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By-Youngs, Richard C.

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A set of instructional materials and methods, designated Inquiry Development Program, was designed to teach children how to learn independently. The student was presented with an event which had an outcome that ran counter to his expectations. Motivated by his curiousity, he then searched for an explanation to the discrepancy between what he expected and the actual event. Several avenues of inquiry were offered to assist him in his investigations. To test the program, 71 fourth grade students were divided into three groups--one control and two experimental. The experimental groups used the Inquiry Development Program in addition to their regular curriculum. Pre- and posttests were administered to determine the levels of achievement responsibility and academic achievement in science. A test to measure the level of inquiry was administered afterwards. The results of the tests for independence and academic achievement were compared through an analysis of covariance. The test for inquiry was analyzed by a one-way analysis of variance. The only significant difference was shown to be that the students of the experimental group offered more explanations to a problem situation than did those of the control group. The test materials used and a bibliography supplement the report. (JY)

FINAL REPORT

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Richard C. Youngs
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PROJECT PERSONNEL

Project Director----------Richard C. Youngs, M.A.
Assistant Professor and
Supervising Teacher
of Science
Metcalf Laboratory School

Supervising Teacher of the Control Class (4A)----------Alice Sheveland, M.A.
Assistant Professor and
Supervising Teacher
Metcalf Laboratory School

Supervising Teacher of the Experimental Class (4B)---------Anita F. Jones, M.S.
Instructor and Supervising
Teacher
Metcalf Laboratory School

Supervising Teacher of the Experimental Class (4C)---------Ruth L. Hulbert, M.A.
Instructor and Supervising
Teacher
Metcalf Laboratory School

Research Consultant----------Robert E. Rumery, M.A.
Assistant Professor of
Psychology

Research Assistant----------Constance D. Woodward

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Miss Esther Groth, Miss Joy Perisho, Miss Rita Fischer, and Mrs. Constance Woodward contributed to the typing of the final report and assisted in various capacities during the study. Mr. Larry D. Kennedy served as the editor of the final draft.

Richard C. Youngs

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CHAPTER ONE

Statement of the Problem

This study is concerned with the testing of instructional methods and materials which teach children how to learn independently.

Definition of Independent Learning

Congreve (1965) defines academic independence for junior high students in the following way: "We feel that a student has reached a state of independence when he has the skills and basic understandings necessary to pursue knowledge on his own and when he also has the personal drive or motivation to do so." For younger children, Heathers (1955) says that "instrumental independence means conducting activities and coping with problems without seeking help."

Specifically, the term independent learning, as it is employed operationally in this study, means that a learner has developed skills and understandings such that he can engage successfully in worthwhile learning experiences with a minimum of directions.

Elements of Independent Learning

The researcher suggests that there are at least three general areas existing which are the concern of educators who attempt to bring about independent learning. These areas describe three corners of a

triad of independent learning in which two corners can compensate for the third. These aspects of independence are basic operations, facilities, and motivation.

Basic Operations

The category of basic operations includes basic skills. As an example, reading, computation, and communication skills are considered to be basic skills. The category also includes modes on inquiry such as experimentation, problem solving, critical thinking, and research. The basic operations also include a knowledge of conventional models and symbols.

A question is frequently raised regarding the minimum of basic knowledge which is necessary to engage in independent learning. There are those who suggest that the ability to read coupled with the motivation and facilities for learning constitute sufficient conditions for independent learning. On the other hand, others suggest that a knowledge of the particular discipline is essential before an individual can operate in an independent manner within the discipline. The advocates of the minimum knowledge view are challenged by those who contend that much of the motivation for independent learning is dissipated if a student is not offered an opportunity to learn independently early in his educational career.

A practical alternative to the issue recognizes that children can learn independently early in their educational careers while

independent learning in other areas requires considerable academic background for even modest success. Educators have the responsibility to identify those areas in which independent learning can be avhieved with a minimum of academic background and to encourage the child to learn independently in these areas.

Facilities

This category includes the physical facilities: reference materials, qualified staff, and learning atmosphere. It is desirable to offer a variety of learning environments to the students. Certainly, it is necessary for a student to have a place where he can study and concentrate without being interrupted or distracted. On the other hand, students should be able to discuss, to plan, and to organize with one another in small groups or to meet with qualified staff members.

Space, equipment, and materials should be available to these students so they can explore and experiment with significant concepts in the various disciplines. Materials which are appropriate and easy to locate should be readily available. In addition to printed material, visual and audio materials should be provided also.

Guidance and assistance should be available also from competent staff members. Such assistance requires individual or small group conferences and a continuing awareness of the progress of each student.

