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Class Size Neo-Piagetian Testing: Theory, Results, and Implications

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Theory , Results , and Implications

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Introduction

A comprehensive theory explaining the processes involved in human learning has been avidly sought by educators and social scientists. The value of such a theory is not merely seen as an aesthetic or intellectual pursuit. A theory which describes how a person learns could be valuable both in structuring lessons and in evaluating proposed techniques for educational goal setting and achievement. Such a theory could also provide a more efficient educational system and a more satisfied clientele. In addition to this general use for the theory, applications for it would abound in many related endeavors from use in aiding learning disabled students to the use in programing of computers to think like humans.

Jean Piaget's approach to conceptualizing the process of human learning has been based upon a developmental perspective utilizing stage theory. Since Piaget's theoretical work in developmental psychology, educators have attempted to utilize his theory as an aid in preparing curricula and the objectives for such curricula. After a series of unsuccessful attempts at applying his conceptualization of learning with pre-school children (Kuhn,1979), educators regrouped and began investigating the nature of the learning processes demonstrated by students at the interface between the concrete and the formal operational development stages, during the age span from eleven to fourteen years (Case , 1974).

One group of researchers has focused upon testing and teaching seven to eight year olds who showed a high ability in handling complex problem solving tasks. Their abilities appeared to be enhanced by the procedures utilized by Case and associates in one to one interviewing techniques.

The present study undertook to investigate the results which might be obtained if the procedures were used with a large statistically homogeneous group of classroom students. The main thrust of this study, therefore, revolved around the 'scale-up' of the Case Instructional Sequence into a classroom size application able to be implemented by instructors with little additional practice in employing this type of instructional sequence.

Specifically, the purpose of this study was to determine the effect of the Case type treatment on the performance of two successive ninth grade physical science classes at a private, college-preparatory, secondary school in northeast Florida. These groups were to be assessed using the Tobin and Capie Test of Logical Thinking, a measure which could help assess their respective Piagetian stage. A certain testing schedule would be used in which the time lapse between the first test and the second would be approximately nine weeks, during which time the two day treatment would be administered. An additional post test would be administered nine weeks after the second of the two tests.

If this technique were to be viewed as successful on a large scale such as this, then it could be seen as appropriate to adopt it within the regular classroom curriculum in physical science for this age group. The implications for applying insights drawn from this study to other areas of the school curriculum might also have a significant impact upon the nature of the educational experience offered to students. The implications of this study on the validity of present educational theory will also be examined with an eye to the theory's ease of application to classroom situations.

Review of Related Literature

Since the dissemination of the work conducted by Jean Piaget in Switzerland during the 1950's, the broad outline of the steps postulated for human mental growth and learning have been debated; these steps are, however, now widely accepted (Pascual-Leone et.al., 1978). A great deal of current research has been based on the assumption of the validity of Piaget's Theory of Development. Within his theory there is a descriptive developmental sequence containing four main stages of mental growth. Each of these stages has distinctive characteristics. The attainment of each stage of development allows the indivdual to operate on problems of increasing complexity. Chronological age is used as a qualitative indicator of the stage the individual should be exhibiting.

The Sensorimotor stage is the first experienced by the child. During the first two to three years of growth, the child is simply learning coordination with his world and absorbing simple stimuli-response patterns into his experience (Okun and Sasfy, 1977).

During the next stage, the preoperational, the child moves into more complex hand to eye coordination tasks--shoe tying, baseball throwing, kit building, maze solving--and socialization behaviors. Using these types of skills the child becomes an explorer into the wider areas of his environment and learns where new horizons exist (Okun and Sasfy,1977). Mentally, the child is beginning to see more complex relationships between things and humans. He becomes competent during this stage to judge what he wants and does not want in some restricted circumstances. The preoperational stage exists until approximately the age of seven (Okun and Sasfy, 1977).

After his preoperational background has been absorbed, the child is ready to move into a higher level of problem solving ability: the concrete-operational stage. His development up to this stage has been a process of skill learning and data acquisition; from now on generalizations, concepts and complex creative actions become possible. The concrete-operational child is not introspective, he needs hands on experience to solve problems and he tends to deal primarily with the one feature of the problem which he sees as dominant. He cannot, at this stage, assign levels of priority to various facts or hypotheses and does not search for more than one obvious feature of the situation. Until he is eleven or twelve years of age, the concrete-operational child must sit down with the objects involved in the situation to solve problems. He starts in reality and can be trained to consider possibilities; but, all possibilities appear to him as equally likely (Okun and Sasfy, 1977).

According to Piagetian theory, the summit of cognitive ability is achieved after the concrete-operational child begins to function as the more mature formal-operational adult. When this happens, the individual merely needs to continue his data acquisition so that he will be able to handle complex problems with more understanding and better consideration of their many possible facets. The formal operational person is interested in privacy and protection of his space. He is able to prioritize his facts and is capable of understanding the multiple meanings of symbols; he is also beginning to appreciate that king of humor--the pun (Okun and Sasfy, 1977).

According to Piaget, the process of intellectual development is a continual process of organizing old data into new structures and categories in a manner that is discontinuous and qualitatively distinctive depending on the stage of the individual (Okun and Sasfy, 1977). This process of reorganizing data, however, does not always happen at the highest level of which the individual is capable , but it can never be done at a level above that which characterizes the individual (Hooper and Sheehan, 1977). When formal operational thought processes are attained, the individual usually develops these processes in his or her particular area of expertise. There is some research which indicates that this ability can not necessarily be carried over to help the individual solve problems in this manner in other areas of specialization(Kuhn,1979).

Having attained formal operational processing ability, stability is predicted for the individual's mental development with no provision made for further cognitive stage changes (Hooper and Sheehan, 1977). Formal operational processing is the highest qualitative process advanced by Piaget to explain mental growth and development.

After Piaget's theory was accepted, researchers began the task of applying it to situations found in human mental development. Using the theory to attempt predictions of the value of various teaching techniques and the validity of teacher expectations in encouraging student advancement from one stage to the next led to some disappointing results. It was during this period of application that researchers lost some of the euphoria concerning the universality of this theory of human learning (Pascual-Leone et.al., 1978). These workers agreed that the theory of Piaget did indicate quite accurately the stages observed in mental development, but that the theory was not able to give consistently reliable insights into which techniques were useful in producing the most effective mental growth at each stage.

This failure did not detract from the utility of Piaget's theory. The understanding of this hole in the theory started researchers asking questions about the more basic problems within the theory. The primary question still being addressed by many researchers is: " How does an individual develop from one stage into a higher stage ?". The ideal of continuous development between and within stages in the original Piagetian theory appears to be overlooked almost as if an individual simply leaps from one stage into the next in a quantum-like jump. Observations conducted by workers have indicated that this quantum jump is not universally true (Linn, 1978). The development of the complete answer to this " How ? " question has led to a new type of researcher called a Neo-Piagetian. Acceptance of the broad outline of Piaget's theory is not questioned by these researchers, but the mechanism used in the development from stage to stage is hotly debated in the literature.

Neo-Piagetians indicate that the dilemma within simple Piagetian analysis hinges on the mechanism of change within each level of growth; Piaget ignores this by citing a universal average age as a standard for attainment of each level (Pascual-Leone et.al., 1978). The new researchers are concerned that such a system does not allow for accurate prediction of the position occupied by the individual within the level or between levels. Instead of such a simple system, they indicate that a "relational model of development would incorporate all the influences of historical, sociological and demographic actions" of society on both the social and mental development of the individual (Pascual-Leone et.al., 1978). The Neo-Piagetians appear to search for a theory which analyzes the process of mental development utilizing a greater variety of educational factors than simple mental development through age; moreover, the debate concerning hereditary vs. environmental effects on learning is still recognized as not resolved satisfactorily by the profession.

One of the current subtheories proposed to fill in the mechanistic gaps in Piaget's stages was postulated by J.Pascual-Leone in 1976. His theory of constructive operations argues for the process of scheme development as the mechanism of mental development. Pascual-Leone's schemes are sequences of actions or thoughts which are developed to interact with the outside world. The complexity of these schemes tends to indicate the Piagetian stage of development which the individual has achieved. The schemes of Pascual-Leone are classified as either affective or cognitive. Affective schemes are subjective operators developed by the individual's affective mental state and are used to generate the affective goals of the individual. Cognitive schemes do the same type of operations to achieve cognitive goals (Pascual-Leone et.al., 1978). To control the affective vs. cognitive interplay, an individual constructs executive schemes to coordinate his development in some normal fashion. This term, executive scheme, is also used to indicate a cognitive scheme which coordinates two simpler schemes. Executive schemes rule or coordinate operative schemes. Operative schemes are those employed in simple stimulus-response type acts. These acts can be as basic as picking up an object or as complex as riding a bike. Operative schemes can be very complex but in general can be identified as an active participation in the concrete stimuli offered. Executive schemes are a special sort of operative scheme which call for the procedures, strategy or generic type of operations to be used in controlling other mental processing. These executive schemes organize data, plan sequences of actions, allow for new creative patterns to be initiated, and in general, control the chunks of information being processed (Pascual-Leone et.al., 1978). The development of more complex schemes accounts for the progression of intellectual growth in Pascual-Leone's Theory of Constructive Operators. The research presented in this study was developed in light of Pascual-Leone's insight into the processes which influence the "How ?" of Piaget's stages of development (Pascual-Leone et.al., 1978).

Development, according to Pascual-Leone, consists of the equilibration of existing executive schemes with : new data input, additional motor dexterity and a more comprehensive view of the stimulus situation. Therefore, development is not only simply exercising existing executive schemes but also modifying and rebuilding these schemes into new and more efficient executive schemes. These equilibrations can lead to novel solutions and performances of increasing complexity within the schemes which are retained by the subject. Development has occurred when the retained schemes consolidate previous schemes into a higher level scheme which replaces the old and allows the new to handle more information more efficiently. This occurs most readily when the subject can equilibrate all the necessary schemes and structures with a minimum amount of interruption from distractors or other unnecessary information into new executive schemes of processing (Case, 1974).

Once the relationship of the schemes in Pascual-Leone's Theory becomes apparent, a new question can be attacked: " Can intellectual development be hastened by presenting the developing subject with the information required for him to develop a scheme characteristic of a higher level of mental maturity ?" The proof of any theory rests in its ability to be applied predictively to novel situations. In order to guage accurately if development has occurred, the subject's present Piagetian stage must be well known. After that is established, then training schemes can be prepared which will offer the subject the opportunity of developing the more complex schemes required of him to attain a higher level of information processing.

There are many ways of judging Piagetian development level and the difference between a concrete-operational and formal-operational individual is obvious enough to be judged relatively accurately. Typically, success on five basic tasks is held to be indicative of Piaget's late formal-operational level reasoning (Betkouski and Lamb, 1981). A comparison of the performance of typical students on these tasks has been shown to increase dramatically with increasing age from eleven to twenty. Through the use of these five tasks, a researcher will be able to show the extent of development on a Piagetian scale. Generally, these tasks are classified as testing the student's ability in proportion, probability, correlations, combinations and control of variables. The differences in the success among students attempting these tasks has been explained by indicating the relative complexity of the executive schemes which are needed to successfully handle these tasks. If the individual has trouble with the task, he probably cannot handle enough operator schemes and information in his working memory to be able to come up with a coherent answer (Betkowski and Lamb, 1981). The task of educators, according to Pascual-Leone's theory, is to increase the size and amount of information the individual can handle competently and to develop more spphisticated executive schemes to do the work for him.

After establishing the developmental level of the subject, a researcher can then expose the individual to the conditions which Pascual-Leone's theory indicates should cause him to advance in his maturity. Descriptions of tasks with specific teaching instructions have been developed by researchers to achieve this type of advancement in the student (Case, 1974). Prior work has indicated the success of this type module in one to one interview situations. Upon completion of these types of tasks, the subject should show an increased ability to function at the higher formal operational levels. The main thrust of this study was to apply a specific instructional sequence to class-sized groups in order to determine if achievement of a higher level of mental processing was gained, two main problems had to be resolved. The application of this instructional sequence to a large group of students required both a modification of the sequence procedure and that a method of statistical analysis be developed that would make the data collected understandable to the classroom teacher.

Procedures

This study required the designing of a total treatment for establishing the Piagetian level of the student, increasing that student's ability on typical Piagetian tasks, and assessing the student to determine the amount of achievement on those tasks. Reviewing past studies served as a beginning point in this process. A few of the preliminary steps involved solving the simple problems associated with including larger numbers of students and instructors than had been previously been reported. In using the Case-type instructional sequence (see Appendix A), there needs to a large amount of equipment available for each individual. It was decided that the students would work more constructively and be more accessible to the instructor for monitoring and prompting if they were allowed to work in small (three to four students each) groups using only one set of equipment. The equipment was selected according to Case's suggestions in the treatment described in Appendix A, with only the exclusion of the three variable problem. Instead of the battery and bulb setup he describes, a three variable problem using the SCIS rotoplane was posed to the students. The substitution was made in decrease the amount of equipment the teacher would have to account for in the exercise. This allowed the teacher to concentrate on the outcome of the problem rather than getting bogged down in the mechanics of equipment distribution.

Monitoring the individual responses within the groups would put a greater burden of prompting and remembering on the instructor if the group strategy was employed. In order to overcome this difficulty a short form was designed on which the students could record their groups' or their own observations concerning the problems presented to them in the instructional sequence (see Appendix B).

After determining how to teach the treatment in this context, the evaluation techniques to be used in determining stage and achievement of students needed to be selected and arranged in order of administration. The use of the two forms of the Tobin and Capie Test of Logical Thinking were to be given in the typical testing sequence of pretest, posttest and retention test. The same form of the test was to be given as the pretest and the retention test, while the second form of the test was to be given as the posttest.

The classroom teachers were asked to administer the two-day Case treatment between the pretest and the posttest (see Appendix C). During the treatment the teacher was also asked to monitor the students' responses on the report form to make sure these answers represented both the most correct response of the group, as well as the correct answer by the time the problem was finally discussed by the class. The student was asked to describe the procedure his group used to determine the correct response and was also asked to record this procedure on the report form. Instructor discussion and reinforcement were important in establishing the correct methods and responses in the class' conscious memory. The report forms were used principally as reinforcers of ideas for the students and not as grading tools.

