds.
4. Impossible to say.

23. **The cook has two pieces of cookie dough of the same size and weight.** With one piece of dough she makes a boy cookie, and with the other piece she makes a football cookie.

Which of these statements is true?

1. The boy cookie and the football cookie weigh the *same.*
2. The boy cookie weighs *more* than the football cookie.
3. The football cookie weighs *more* than the boy cookie.
4. Impossible to say.

24. Linda and Cindy are going to paint the shapes drawn in the following boxes. Linda will paint the shapes in the box on the left and Cindy will paint those on the right.

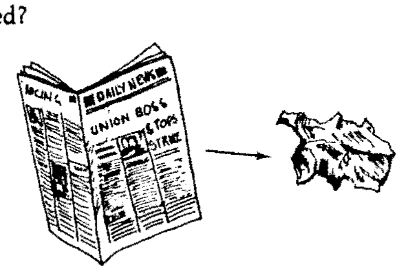


Linda Cindy

Which of these statements is true?

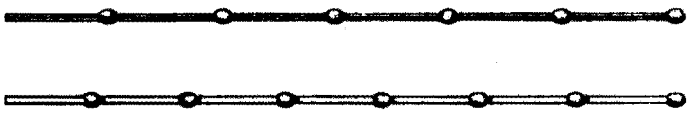
1. Linda will have to do more painting.
2. Cindy will have to do more painting.
3. Linda and Cindy will do the same amount of painting.
4. Impossible to say.

25. A newspaper has been crumpled up into a ball and thrown on the floor, as shown below. Does the crumpled newspaper weigh more, the same, or less than it did before it was crumpled?

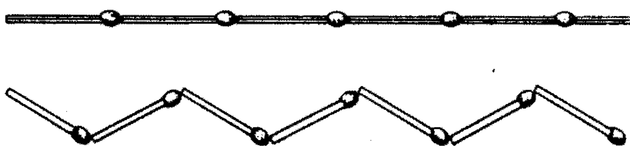


1. It weighs the same.
2. It weighs less.
3. It weighs more.
4. Impossible to say.

26. A person using two different kinds of matches builds two roads as shown following.



Suppose road 1 is left just as it is, while road 2 is changed into a zigzag pattern, as shown below.



Which of these statements is true for an ant walking from end to end after road 2 is changed?

1. Road 1 is longer for the ant.
2. Road 2 is longer for the ant.
3. Road 1 and 2 are the same length for the ant.
4. Impossible to say.

27. Susan is taller than Mary. Mark is shorter than Mary.

Which of these statements is true?

1. Susan is taller than Mark.
2. Mark is the same height as Susan.
3. Mark is taller than Susan.
4. Mary is taller than Susan.

28. With a train set a boy sets the tracks as shown in Figure A. Next, using all of the same sections of track, he sets them as shown in Figure B.

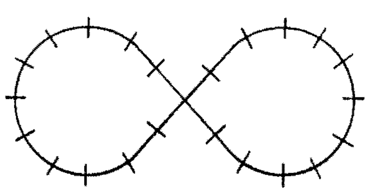


Figure A

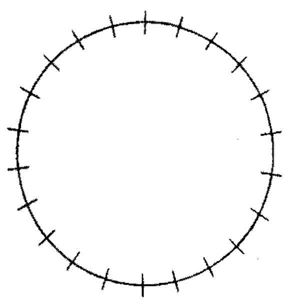
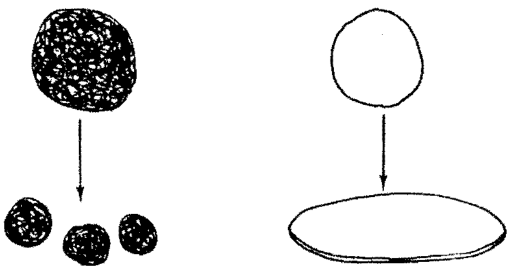


Figure B

Which of these statements is true?

1. The train will have a longer trip around the track in Figure A.
2. The train will have a longer trip around the track in Figure B.
3. The length of the trip is the same on both sets of tracks.
4. Impossible to say.

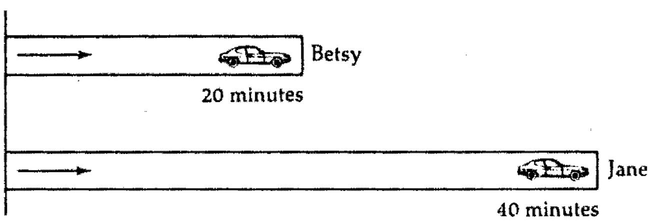
29. John has two colored balls of clay, one dark and one light. The balls weigh the same. He separates the dark ball into three small balls, and flattens the light colored ball.



Which of these statements is true?

1. The three balls weigh more than the pancake.
2. The pancake weighs more than the three small balls.
3. The pancake weighs the same as the three small balls.
4. Impossible to say.

30. Two cars, called *Betsy* and *Jane*, are travelling along two roads side by side. In twenty minutes, Betsy goes six miles. In forty minutes, Jane travels ten miles. The figure following describes the distance each car travelled.



Which of these statements is true?

1. Betsy has a higher speed.
2. Jane has a higher speed.
3. The speeds of the two cars are equal.
4. Impossible to say.