Motivation

One of the major problems in the nurturance of independent learning is the problem of motivation. Motivation for all learning is extrinsic or intrinsic, in some cases, both extrinsic and intrinsic. Some forms of extrinsic motivation are artificial and are not commonplace in adult society. The giving of grades, candy, gold stars, and other types of competitive rewards are examples of extrinsic motivation. Money is an example of a competitive reward which is commonplace in adult society, but one which is not generally used as an extrinsic motivator in public schools. Other types of extrinsic motivation which are common in society and in education are peer acceptance, competition and recognition by peers and/or superiors.

Intrinsic motivation may be derived from curiosity, the desire to do one's best, and the drive for independence. In the nurturance of independence, motivational systems which are common in education and in adult society need to be employed. A fruitful avenue for motivating independent learning may very well parallel a method of nurturing independence itself. As an example, independent training in young children is frequently accomplished by shaping behavior. (Bandura and Walters, 1963)

A similar sort of behavior control coupled with the drive to manipulate and to control one's environment (learning experience) can be used to bring about independent learning.

Independence and Academic Achievement

One of the primary reasons for focusing on independence and independent learning is that there appears to be a direct and positive correlation between a child's ability to attack problems independently and his academic achievement. Crandall (1960) reports that "high achieving children are less dependent on adults for help and emotional support." Winterbottom (1953) hypothesizes that "The training of children with strong achievement motivation would differ from that of children with weak achievement motivation in the following respect: Fewer restrictions imposed on behavior and independent situations and fewer and less intense rewards and punishments for conforming and nonconforming to restrictions." McClelland (1953) further supports the contention that academic achievement is positively related to independence, stating that "Achievement related behavior of highly motivated children would be more persistent, more independent, and more responsible to success cues than the behavior of less motivated children." Moreover, children who are highly motivated for achievement showed the general characteristics of independence, persistence, popularity and success in school.

Independence and Academic Responsibility

It has been asserted by Crandall, et. al., that the resolution of dependence and the acquisition of independent problem solving is

related to the degree to which children recognize that the reinforcements they receive are a result of their own actions.

> "The dependence of young children upon others for instrumental help and emotional support is, of course, a necessary condition of early development. However, the resolution of dependence on such caretakers and the concomitant acquisition of independent problem-solving techniques are equally important requisites of normal personality development. It would not be surprising then, to find that infants and pre-school children if they could report such beliefs- would ascribe reinforcement responsibility to the powerful others in their environment. But with age and experience, most children should begin to feel that their own actions are often instrumental in attaining the reinforcements they receive." (Crandall, Katkovsky, Crandall, 1965)

Moreover, Coleman (1966) contends that students achieve more when they feel that they have control over their environment and their destiny.

For the purpose of this study, the researcher accepts as a more autonomous student those who recognize that they, rather than other people, are responsible for their intellectual and academic success and failures. Students who fail to recognize that they are responsible for their academic success cannot be considered autonomous or academically independent. Those students who acknowledge this fact have made a significant move towards autonomy and independent learning.

The Specific Concern of This Research Study

It is acknowledged that the nurturance of independent learning is a multi-faceted problem. For the purpose of this study, however, the

investigation is limited to one aspect of independent learning. This aspect has to do with the development of inquiry and the ability to inquire effectively.

The instructional materials used in this study are those developed by J. Richard Suchman and published by Science Research Associates. In brief, the students are presented with events which are contrary to their beliefs about reality. They reconcile the discrepancy by inquiry. (A more extensive explanation is offered in the Appendix, page 33-35)

Two significant studies have been conducted in which the inquiry materials developed by Suchman were used. Suchman (1962) himself compared twelve sixth grade classes which received inquiry training with twelve who had not. He found that the trained group asked more questions, but the content mastery for both groups remained about the same.

The materials were also used with three hundred children in grades four, five, and six by Scott and Sigel (1965) to determine the effect of the program on 1) creativity, 2) cognitive style, and 3) knowledge of science concepts. Half of the sample received science instructions in the conventional mode while the other half received instruction using the approach developed by Suchman. The children who received the inquiry training showed superiority in grade five of science concepts achievement, however, no difference was noted in the creativity tests. The children who had had inquiry training appeared to use more sophisticated styles of categorization.

The author and publisher specify the following goals and objectives for the Inquiry Development Program:

1. "Inquiry Development Program has two primary objectives: to provide the climate and conditions that will stimulate productive inquiry and to facilitate inquiry by students into their own process of learning." (Science Research Associates, promotional literature)

2. "Inquiry Training is not proposed as a new way to teach science, but as a way of teaching basic cognative skills that are just as important to the intellectual development of the child as reading and arithmetic. It belongs in the science program and in every other curriculum area that requires the performance of empirical operations, inductive and deductive reasoning, and the formulations and testing of hypothesis." (Suchman, 1961)

3. "It is the goal of inquiry development to produce an autonomous student whose inquiry is directed largely by the motivations of curiosity." (Suchman, 1966)

From these goals, three general questions were formulated.