After administration of the instructional sequence as required, a varying period (two weeks to one month) elapsed until the posttest was administered. The retention test was administered approximately two months after the posttest depending on the scheduling requirements of the particular class. The results of these three tests were recorded onto computer grading sheets by the student at the time of the testing and these sheets were used in the subsequent statistical analyses.

The test chosen to measure the student's devolopmental stage was the Tobin and Capie paper-and -pencil measure called the Test of Logical Thinking. This test was designed to determine the students' ability to answer ten items which were designed to test reasoning ability on five Piagetian formal-operational tasks. The test items required an answer to the question posed and also a selection of the reason for the students' choice. These items were scored as either correct or incorrect with respect to both the answer and the reason selected. Tobin and Capie have verified that the test is a good predictor of success at the formal-operational level on combinatorial reasoning, correlational reasoning, probalistic reasoning, proportional reasoning and controlling variables. The Case instructional sequence dwells mainly on increasing the students' ability to control variables; therefore, this particular portion of the test should show the most effect in the students exposed to this sequence. There is some opinion that if a student increases in ability on the controlling variables portion of the test, then the student should increase on the other type items also. This would be expected if all these abilities mark the same maturation level in the individual as suggested by the theories already discussed.

There are two basic forms of the Tobin and Capie test. On the pretest and retention test the same form was used--Form A, while at the post test situation the Form--B of the test was used (see Appendix D). This sequence of test administration was followed each of the two years to prevent any variations within the different forms which could lead to an avoidable contamination of the results. Varying the form of the test also allowed us to limit the amount of learning which could have been due to gradual test-wiseness of the student groups.

A pair of trial runs were planned to allow the investigators to iron out any problem which could develop in this system devised to administer the Case treatment and the Tobin tests. Two main groups were chosen for this preliminary effort. Composed of students in elementary and secondary methods courses at this university, the total population turned out to be about thirty adults ranging in age from twenty to fifty. The preliminary results allowed the investigators to use the pilot system just described on a more representative class of students.

The main testing sample was selected as all members of the 1980 ninth grade class at a small, private, college preparatory secondary school serving principally an urban population. Since three instructors taught all 172 members in ten academic classes (which were randomly assigned by the schools' administrative apparatus which was not controlled or influenced by these researchers) prior to this work, it was decided to assign entire classes to the control and experimental sections of this study. Two particular groups of these ten classes were considered as honors track students and these two classes were separated in the study. A total of six classes taught by two teachers received the entire treatment and were considered the experimental group. The other four classes received only the normal academic instruction and took the tests. This control group received no formal practice as such on the Piagetian tasks to be measured. Since it was earlier decided that only those who participated in the three tests would be considered in the final statistics, all 172 participants do not show up in the two reported groups. Due to unforseen problems, only half the total population was able to participate in the retention test. This should have little effect on the validity of the statistics because of the statistical model used to determine the results of the study.

In the next year's study, the same type population was selected. The 1981 ninth grade class totaled 157 students, who were taught by three instructors, only two of which had participated in the study the year before. The same system was used to split the nine classes into experimental and control portions of the study. While the time schedule and testing sequence was the same as the previous year, there were more participants who completed the three tests.

The total populations for each year are indicated in Table 1. These populations are indicated for each test and for the experimental and control groups only for the individuals who influenced the final statistical analysis.

Table 1

Populations of Students in Each Testing Situation

TEST	1980		1981	
	exp.[1]	con[2]	exp[1]	con[2]
Pretest	96	49	69	64
Post test	100	48	69	64
Retention test	34	52	66	67

exp[1]. experimental group con[2].control group

Results and Discussion

Having obtained data from these two years of administration of the instructional sequence, the data field was analysed using the Standard Statistical System available at the University of North Florida Computing Center. The first technique that was attempted, merely tried to assure the investigators that the test was the valid measure that Tobin and Capie promised. In order to attain this assurance, a factor analysis was performed on the data to see if five basic types of questions were available. In Table 2 ,the typical rotated factor pattern which was observed is listed. As can be seen by inspection, there are definitely five pairs of items on these tests. These investigators have elected to assume that these five groups indeed are indicative of the five Piagetian tasks as Tobin and Capie promise.

The data listed in this table should be read by glancing down the factor columns to see which items have the highest numerical value. Any items with a large value are said to test the same process or technique. In looking at the variance list in this table, one will observe that the factors all contribute approximately the same amount to the test and this is further evidence that the tests are indeed five task oriented.

TABLE 2

Factor Analysis on 1981 Data
Rotated Factor Pattern

Item #	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1	.8183	.1409	.1388	.1378	.2963
2	.8883	.0837	.1548	.1360	.1214
3	.1480	-.0355	.8785	.1206	.0961
4	.1196	-.0226	.8667	.1770	.1118
5	.1962	-.1259	.1487	.8723	.2327
6	.0836	.1735	.1764	.8355	.2327
7	.4285	-.0245	.1139	.2013	.6947
8	.1272	.0031	.1224	.1460	.9050
9	.0069	.9285	-.0070	.0058	.0172
10	.1811	.9086	-.0505	.0234	-.0239

Variance Explained By Each Factor

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1.7731	1.7630	1.6502	1.6049	1.4892

After procuring the statistical verification indicated above, the analysis was extended to include a General Linear Model. This analysis indicates two separate pieces of information concerning the data collected. First, the item mean scores and their standard deviations are calculated. Second, the significance of the data trends are evaluated. In determining these significance terms, the data is compared with itself to determine how much it varies from a simple random sample. In other words, this factor tends to indicate that the data is actually helping to prove whether the specific hypothesis is correct or to discredit that hypothesis. This factor does this by comparing the results from the data entered to a completely randomly assigned data set. The bit of the calculation that is important is the regression parameter called the PR > F term. A value of 0.05 or less was considered to indicate a statistically significant finding. In Table 3, a listing of this parameter for each type of item as well as for the total test score for each year is listed. Also, it lists the comparisons done on the data with respect to the different trials, different groups, and interactions between both of the groups and trials. This last entry is the more important comparison for determing the quantitative effect of the treatment.

TABLE 3

Year	Regression Parameter (PR > F) Trials	Exp/Con[1]	Exp/Con * Trials[2]
1980			
Total Score	.0001	.1568	.7397
proportion[3]	.0056	.3300	.2229
variation[4]	.0001	.0813	.1447
probability[5]	.0071	.6510	.4311
correlation[6]	.0097	.3758	.1901
combination[7]	.0001	.3337	.0004
1981			
Total Score	.0001	.3201	.7830
proportion	.1837	.1863	.7830
variation	.0001	.9510	.2345
probability	.0321	.8133	.0960
correlation	.0724	.0910	.1536
combination	.0001	.7059	.0063

1 experimental vs control
2 experimental vs control vs trial
3 proportional reasoning
4 controlling variables
5 probalistic reasoning
6 correlational reasoning
7 combinatorial reasoning

It can be seen that Table 3 indicates a significant statistical effect in nearly every entry in the trials column. This suggests a definitely significant trend as the group takes each additional test, irrespective of the group in which they participate. Whether this trend indicates that learning or regression has taken place can not be determined by this statistic.

In the experimental vs. control comparisons, virtually no significance can be assigned to the results. This appears to indicate that little or no learning of the required tasks occurs in the treatment group that did not also occur to the control group.

No significant trends are observed in this analysis when the more complex comparisons of testing group with test taken are considered except for the combination item.

In each case, the hoped for significance is not present in the items analyzed. No significant increase in performance on either the controlling variables portion, or any other item, was observed in the experimentally treated groups. The variability of the trends indicate that there is much more work to be done with this data. Since the quantitative significance can not be readily assessed, it will be difficult to determine whether learning has occurred. To better examine the qualitative trends exhibited in this data an additional comparison can be made using the calculated item means also given in this procedure. The relationships amoung the various means are displayed on the next twelve graphs. The data from which these graphs were prepared is listed in Table 4.

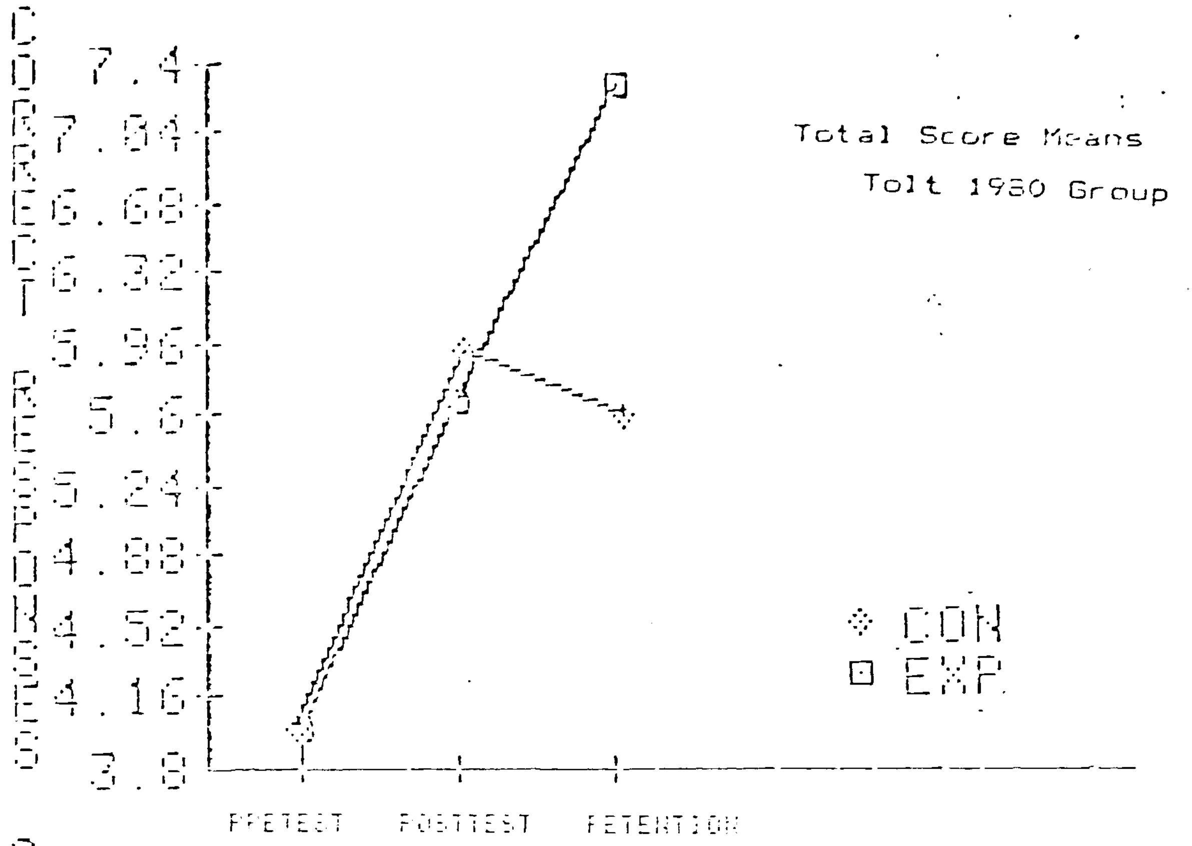
Table 4

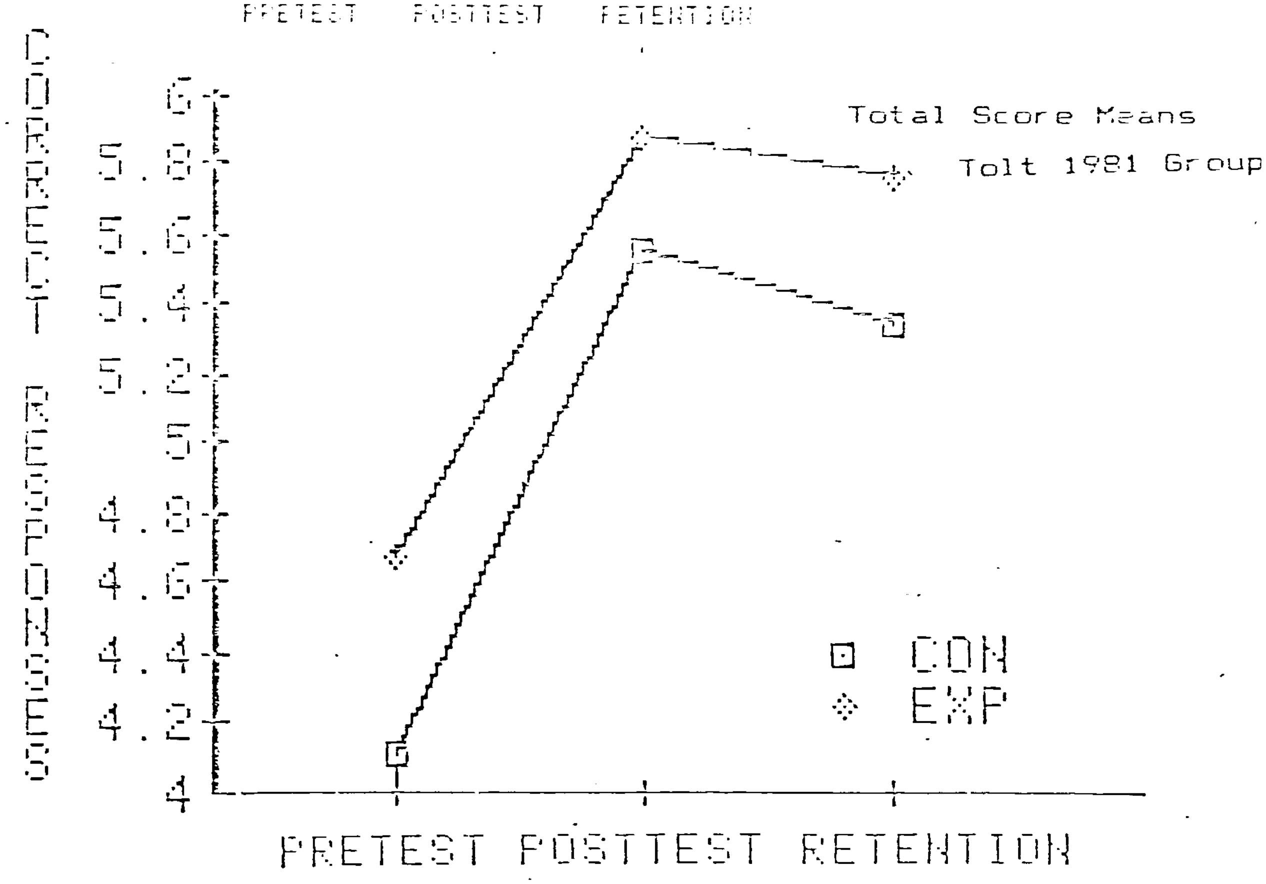
Goup Means For Each Test Item and the Total Score

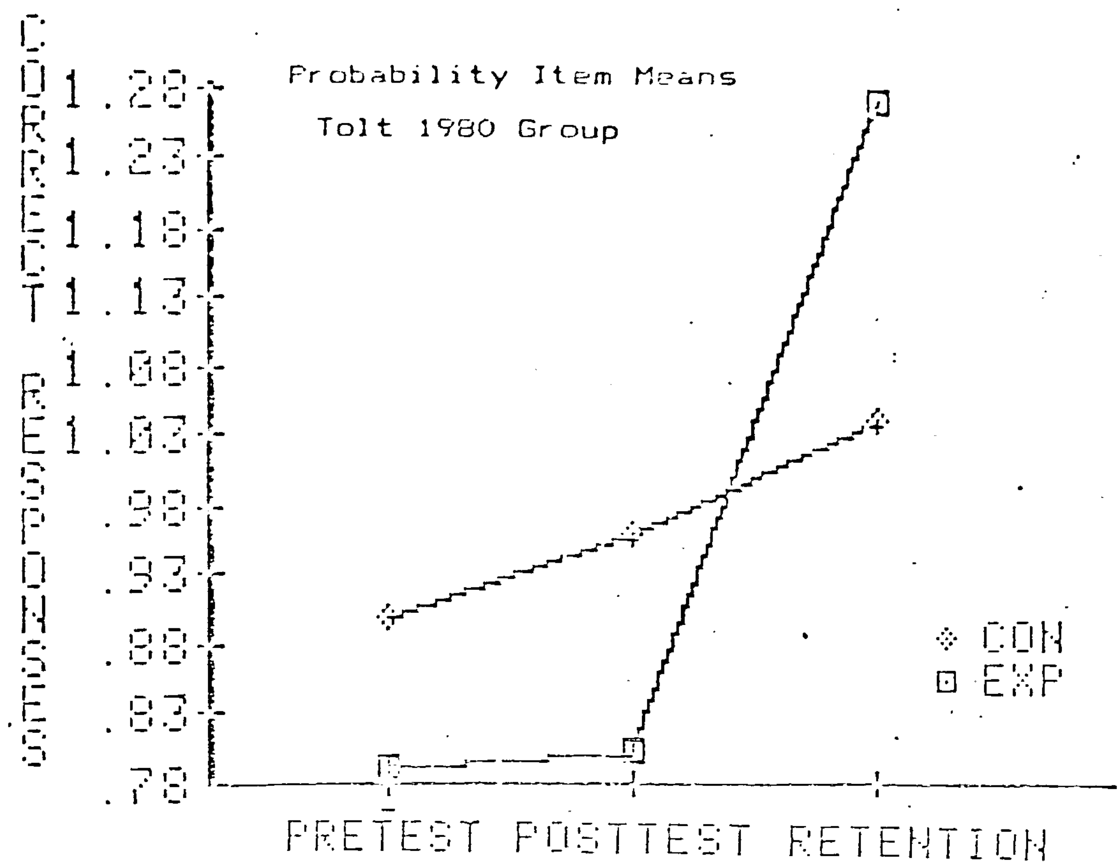
Group	Test	1980	1981
Total Score			
Control	pretest	3.97959	4.10937
	posttest	5.9166	5.54687
	retention	5.5384	5.32835
Experimental	pretest	3.98958	4.66666
	posttest	5.6700	5.8695
	retention	7.2647	5.7575
Item: Proportional Reasoning			
Control	pretest	.95918	.96875
	postest	1.020833	.8906
	retention	1.07692	.92537
Experimental	pretest	.86458	1.0289
	posttest	.9700	1.0289
	retention	1.4705	1.2424
Item: Variation			
Control	pretest	.61224	.65621
	posttest	1.3333	1.4218
	retention	.7692	.97014
Experimental	pretest	.5833	.55072
	posttest	1.3300	1.4347
	retention	1.38235	1.0909
Item: Probalistic Reasoning			
Control	pretest	.89795	.87500
	posttest	.95833	.9375
	retention	1.0384	.95522
Experimental	pretest	.79166	.81159
	posttest	.8100	.91304
	retention	1.2647	1.1666

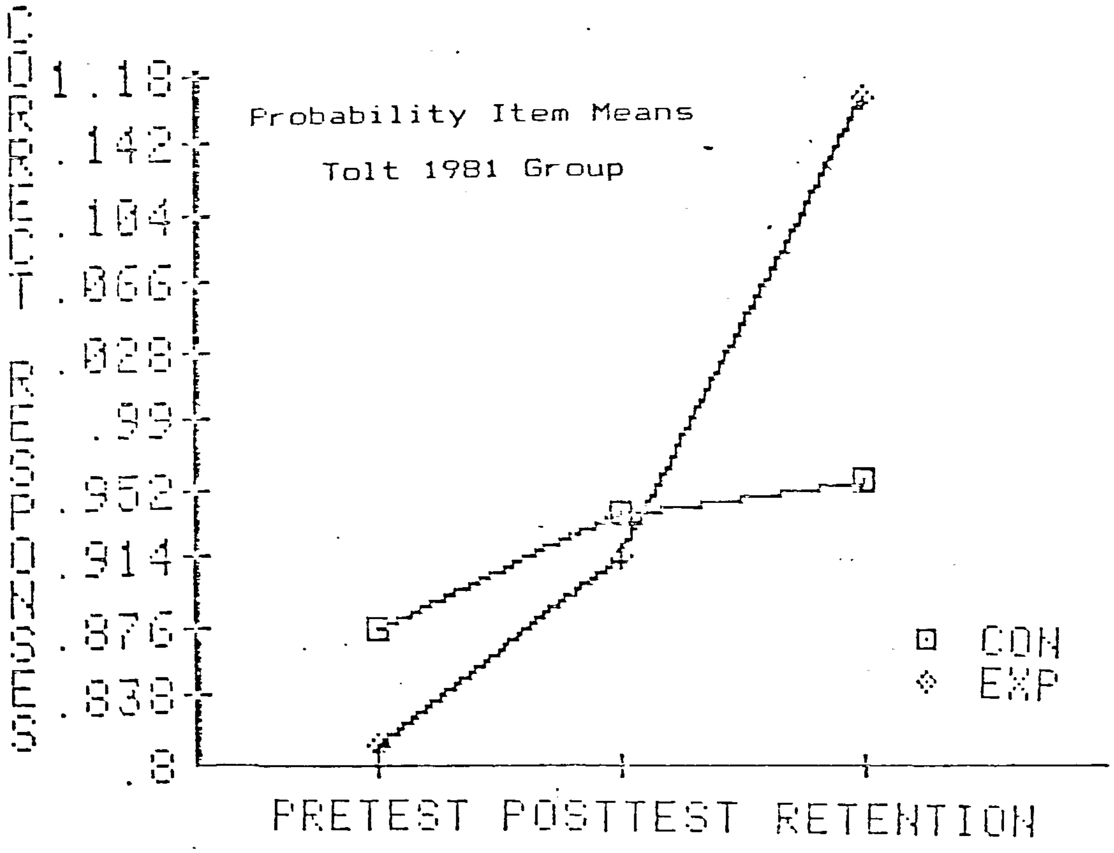
Table 4 (continued)

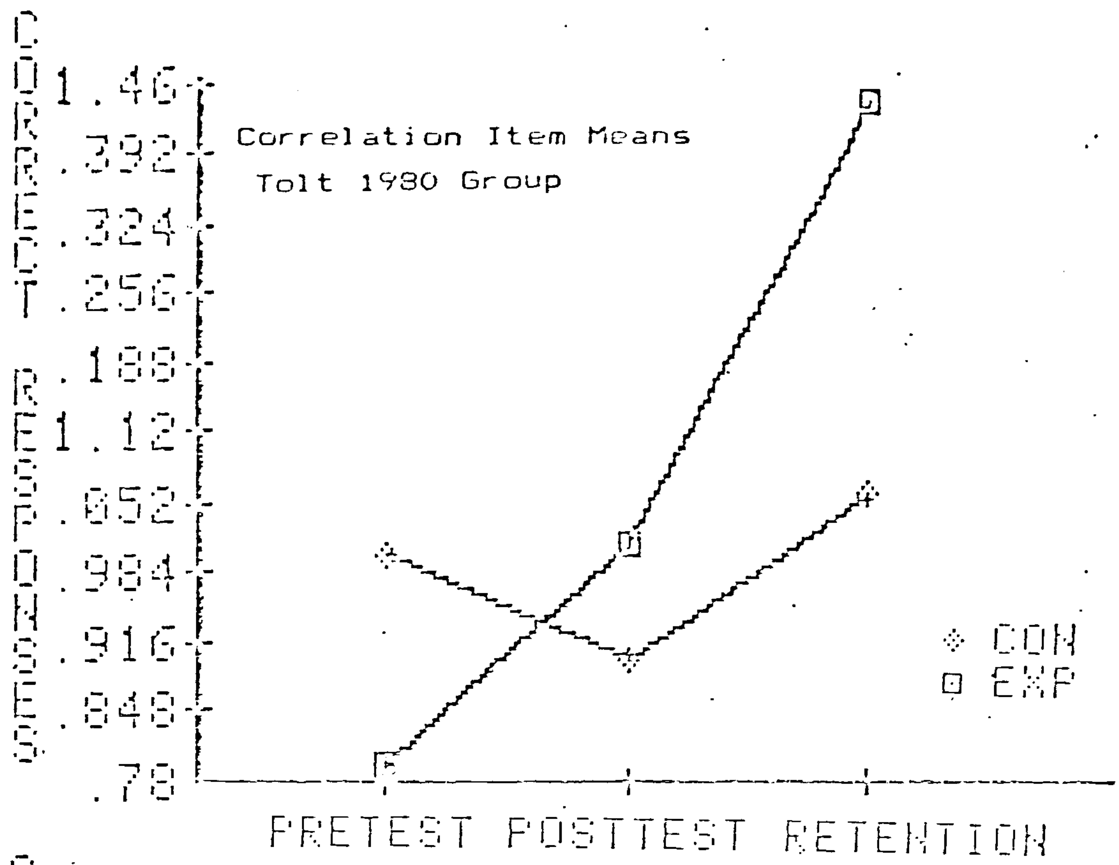
Item: Correlational Reasoning			
Control	pretest	1.000	.84375
	posttest	.89583	.8281
	retention	1.05769	1.1641
Experimental	pretest	.79166	1.1739
	posttest	1.0100	1.0741
	retention	1.4411	1.1363
Item: Combinatorial Reasoning			
Control	pretest	.5102	.76562
	posttest	1.7083	1.46875
	retention	1.5961	1.3134
Experimental	pretest	.9583	1.1014
	posttest	1.5500	1.4202
	retention	1.7058	1.1212


CORRECT ANSWERS
7.4
7.04
6.68
6.32
5.96
5.6
5.24
4.88
4.52
4.16
3.8
PRETEST
POSTTEST
RETENTION
Total Score Means
Tolt 1980 Group
CON
EXP

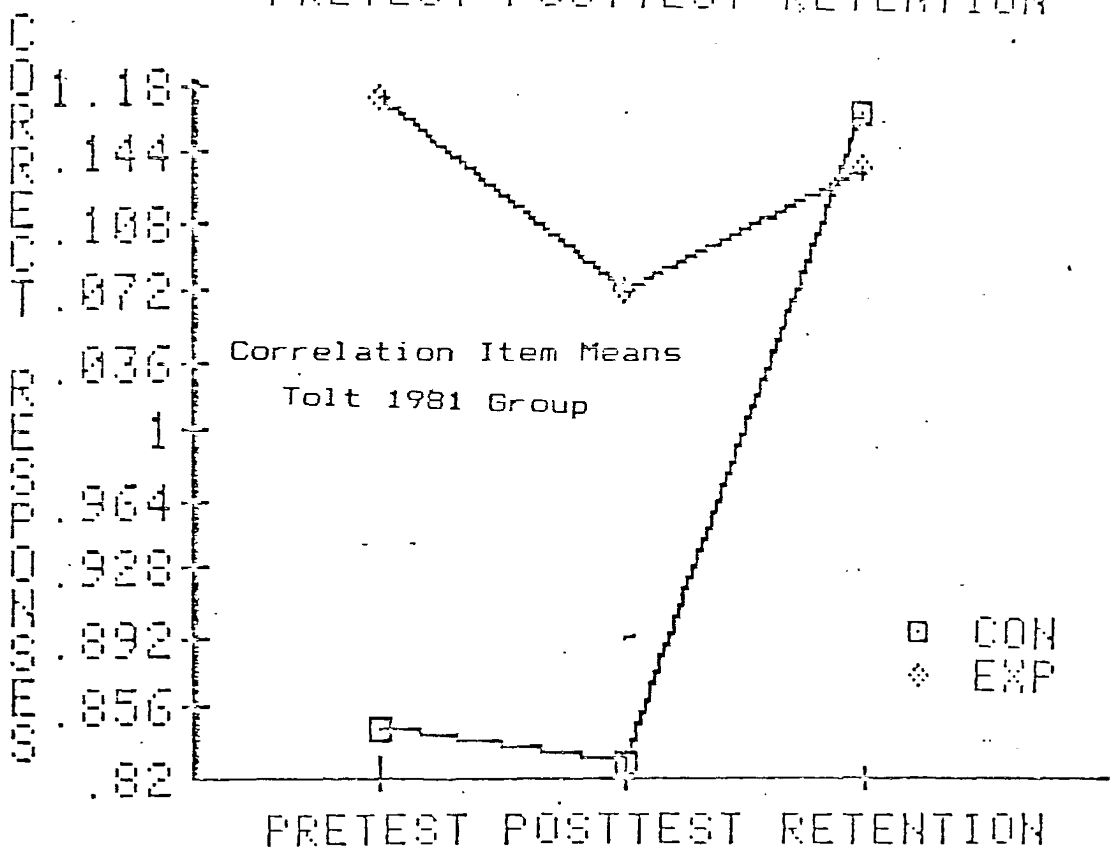

CORRECT ANSWERS
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
PRETEST
POSTTEST
RETENTION
Total Score Means
Tolt 1981 Group
CON
EXP


Probability Item Means
Tolt 1980 Group
CORRECT RESPONSES
1.28
1.23
1.18
1.13
1.08
1.03
.98
.93
.88
.83
.78
CON
EXP
PRETEST POSTTEST RETENTION

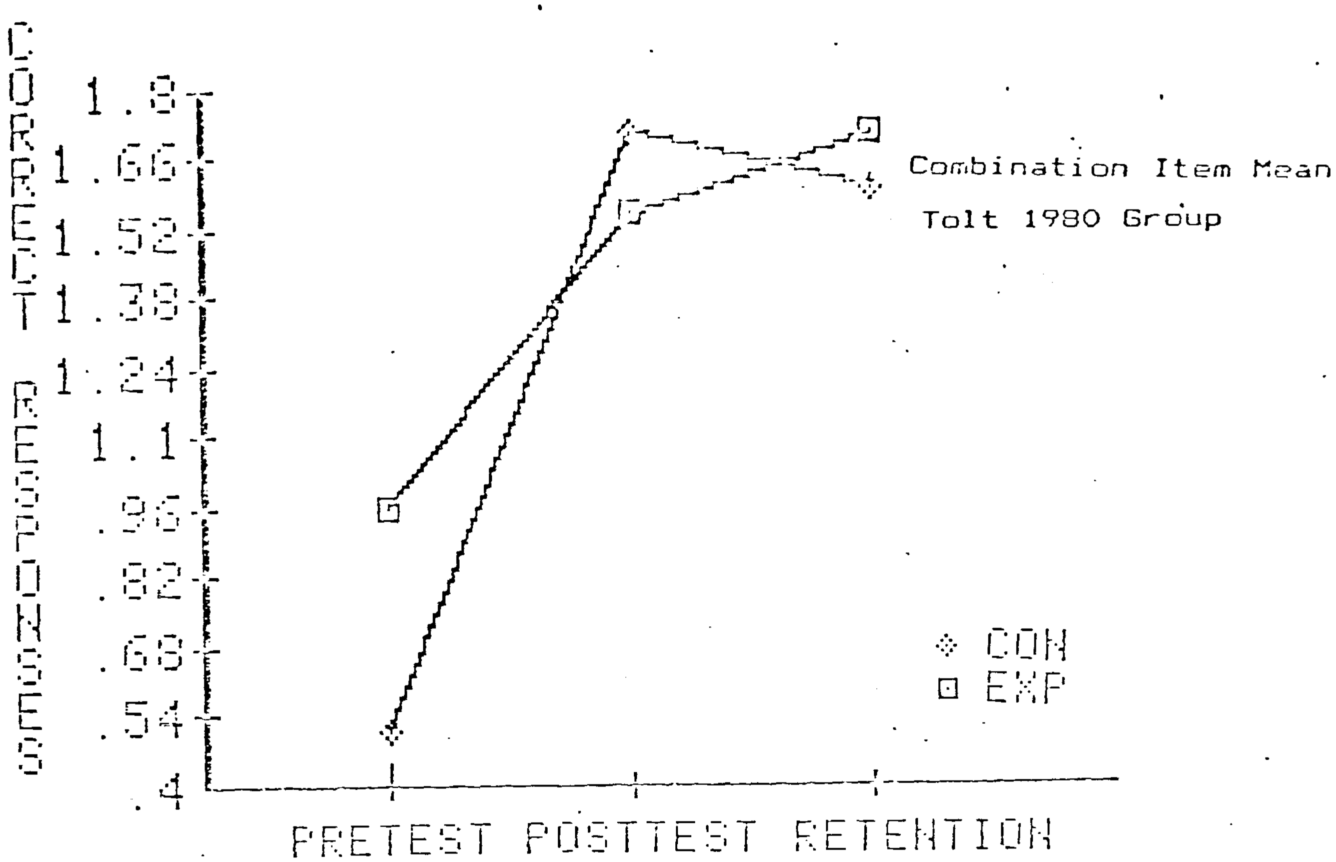

Probability Item Means
Tolt 1981 Group
CORRECT RESPONSES
1.18
.142
.104
.066
.028
.99
.952
.914
.876
.838
.8
CON
EXP
PRETEST POSTTEST RETENTION

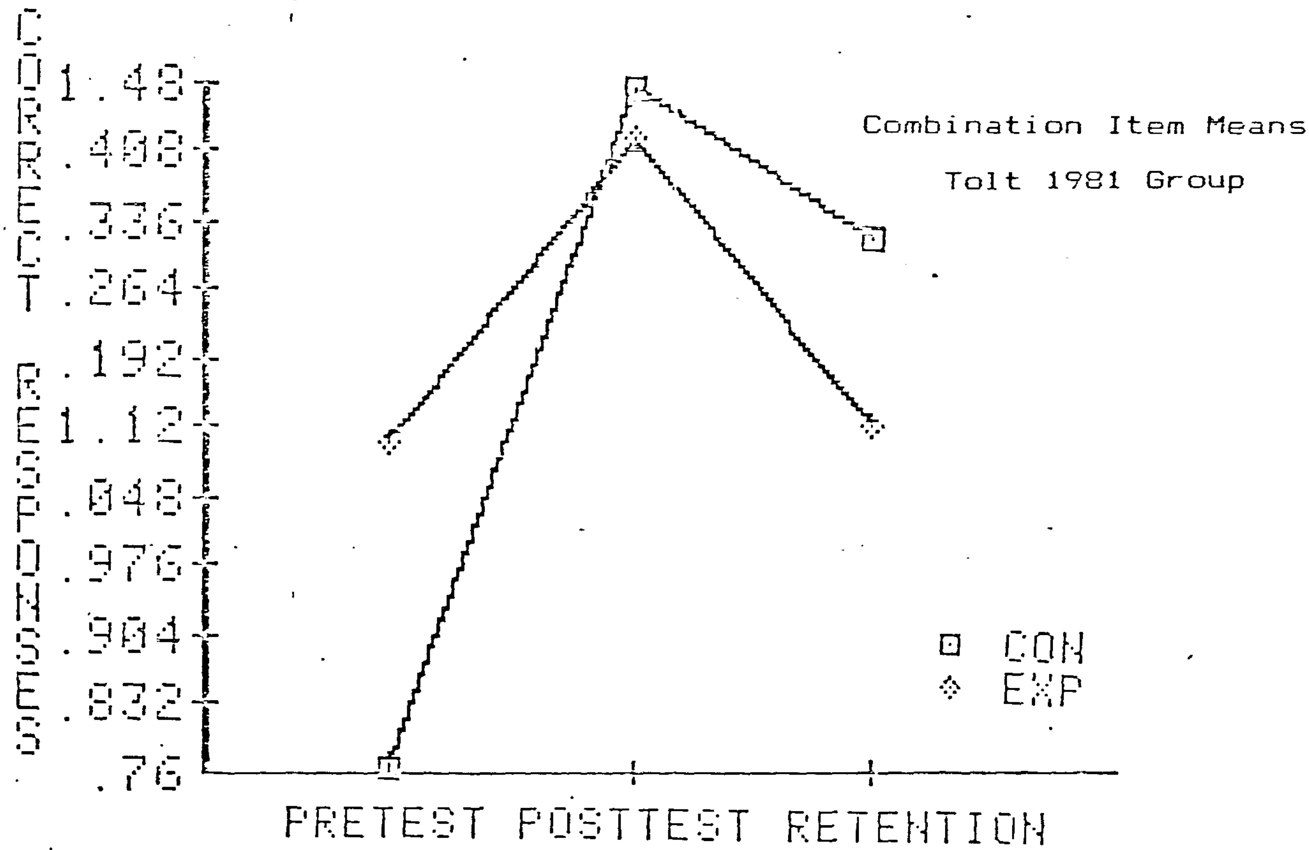


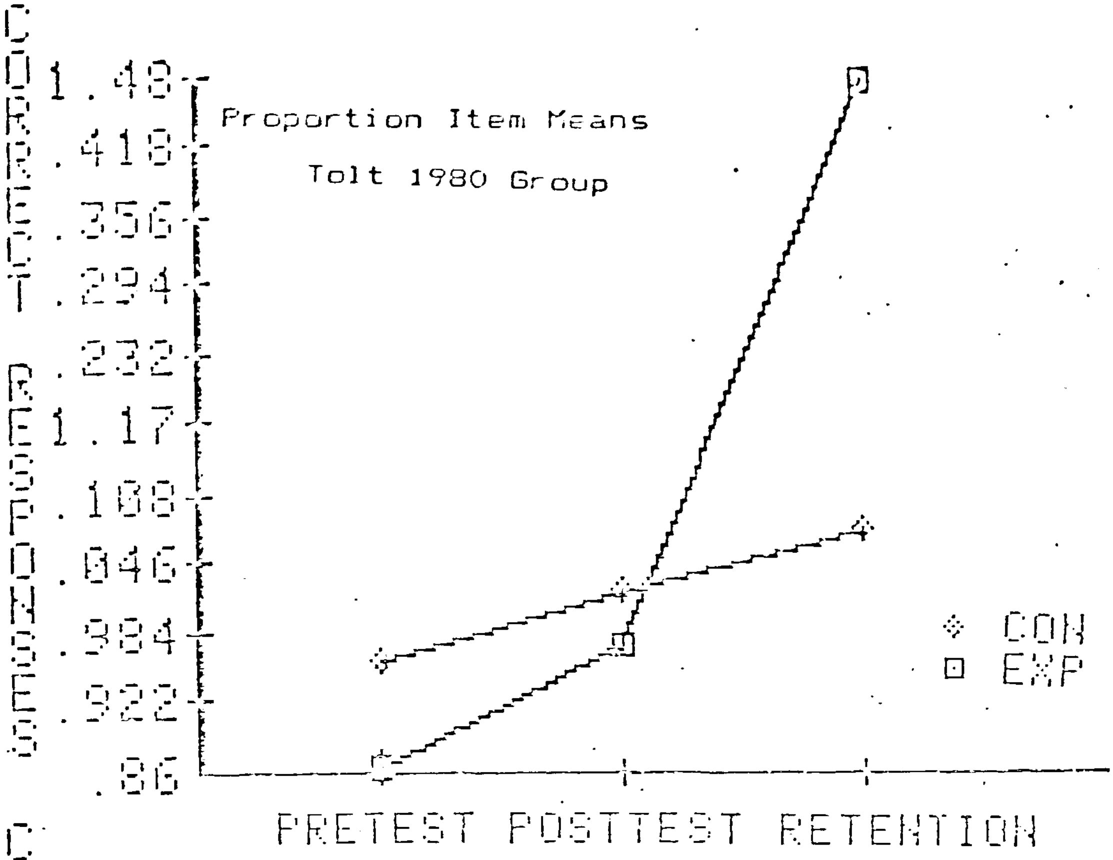
Correlation Item Means
Tolt 1980 Group
CORRECT RESPONSES
1.46
.392
.324
.256
.188
1.12
.052
.984
.916
.848
.78
CON
EXP
PRETEST POSTTEST RETENTION

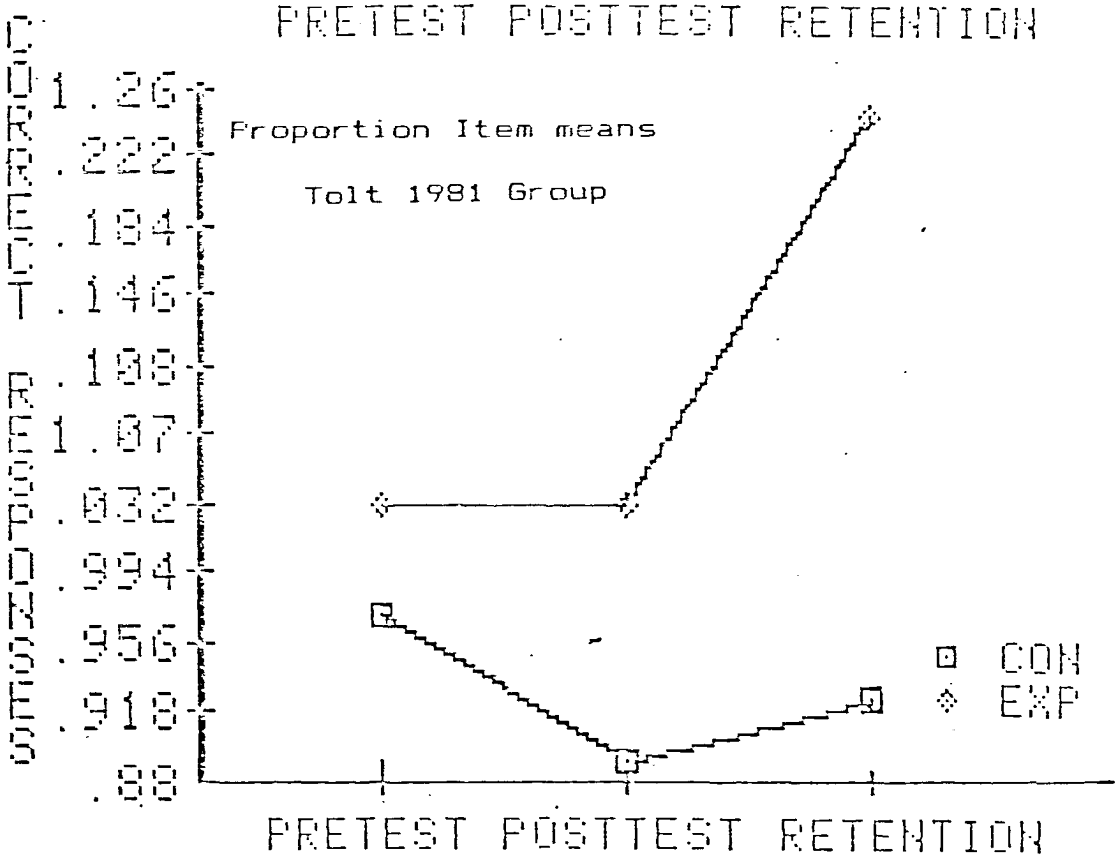


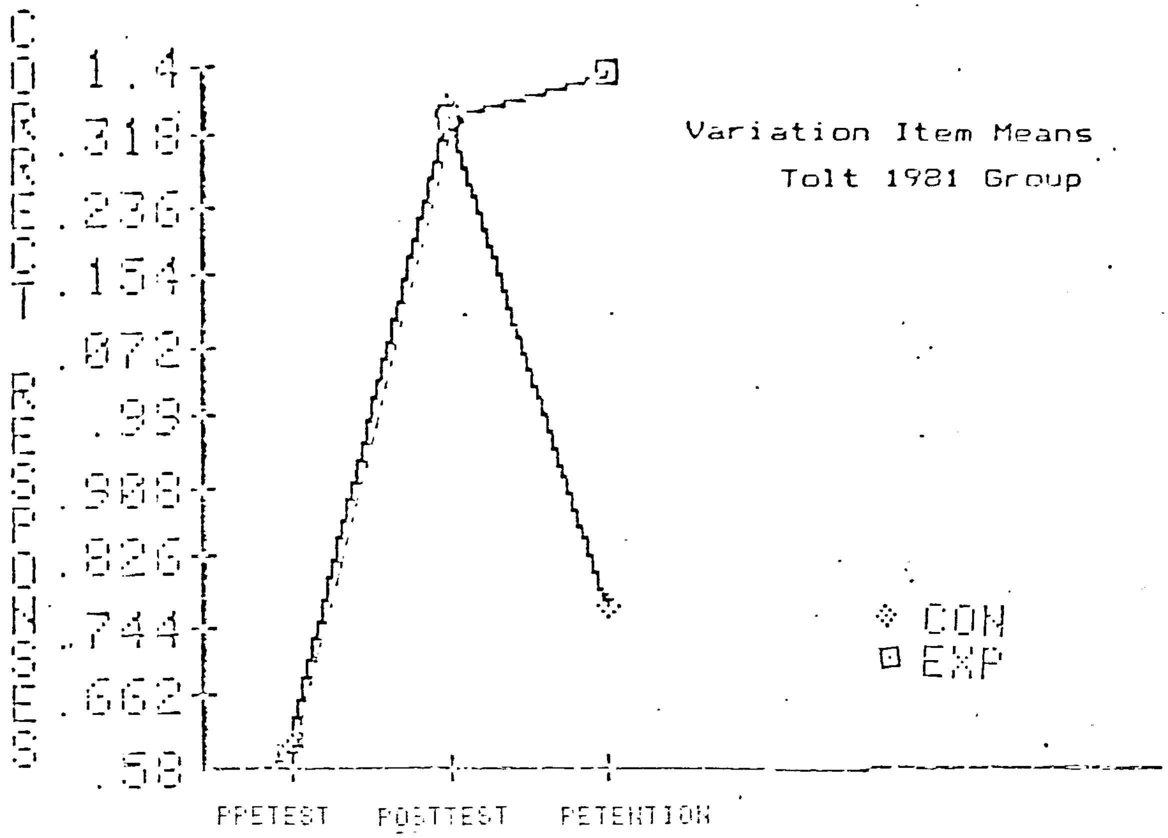
Correlation Item Means
Tolt 1981 Group
CORRECT RESPONSES
1.18
.144
.108
.072
.036
1
.964
.928
.892
.856
.82
CON
EXP
PRETEST POSTTEST RETENTION


CORRECT RESPONSES
1.8
1.66
1.52
1.38
1.24
1.1
.96
.82
.68
.54
.4
Combination Item Mean
Tolt 1980 Group
CON
EXP
PRETEST POSTTEST RETENTION

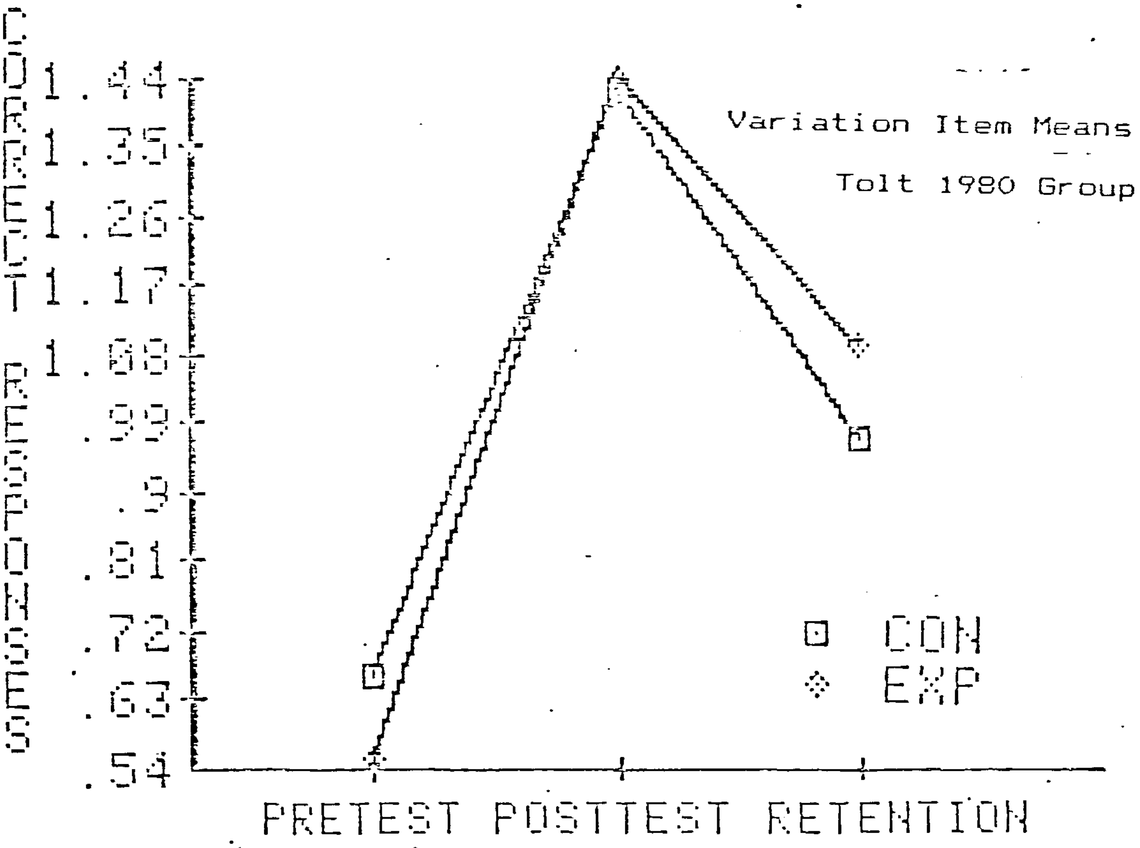

CORRECT RESPONSES
1.48
.408
.336
.264
.192
1.12
.048
.976
.904
.832
.76
Combination Item Means
Tolt 1981 Group
CON
EXP
PRETEST POSTTEST RETENTION


CORRECT RESPONSES
1.48
.418
.356
.294
.232
1.17
.108
.046
.984
.922
.86
Proportion Item Means
Tolt 1980 Group
CON
EXP
PRETEST POSTTEST RETENTION


CORRECT RESPONSES
1.26
.222
.184
.146
.108
1.07
.032
.994
.956
.918
.88
Proportion Item means
Tolt 1981 Group
CON
EXP
PRETEST POSTTEST RETENTION



CORRECT RESPONSES
1.4
.318
.236
.154
.072
.99
.908
.826
.744
.662
.58
PRETEST
POSTTEST
RETENTION
Variation Item Means
Tolt 1981 Group
CON
EXP



CORRECT RESPONSES
1.44
1.35
1.26
1.17
1.08
.99
.9
.81
.72
.63
.54
PRETEST
POSTTEST
RETENTION
Variation Item Means
Tolt 1980 Group
CON
EXP

In these graphs, the qualitative trends in the student's mean scores are more readily apparent. The results from the 1980 Tolt group are irregular and sometimes anomolous, especially in the graphs of the retention test mean value. In each case the unexpected result was that the experimental group mean exhibited a non-classical retention type learning curve while the control group showed the more classical type curve. In nearly every item the control group means were more than the experimental group for the other two tests, but the anomolous behavior exhibited in the retention test increases is difficult to explain. The experimental test group exhibited less classical behavior in its testing relationships. In the combinatorial and variation items, as well as the total score graph, this classical learning behavior is observed for the control groups. There is some discussion as to where the control groups were learning the tested behaviors, but as yet, no consensus has been reached to exlain this effect. The correlational, probalistic and proportional reasoning items indicate a markedly different pattern for both types of groups. These items usually show an overall increase in ability on the items being tested which is indicative of an enhancement of learning <u>after</u> the instructional sequence is finished and allowed to incubate for a longer period of time. This is expected from

Pascual-Leone's theory, for the theory requires time to incorporate new problem solving schemes into executive schemes. The non-classical curves observed in this data indicate that some, as yet unidentified, contaminating factors are present in the study.

In each of the graphs, the lines representing the achievement of each group are almost parallel in their respective increases or decreases. This pattern indicates that the result is similar in each group and that some other factor could account for any of the changes. In few cases do the representative lines deviate from one another, and these are the instances which need to be investigated further. From the 1980 graphs there appears to be little clear significant effect which can be directly explained by the instructional sequence alone. However, there is a small breakdown in the validity of this assessment after the post test because of the slightly smaller sample used in the retention testing. The problem is worth mentioning because thirty-four of the participants of the eighty-two participants were of the honors track classes. This proportionally larger segment of the brighter students could lead to slightly skewed results.

The results of the 1981 Tolt group indicate a slightly different set of trends exhibited in the testing means. The classic retention type curves mentioned above are observed in the total score means as well as the variation and combination item means. In the combinatorial item, however, the control group surpassed the experimental group. In the proportional item graph, there was no increase in scores in either group until after the post test, then the experimental group became better at this specific task than the control group. This could possibly indicate a rather long incubation period until absorption and achievement of this particular skill, as already explained this effect is to be expected by theoretical considerations.

This same type of time dependent increase is observed in the probability item graph. Since the experimental group shows this increase to the exclusion of the control group, the effect is probably attributable to the instructional sequence, but more investigation is required to confirm this opinion.

In observing the correlational item pattern, the effect of the treatment appears negligible with no change in the experimental group means on each test. The control groups' mean increased precipitously, however, and this appears to contaminate the significance relationships within this item severely. The comparison of the two lines in this graph are interesting because the group without the instructional sequence showed a steady increase in achievement. Yet the experimental group showed a definite reversal and then a slight increase, but still not to the extent it had already possessed previous to the treatment. The treatment appeared to inhibit positive performance on this item.

In summation, the data presented in the 1981 study appears to be more indicative of what the instructional sequence can do. The data from 1980 appears to present more problems than it explains. Obviously, the treatment to enhance skill in controlling variables does not increase the students' ability on all five of the Piagetian tasks tested. The value of this treatment cannot be assessed from this study. The treatment indicates that it is a very specialized tool and is not to be used for attaining a wide range of Piagetian objectives.

During the 1981 study, all participants were tested for retention results and this appears to have made the trends more close to the classically expected patterns. Yet, there are still problems which need to be addressed in these results. In order to determine the significance, or importance of these problems, one merely needs to observe the relationship between the test item means and their respective regression parameters. If this is considered, then the relationships graphed can not be considered absolute, but, merely indicative of trends which may be observed if more data is analysed or this data is treated differently. This lack of absolute value does not hinder a discussion of trends and the appropriateness of the instructional sequence for teaching certain Piagetian tasks.

More data gathering on a large scale is certainly indicated as a positive first step in verifying the validity of the present qualitative results. Two more years of this study would certainly help rid the data of several possible seasonal contaminants such as; the overall brilliance of the particular class, the possible success of the ninth grade football team, economic worries and even variations in the social pressures exerted by the peer group. Additional valid data would also help define a more narrow regression parameter value which could then be used in discussing quantitative trends.

More data accumulation, by itself, will not help eradicate all the specific anomolies is this study. Some statistical technique should be employed to eliminate those individuals who achieve the objectives in the initial testing period. They should be removed from consideration in the analysis as possible contaminants. This elimination would allow a less biased conclusion to be reached because only those who needed to learn would be included in the final analysis. This could be done for each of the five tasks and would allow a more significant presentation of the particular item data.

Such items as total score cannot easily be used to guage the effectiveness of the treatment sequence, because of the complexity of the test. In the Tolt, each pair of two items evaluates a completely different type of Piagetian problem solving strategy, and as such the total score only gives a partial view of the developmental stage of the individual.

Having achieved the purpose of gathering quantities of data with respect to the aedequacy of this particular instructional sequence, one can look at the trends reported to see that some valuable effects have been realized. Students increase their abilities in several of the reasoning strategies cited by Pascual-Leone and Piaget as important in their intellectual development. In a qualitative sense this treatment system was a successas it was administered by these researchers: In a more quantitative evaluation, the conclusions of this study are not as clear cut, and indicate that a great deal more evaluation can be done to explain these results.

Many additional steps need to be undertaken before this type sequence can be validly established in a curriculum.

Principally, the success of these individuals in academic pursuits as well as life goals should be observed to determine the real value of these five skills. If a student achieves these skills, can we really promise him that it willlmake an appreciable difference in his life?

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Appendix A

INSTRUCTIONAL SEQUENCE

1. Rods and Blocks (2 variables which can be physically separated)

This experiment uses heavy and light rods of different colors and heavy and light blocks, also of different colors, through which holes of rod-size diameter have been drilled. Case used aluminum and brass rods with blocks in which lead weights could be inserted. This is probably inappropriate for older students unless the rods are painted so as to hide their aluminum and brassness. We will use 4" long x 1/4" diameter oak and balsa dowels -- sanded, sealed and painted (black for oaks, white for balsa for trial one; bright red and blue for trial two; bright yellow and green for trial three. Our blocks will be 2 x 2 x 2 oak and balsa blocks. The oak block with the balsa dowel is enough heavier than the balsa block with the oak dowel that a four year old can tell which is heaviest 100% of the time without a balance. The blocks should be painted bright colors as well -- perhaps orange and hot purple.

For actually teaching the lesson, you'll also need as many balances as you have experimental groups. The task for the students is to determine the relative weight of the rods without removing them from the blocks. It is important to monitor this because many of the children will induce that comparing the rods directly is a lot more efficient than leaving them in the blocks. Show them the combinations (black rod, orange block; black rod, purple block; white rod, orange block; white rod, purple block). Tell them that the white rods are the same, the black rods are the same, the orange blocks are the same, and the purple blocks are the same. If you've done a really good job of preparing materials, you can even demonstrate their equality with a balance. Do not compare different colors with each other, however.

Then provide each child or group with each of the four combinations and a balance. Repeat the problem: (decide which rod -- white or black-- is heavier but do so without taking the rods out of the block. As they work, circulate through the room. When a group has "solved" the problem, aske them to explain how they did it; be on the alert for groups with alpha monkeys and make sure the betas can explain: (a) what was done; (b) why it was done; and (c) why that is good evidence. Getting them to verbalize this is important, especially if they did it right. Then, allow them to check their findings by removing the rods and weighing them separately.

For a group whose strategy is unsuccessful, ask them to figure out a better way to do it. Leave them for a few minutes to work on this. When you return, have them explain what they have figured out. If they still do not control variables, ask them directly a question like: Would it be a fair test to weigh this rod and block (pick up heavy block and light rod) and place on balance pan, against this rod and block (place light blocks and heavy rod on other balance pan? followed by "if you can't tell, how could you weigh the rods and blocks together to make a fair test of which rod is heavier?

If the above fails to induce an experiment in which variable are controlled, use the following: "Feel these blocks. (Have then heft the blocks) They fooled you because this (pick up heavy block) block was so heavy it pulled the balance down (gesture). It made the white rod look heavier even though its not." NOTE that the language is simple, reducing the number of items of information which must be processed to a bare minimum. The students do not even have to focus on both blocks, just the heavy one. No reference is made to the technical term "variable," just to blocks and their weight.

Replace rods in the blocks and pick up a light block with a heavy rod, placing it on the balance. Then pick up a light block with a heavy rod and place it on the other side, holding the balance so it does not move. Explain: "you should pick up two rods where the blocks are the same. See (release balance), the white one doesn't look heavier this time."

"Now pay attention carefully and I'll explain why the blocks have to be the same. (Place a black rod on one balance pan and a white one on the other.) Which rod is heavier, _____________? (Student answers: "the black one") Right. Now, look (put light block on each pan but don't connect them to rods), when the blocks are the same, the black one still looks heavier. The blocks don't fool you because they're the same. (Demonstrate by removing the rods from the balance pan). See, if the blocks balance each other, they can't fool you.

"Even if I use these two (remove light blocks and replace with heavy blocks), they can't fool you because they're the same. They can't make the white rod look heavier. (Put white rod on one pan and black rod on other pan to demonstrate that side with black rod still looks heavier.) As long as you make sure the blocks are the same, only the rods will make a difference."

"But look what happens when you use two different blocks (replace the heavy block with a light block in the balance pan holding the heavy rod). This block (pointing to heavy one on balance pan with light rod) can make the white rod look heavier even though it really isn't. (Remove all materials from balance)."

"It always works like that. If you make sure the two blocks are the same when you test the rods, the blocks can't fool you. If the blocks are the same, the test is fair. If you don't make sure the blocks are the same, this heavy block (hold up) can fool you."

In presenting the above, be sure to eschew pronouns. Even when context makes clear what you're talking about, say "this block" or "this light rod," not "it" or "this one."

Following this, reconstitute groups so that students whose ability to control variables is suspect are together where a colleague can't solve the problem for them. Present the student with new rods (different colors) embedded in the same old blocks and have them solve the problem again. Follow the instructional procedure as described above.

If necessary, repeat with yet another set of rods. It's important that your students be able to use and explain the strategy for controlling the variable of block weight in this simple experiment. If the faster students get bored, it might be a good idea to have an extra series of rods and blocks available (say pine blocks, pine rods, etc.) so as to increase working time without increasing the experiment complexity. That is, have them order 4-5 different rods embedded in 4-5 different kinds of blocks. If you do this, be sure and note which students did this experiment.

2. <u>Bouncing Balls</u> (2 variables which can't be physically separated.)

Although we haven't searched for them yet, Whamo co. (Hula-Hoops, Frisbees, etc.) used to make a handball-sized superball which works just fine for this experiment. (Squash balls might be better since the difference is smaller.) Anyway, make sure that the diameter and apparent surface are similar but that the balls can be distinguished from each other.

For this task, Case used two different kinds of squash balls and bounced them from two different heights. Case gives no details in regard to how the kids measured bounce height. In doing similar experiments in the past, we've found it useful to mark off a piece of butcher paper in alternating colors with large numbers clearly displayed beside the reach marks. The paper is attached to the wall. Students drop from a height measured on this backdrop and measure bounce height.

First, review the correct strategy for Rods and Blocks, using language and demonstration similar to that described above. Then present the new problem which is to determine the effect of each variable (drop height, ball type) on how high the balls will bounce. While introducing the problem, show the balls and bounce the balls in a fashion that does not let them know which is really best. Challenge them to construct an experiment that proves which ball is the best bouncer, provide each group with a pair of balls, and allow them to explore and experiment. Use your judgement in time, but record how long they explore. As you move among the groups, make sure their experiment is controlled. Ask questions like: "How do you know it's the better bouncer? How do you know it wasn't dropped from a different height?" and offer counter suggestions to their assertions. In short, make them prove which is bouncier with a controlled experiment. If any of them have a problem with this even after careful probing and drawing analogies with the "rod and block" task, (and younger students, especially, will have problems), explain and demonstrate in a fashion exactly analogous to the above. That is: (a) explain how failure to control height "fools" them; (b) explain and demonstrate how to solve the problem.

Especially for older students this can be an easy task and it might take only about half a regular period (20-30 minutes) so be sure to have the next experiment ready to start.

3. Three Variable Problems

(a) Batteries and Bulbs

Problem: Determine the effect type of flashlight bulb, type of wire (say aluminum or nichrome) and number of batteries has on current flow. You'll need an ammeter, two different kinds of flashlight bulbs and holders, 2 batteries, and 2 different resistors. Try to choose resistors such that the more resistant one + 2 batteries gives less current than the less resistive one = one battery. Scrounge the materials from physics labs, SCIS and ESS kits, etc.

(b) "Roller Race"

Problem: determine the effect of roller material, roller diameter and hollow or solid on the rate at which a roller rolls down an inclined plane. (Incline stays at same angle throughout the experiment, otherwise this is a four variable problem. You will need: rollers, an inclined plane and a means of accurately determining roll-time. For rollers, visit a metal shop or the school shop and have them choose 2 different diameters (say 1/2" and 1" or 3/4" and 1 1/2") of rods and pipes of two different materials say brass and aluminum. Cut the selected rods and pipes all the same length (about 1 1/2") until you can give each group one of each bend: 1/2 x brass x solid, 1/2 x Al x Solid, 1/2 x brass x hollow, 1/2 x Al x hollow, 1 x brass x solid, 1 x Al x solid, 1 x Brass x hollow, 1 x Al x hollow. For ramps, use about 2 feet of 2" wide board with narrow wooden strips glued or nailed along the sides to keep the rollers from rolling off the ramp. To insure uniformity clearly mark the starting point. Attach a small piece of 2 x 4 scrounged from a local construction project trash pile to the starting end to insure only one elevation. (If you want to use the ramps for something else, put a couple of small nails in thin bottoms near the starting end and instruct students to make sure these nails are touching the 2 x 4 you have refused to nail to their ramp.

Review the successful strategy for the bouncing ball problem. Then present the apparatus and the problem. Demonstrate the apparatus and be sure each variable is clearly identified. Restate the problem and allow students a period for system exploration and problem solving. As with the bouncing ball, use your judgement in re; time but <u>record</u> the time. After a period of exploration, interact with various groups, presenting them with unopportunity to prove their point. Probe and offer counter suggestions as bove to insure that they not only control variables but can verbalize their strategy. (Remember that their ability to say "I controlled all the variables" doesn't mean they really did or that they know operationally what this means. Likewise they can give an adequate explanation without mentioning the words "control" or "variable"). For those who do not successfully solve the problem. explain and demonstrate why their strategy is ineffective and what the effective strategy is, referring to the "Rod and Block" and "Bouncing Balls" experiment as analogies.

4. SCIS and Whirly Bird - A Four Variable Problem.

The problem: What are the affects of number of turns (10 vs 20), weight, bolt placement, (inside or outside) and rubber band arrangement (singled or doubled) on "whirl time?" In order to decrease the complexity of the experiment, two modifications are required. The first is to tape over all but the innermost and outermost holes of the Whirly Bird arms. The second is to alter the bolts such that there is a distinct difference in weight.

One way to do the latter is to use a hack saw to decrease by about half the length of some of the bolts furnished in the SCIS kit, thereby decreasing their mass. Massive bolts can be made by purchasing #4 pyramidal lead fish hook sinkers, removing the brass loop there embedded with a pair of pliers, drilling an appropriate diameter hole (use a masonary bit!), screwing in a wood screw of diameter equal to the SCIS bolts, and cutting off the head of the screw at a point such that the shaft distance of SCIS and lead-top bolts are equal. Make enough materials so that each group has one Whirly Bird, 2 rubber bands from the SCIS kit, 2 shortened bolts from the SCIS kit, and 2 massive bolts.

After reviewing and briefly demonstrating the strategy that was successful for solving the three variable problem, demonstrate the Whirly Bird apparatus, present the problem and demonstrate each variable so that you and the students have a common language for discussing the system. As before, allow them a period of time for system exploration and experiment construction, and record the time. Have each group "prove" the affect of each variable and use probes and counter-suggestions to insure that they are consciously and systematically controlling variables. Those who do not design a systematically controlled experiment receive: An explanation and demonstrate of why their strategy is unsuccessful, and an explanation and demonstration of the successful strategy, using the previous successful strategies from the "Rods and Blocks," etc.,

5. <u>SCIS Rotoplane</u> -- a five variable multiple outcome problem.

If you decide to include this, use the same instructional strategy - one problem: What are the affects of the number of propellors used, (1 or the number of rubber bands used, the number of propellor twists (a greatly different pair, say 10 and 50), the propellor positions), and the angle at which the rotoplane is placed on spin conformation (spin or no-spin; if spin, clockwise or counterclockwise), and number of platform rotations. You will need to raid the SCIS box so that each group has 2 propellors, shafts, etc., 1platform, 1 stand and four rubber bands.

Present the problem, demonstrate the apparatus and each variable and provide exploration/experimentation time. Check each group's solution using probes and counter suggestions. Explain and demonstrate why a faulty strategy is faulty, what the correct strategy is and why it works using "Rods and Blocks" and other experiments as examples and analogies.

Appendix B

I. Problem: Determine whether the yellow or white rod is heaviest without removing the rods from the blocks.

Answer: ______________________________

____

Method	Conclusion (Application)
What does change	What doesn't change

II. Problem: Determine which ball bounces highest and why

Answer: ______________________________

____

Method	Conclusion (Application)
What does change	What doesn't change

III. Problem: What effect does changing the number of turns have on the number of spins?

Answer:

Method	Conclusion (Application)
What does change	What doesn't change

IV. Problem: What effect does changing the bolt placement have on the number of spins?

Answer:

Method	Conclusion (Application)
What does change	What doesn't change

V. Problem: What effect does changing the weight, number of bands, and variations affect the number of spins?

Answer: ______________________________

Method	Conclusion (Application)
What does change	**What doesn't change**

Appendix C

To the test administrator: For the test of Propositional Logic

Please allow the student ample time to complete this test. This may be as long as 20 min. or as short as 10 min. Allow no talking while others are taking this test. Have each student fill in the information required on the answer sheet along with their birhdate and year. The code number to be filled in at the left of the name will depend on the student I.D. number for each student and the school I.D. followed by the numeral 11. Therefore the number to be filled in should be:

XXXX101011 The 11 indicates that this is a pretest.
If 22 is used this is the post test.

To the test administrator:

For the test of logical thinking

Once the videotape has started it should be allowed to continue. There are aedequate breaks within the tape for the student to finish the work. Have the student supplied with 1-3x5 card to answer the last two questions on the tape. Make sure that the same code number appears o on each (the card and the answer sheet). Use the 8 spaces from 30 to 37 for the answers to this portion of the test. The I.D. code to be used for this test is as follows:

XXXX101055 The XXXX is the student number of the student and the 55 indicates the pretest of the TOLT.

Appendix D

T.O.L.T. - FORM A

A

Item 1 Orange Juice #1

Four large oranges are squeezed to make six glasses of juice. How much juice can be made from six oranges?

a. 7 glasses
b. 8 glasses
c. 9 glasses
d. 10 glasses
e. other

Reason

1. The number of glasses compared to the number of oranges will always be in the ratio 3 to 2.

2. With more oranges, the difference will be less.

3. The difference in the numbers will always be two.

4. With four oranges the difference was 2. With six oranges the difference would be two more.

5. There is no way of predicting.

A

Item 2

Orange Juice #2

How many oranges are needed to make 13 glasses of juice?

a. 6 1/2 oranges
b. 8 2/3 oranges
c. 9 oranges
d. 11 oranges
e. other

Reasons

1. The number of oranges compared to the number of glasses will always be in the ratio 2 to 3.

2. If there are seven more glasses, then five more oranges are needed.

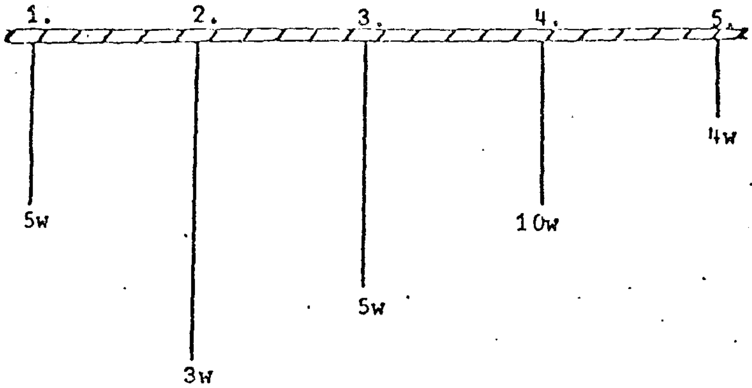
3. The difference in the numbers will always be two.

4. The number of oranges will be half the number of glasses.

5. There is no way of predicting the number of oranges.

A

Item 3 The Pendulum's Length



Suppose you wanted to do an experiment to find out if changing the length of a pendulum changed the amount of time it takes to swing back and forth. Which pendulums would you use for the experiment?

a. 1 and 4

b. 2 and 4

c. 1 and 3

d. 2 and 5

e. all

Reason

1. The longest pendulum should be tested against the shortest pendulum.

2. All pendulums need to be tested against one another.

3. As the length is increased the number of washers should be decreased.

4. The pendulums should be the same length but the number of washers should be different.

5. The pendulums should be different lengths but the number of washers should be the same.

Item 5

The Vegetable Seeds

A gardener bought a package containing 3 squash seeds and 3 bean seeds. If just one seed is selected from the package what are the chances that it is a bean seed?

a. 1 out of 2
b. 1 out of 3
c. 1 out of 4
d. 1 out of 6
e. 4 out of 6

Reasons

1. Four selections are needed because the three squash seeds could have been chosen in a row.
2. There are six seeds from which one bean seed must be chosen.
3. One bean seed needs to be selected from a total of three.
4. One half of the seeds are bean seeds.
5. In addition to a bean seed, three squash seeds could be selected from a total of six.

A

Item 6 The Flower Seeds

A gardener bought a package of 21 mixed seeds. The package contents listed:

3 short red flowers
4 short yellow flowers
5 short orange flowers
4 tall red flowers
2 tall yellow flowers
3 tall orange flowers.

If just one seed is planted, what are the chances that the plant that grows will have red flowers?

a. 1 out of 2
b. 1 out of 3
c. 1 out of 7
d. 1 out of 21
e. other

Reason

1. One seed has to be chosen from among those that grow red, yellow or orange flowers.

2. 1/4 of the short and 4/9 of the talls are red.

3. It does not matter whether a tall or a short is picked. One red seed needs to be picked from a total of seven red seeds.

4. One red seed must be selected from a total of 21 seeds.

5. Seven of the twenty one seeds will produce red flowers.

A

Item 7

The Mice

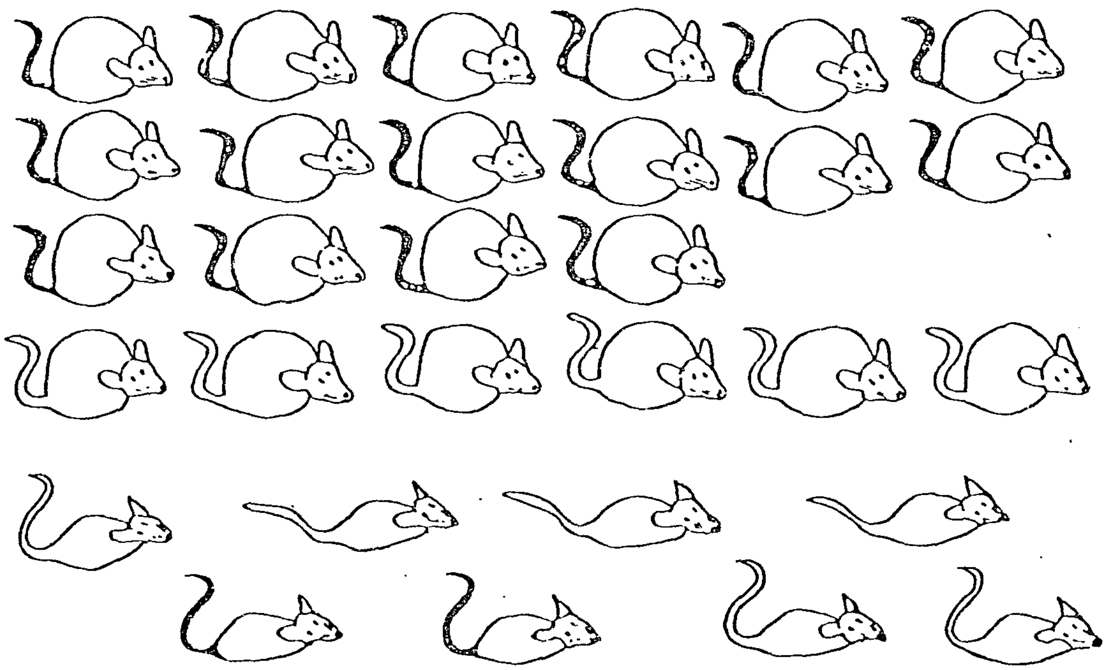
The mice shown represent a sample of mice captured from a part of a field. Are fat mice more likely to have black tails and thin mice more likely to have white tails?

a. Yes

b. No

Reason

1. 8/11 of the fat mice have black tails and 3/4 of the thin mice have white tails.
2. Some of the fat mice have white tails and some of the thin mice have white tails.
3. 18 mice out of thirty have black tails and 12 have white tails.
4. Not all of the fat mice have black tails and not all of the thin mice have white tails.
5. 6/12 of the white tailed mice are fat.



A

Item 8 The Fish

Are fat fish more likely to have broad stripes than thin fish?

a. Yes

b. No

Reason

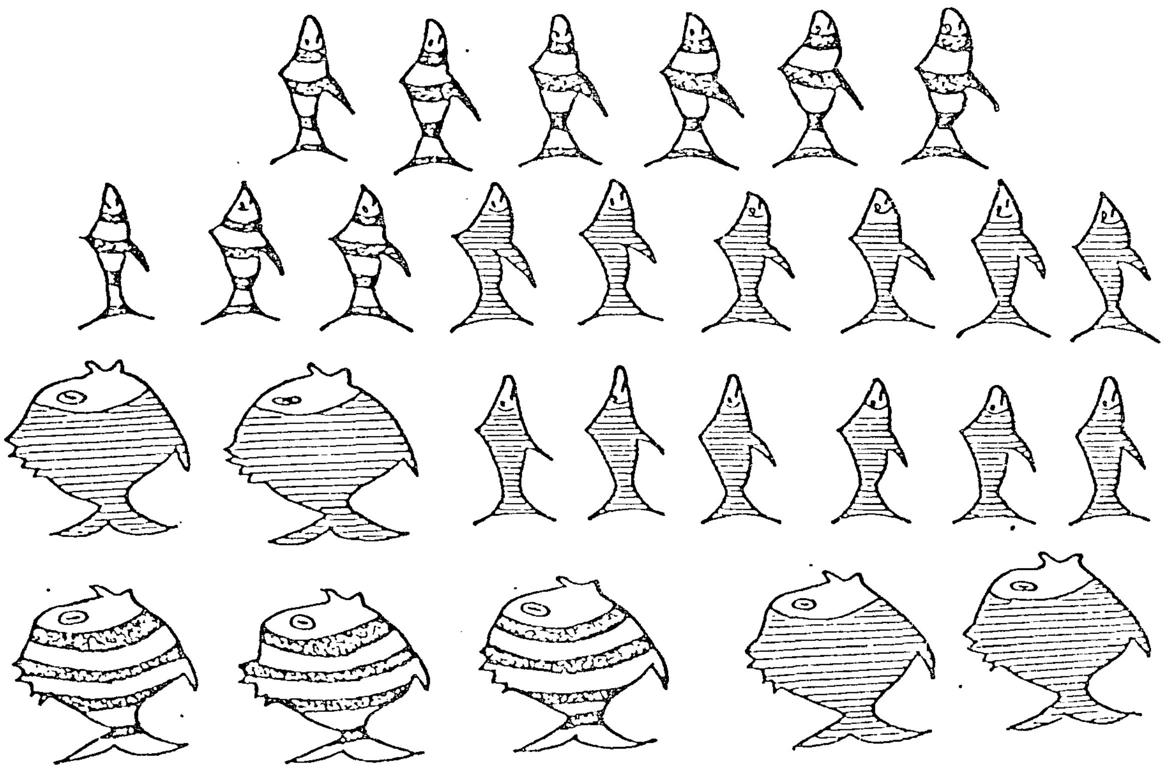
1. Some fat fish have broad stripes and some have narrow stripes.

2. 3/7 of the fat fish have broad stripes.

3. 12/28 are broad striped and 16/28 are narrow striped.

4. 3/7 of the fat fish have broad stripes and 9/21 of the thin fish have broad stripes.

5. Some fish with broad striped are thin and some are fat.



A

Item 9 The Student Council

Three students from grades 10, 11, 12 were elected to the student council. A three member committee is to be formed with one person from each grade. All possible combinations must be considered before a decision can be made. Two possible combinations are Tom, Jerry and Dan (TJD) and Sally, Anne and Martha (SAM). List all other possible combinations in the spaces provided.

More spaces are provided on the Answer Sheet than you will need.

STUDENT COUNCIL

Grade 10	Grade 11	Grade 12
Tom (T)	Jerry (J)	Dan (D)
Sally (S)	Anne (A)	Martha (M)
Bill (B)	Connie (C)	Gwen (G)

A

Item 10 The Shopping Center

In a new Shopping Center, 4 store locations are going to be opened on the ground level.

A BARBER SHOP (B), a DISCOUNT STORE (D), a GROCERY STORE (G), and a COFFEE SHOP (C) want to move in there. Each one of the stores can choose any one of four locations. One way that the stores could occupy the 4 locations is BDGC. List all other possible ways that the stores can occupy the 4 locations.

More spaces are provided on the Answer Sheet than you will need.

ANSWER SHEET

Name ______________________

Birthdate ______________________
Month Day Year

Sex ______________________

School ______________________

Grade __________ Date __________

Directions

A series of eight problems is presented. Each problem will lead to a question. Record the answer you have chosen and reason for selecting that answer.

Problem	Best Answer	Reason
1.	________	______
2.	________	______
3.	________	______
4.	________	______
5.	________	______
6.	________	______
7.	________	______
8.	________	______

Put your answers to questions 9 and 10 below:

9.	TJD	SAM	______	______	10.	BDGC	______	______	______
	______	______	______	______		______	______	______	______
	______	______	______	______		______	______	______	______
	______	______	______	______		______	______	______	______
	______	______	______	______		______	______	______	______
	______	______	______	______		______	______	______	______
	______	______	______	______		______	______	______	______
	______	______	______	______		______	______	______	______
	______	______	______	______		______	______	______	______
	______	______	______	______		______	______	______	______

T.O.L.T. - FORM B

3

Item 1 House Paint #1

A painter uses four cans of paint to paint six rooms. How many rooms can be painted with six cans of paint?

a. 7 rooms
b. 8 rooms
c. 9 rooms
d. 10 rooms
e. other

Reason

1. The number of rooms compared to the number of cans will always be in the ratio of 3 to 2.

2. With more cans of paint, the difference will be less.

3. The difference in the numbers will always be two.

4. With four cans of paint the difference was 2. With six cans of paint the difference would be two more.

5. There is no way of predicting how much paint is needed.

6

Item 2 House Paint #2

How many cans of paint are needed to paint eleven rooms?

a. 5 1/2 cans
b. 7 cans
c. 7 1/3 cans
d. 9 cans
e. other

Reason

1. The number of cans of paint compared to the number of rooms will always be in the ratio 2 to 3.

2. If there are five more rooms, then 3 more cans are needed.

3. The difference in the numbers will always be 2.

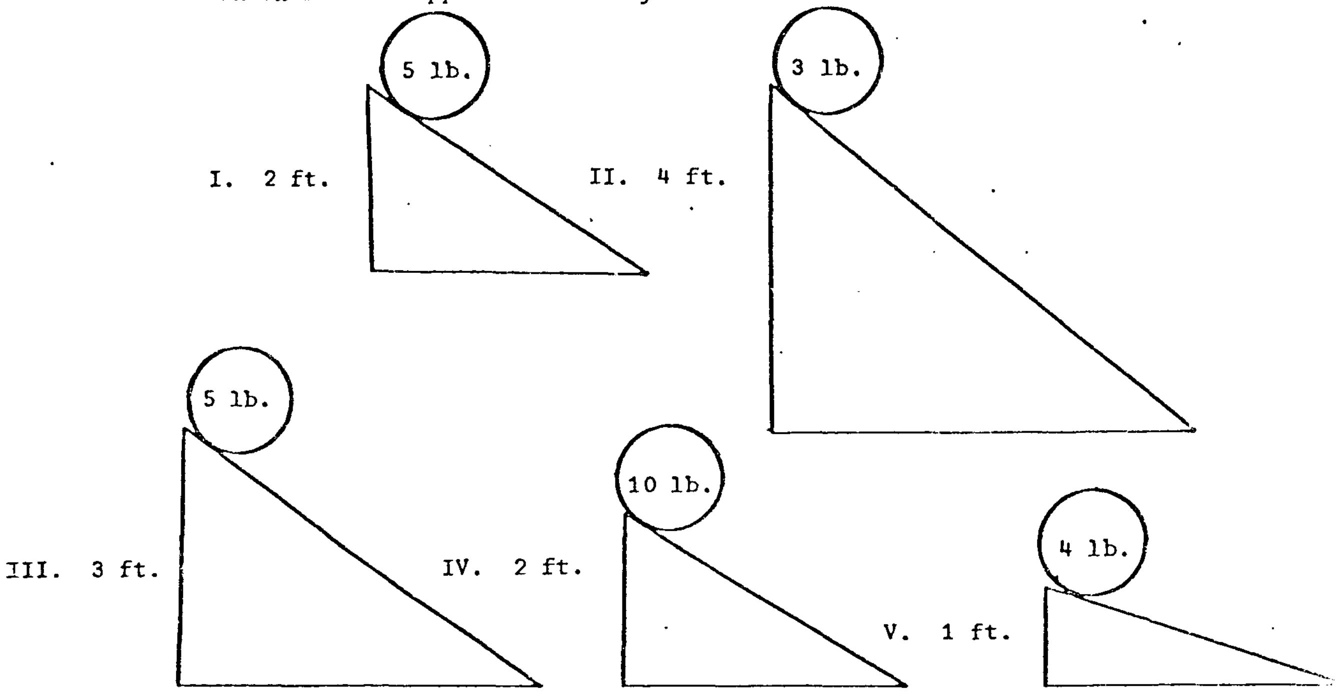
4. The number of cans will be half the number of rooms.

5. There is no way of predicting the amount of paint.

B

Item 3 Rolling Cylinders #1

Suppose you wanted to do an experiment to find out if changing the height of a ramp changed the distance a ball rolled off the end. Which sets of apparatus would you use?



a. I and IV
b. II and IV
c. I and III
d. II and V
e. all of them

Reasons

1. The highest ramp should be tested against the shortest.

2. All sets need to be tested against each other.

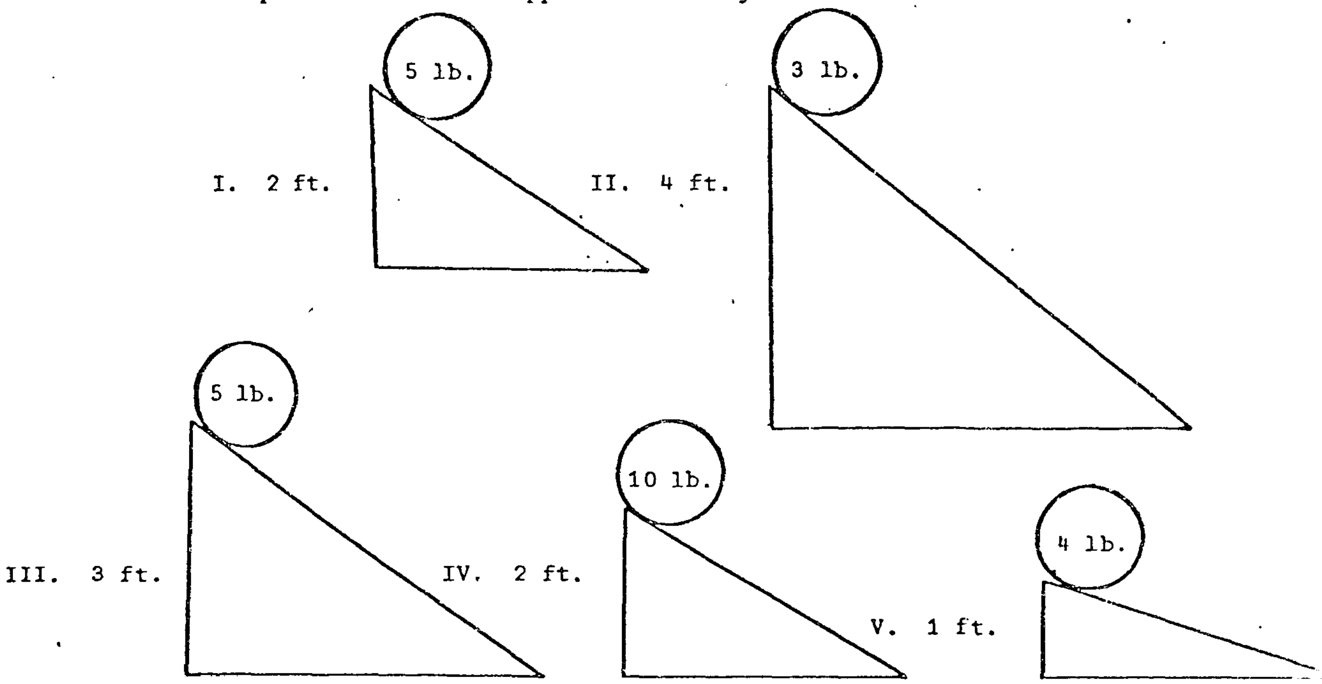
3. As the height is increased the weight must be decreased.

4. The heights should be the same but the weights should differ.

5. The heights should differ but the weights should be the same.

Item 4 Rolling Cylinders #2

Suppose you wanted to do an experiment to find out if changing the weight of the ball changed the distance it rolled off the end of a ramp. Which sets of apparatus would you use?



a. I and IV
b. II and IV
c. I and III
d. II and V
e. all of them

Reasons

1. The heaviest ball should be compared to the lightest.

2. All sets need to be tested against each other.

3. As the weight is increased, the height should be decreased.

4. The weights should be different but the heights should be the same.

5. The weights should be the same but the heights should be different.

3

Item 5 The Swiss Train

An American tourist is sharing a compartment on a Swiss train with six people. Three speak only English and three speak only French. What are the chances of speaking to someone who speaks English on the first try?

a. 1 out of 2
b. 1 out of 3
c. 1 out of 4
d. 1 out of 6
e. 4 out of 6

Reasons

1. Four selections are needed because the three French speakers could be chosen in a row.

2. There are six people from which one English speaking person must be chosen.

3. One English speaking person needs to be selected from a total of three.

4. One half of the people speak English.

5. In addition to an English speaking person, three French speaking people could be selected from a total of six.

Item 6 The Coins and Rings

Three gold coins, four silver coins, and five copper coins are placed in a sack. Four gold rings, two silver rings and three copper rings are placed in the same sack.

What are the chances of pulling out a gold object on the first try?

a. 1 out of 2
b. 1 out of 3
c. 1 out of 7
d. 1 out of 21
e. none of the above

Reason

1. One gold object has to be selected from objects made from gold, silver, and copper.

2. 1/4 of the coins and 4/9 of the rings are made from gold.

3. It does not matter whether a coin or a ring is picked. One gold object needs to be selected from a total of 7 gold objects.

4. One gold object must be selected from a total of twenty-one objects.

5. 7 of the 21 objects in the sack are made from gold.

Item 7 The Gumball Machine

A boy has a penny to use in one of two gumball machines. The first machine has 30 red and 50 yellow gumballs; the second has 20 red and 30 yellows. He likes only red gumballs.

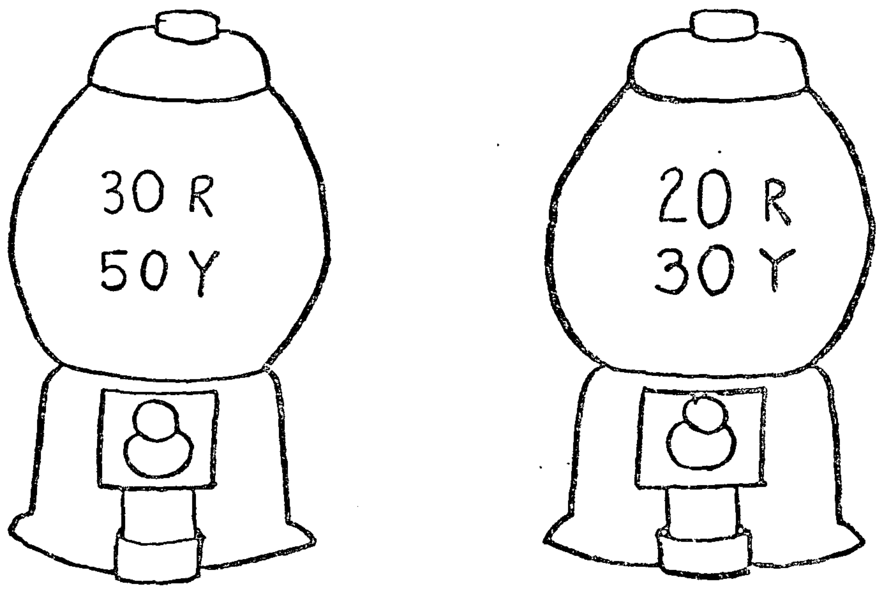
His chance of getting a red is greatest in the second machine?

a. Yes

b. No

Reasons

1. There are 30 red in the first machine and only 20 in the second.
2. There are 20 more yellows in the first machine and only 10 more yellows in the second.
3. There are 50 yellows in the first machine and only 30 in the second.
4. There is a greater proportion of reds in the second machine.
5. There are more gumballs in the first machine.



Item 8 The Spotted Dogs

Seven large dogs and 21 small dogs are shown in the picture. Some dogs are spotted and others are not spotted.

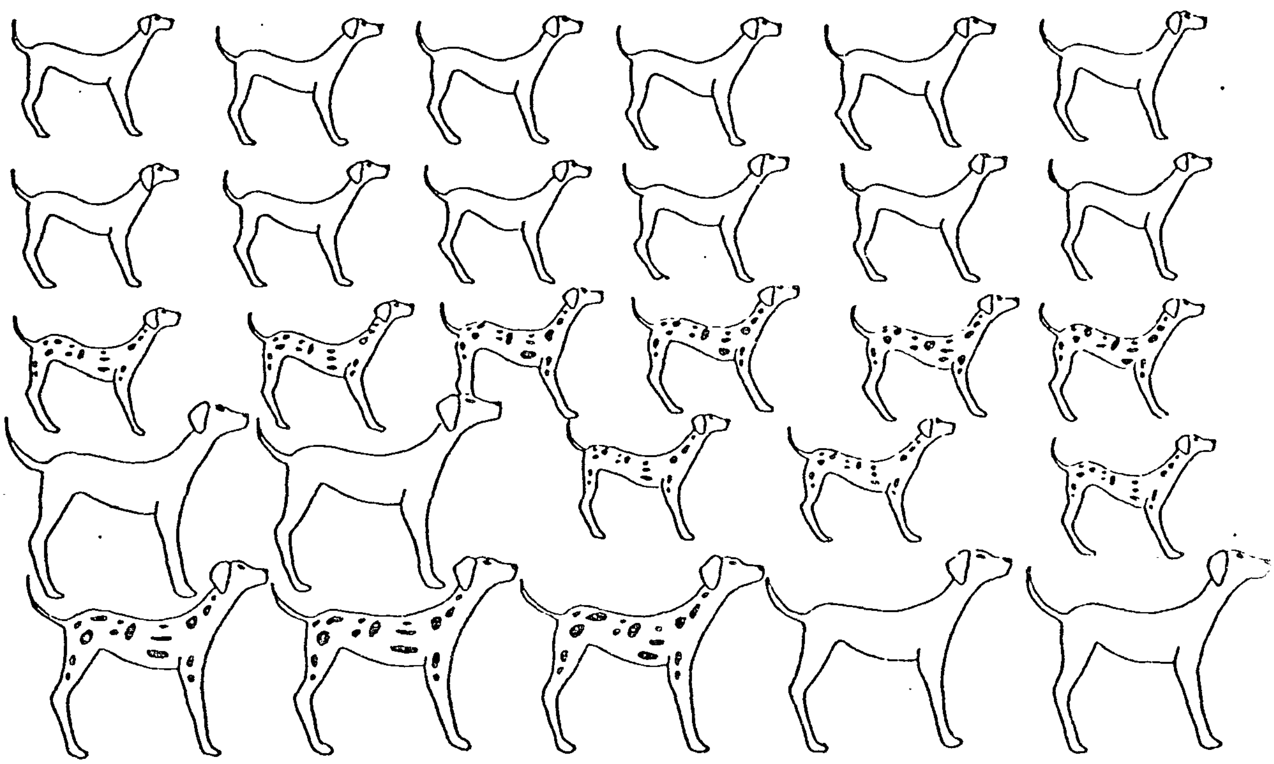
Are large dogs more likely to have spots than small dogs?

a. Yes

b. No

Reason

1. Some small dogs have spots and some large dogs have spots.
2. Nine small dogs have spots and only three large dogs have spots.
3. 12 of the 28 dogs are spotted and 16 of the 28 dogs are not spotted.
4. 3/7 of the large dogs are spotted and 9/21 of the small dogs are spotted.
5. 12 of the small dogs have no spots and only 4 of the large dogs have no spots.



Item 9

The Sandwiches

A restaurant allows a choice of three types of bread, three types of meat and three types of spread.

Bread	Meat	Spread
wheat (W)	ham (H)	ketchup (K)
rye (R)	chicken (C)	mayonnaise (M)
pumpernickle (P)	turkey (T)	butter (B)

Each sandwich must contain bread, meat and spread. How many types of sandwich can be prepared using only one type of bread, one type of meat and one type of spread?

List all of the possible types of sandwiches in the spaces provided on the Answer Sheet. More spaces are provided than you will need. Two examples of different sandwiches are provided for you. (WHK, RCM)

Item 10 The Car Race

In an automobile race there is a Dodge (D), a Chevy (C). a Ford (F) and a Mercury (M). An observer predicts that the order of finish will be DCFM. In the spaces provided on the Answer Sheet list all other possible orders in which the cars might finish.

More spaces are provided than you will need.

ANSWER SHEET

Name ____________________

Birthdate ____________________
Month Day Year

Sex ____________________

School ____________________

Grade __________ Date __________

Directions

A series of eight problems is presented. Each problem will lead to a question. Record the answer you have chosen and reason for selecting that answer.

Problem	Best Answer	Reason
1.	______	______
2.	______	______
3.	______	______
4.	______	______
5.	______	______
6.	______	______
7.	______	______
8.	______	______

Put your answers to questions 9 and 10 below:

9. TJD SAM ______ ______

10. BDGC ______ ______ ______