1. Are the children more able to inquire as a result of the instruction?

2. Do the children improve their level of academic achievement in science as a result of the Inquiry Development Program?

3. Are the children who have used the materials autonomous and independent?

In order to answer these questions, the following hypotheses were tested. (Stated here as null hypotheses) I was hypothesized:

H_1 that children who used the Inquiry Development Program would not score differently on a test of inquiry than would children who had not been similarly trained.

H_2 that children who used the Inquiry Development Program would not score differently on a test of academic achievement in science than would students who had not been similarly trained.

H_3 that children who used the Inquiry Development Program would not score differently on the test of academic responsibility than would children who had not been similarly trained.

CHAPTER TWO

Experimental Design

Description of Population

The children used in this study were the total population of the 1966-67 fourth grade classes of the Thomas Metcalf Laboratory School, excluding those children who were added to the grade after the experiment began, or those who left the school before the completion of the study. In the fall of 1966, all fourth grade children were randomly assigned to three classes. The control group was designated as Class 4A and a teacher was assigned to the group. Groups 4B and 4C were designated as experimental groups and teachers were assigned to these groups. When it became necessary to add children to the fourth grade classes, they were added in random fashion.

Group 4A (Control)

Group 4A contained 23 pupils, 14 were boys and 9 were girls. The mean verbal and non-verbal intelligence quotient as computed from third grade Lorge-Thorndike scores were 109 and 112 respectively.

Group 4B (Experimental)

Group 4B consisted of 24 students, 14 boys and 10 girls. The verbal and non-verbal quotients for this group were 118 and 116 respectively.

Group 4C (Experimental)

The 24 children in this group were divided evenly, 12 boys and 12 girls. The mean verbal quotient for this group was 115 and the mean non-verbal quotient was 112.

The majority of the 71 children who participated in this research project were selected initially to participate in a research project which began in the fall of 1962. These children were grouped into three classes. Two classes were composed of children who had IQ's in the gifted range and the third class was children who were not designated as gifted. Half of the children in the gifted category received specialized instruction which was designed to stimulate and to encourage the utilization of higher intellectual processes. The other half of the gifted group and the children who were not designated as gifted children received conventional instructions. During 1965 (3rd grade) this project concluded. In the fall of 1966, (4th grade), the current research project began. A major portion of the children in the fourth grade at that time were ones who had been admitted as kindergarteners for the original research projects. A majority of the children are children of faculty and come from middle class to upper-middle class homes where there is a concern for academic achievement. The total group consisted of 48 boys and 31 girls.

Pre- and Post-Tests

Pre- and post-tests were administered in order to determine levels of achievement responsibility and academic achievement in science. A post-test to measure the level of inquiry was also administered. The tests were administered at a common time for all classes, and under as identical conditions as were possible.

The science achievement test (Sequential Test of Educational Progress) was available in two comparable forms. Form A was used for the pre-test and Form B for the post-test. An answer key was supplied with the test and correct responses were readily identifiable.

The STEP Tests were generally regarded as superior instruments for measuring academic performance. This test purportedly measured not only knowledge of the discipline, but also the critical understandings and abilities of the discipline. A variety of realistic problem situations were presented which required the students to apply their knowledge and skills. The STEP Test was selected for this study because it appeared to sample the process of inquiry by way of application of knowledge and skills to a greater extent than did other popular achievement tests.

The test of achievement responsibility (Intellectual Achievement Responsibility Questionnaire) was available only in one form and the same form was used as a pre-test and post-test. Responses which

indicated a tendency toward independence or dependence were identified and compared with the student's responses.

The IAR Questionnaire was designed to assess children's beliefs that they, rather than other people, are responsible for their intellectual academic success and failures. (A copy of this questionnaire is included in the Appendix, page 41-48) The children's IAR questionnaire consisted of 34 forced-choice items. Each item described an experience in the child's school or home life for which he either accepted or rejected responsibility. The test was analyzed using several hundred children, over half of the subjects came from the elementary grades. The authors of the test reported a test retest reliability for children in grades 3, 4, and 5, as .69 over a two month interval. (Crandall, Katkovsky, and Crandall, 1965)

The test of inquiry (Youngs Inquiry Test) was developed by the researcher specifically for this project. The test consisted of a problem which is presented to the student and an analysis of the responses the student makes to the problem. The problem was presented to each child individually and his responses were recorded by the examiner as the child considered the problem. The examiner recorded four types of information on a tally sheet: 1) the number of questions the examinee asked; 2) the number of explanations offered or tested; 3) the number of hints asked for; and 4) the degree to which the examinee satisfactorily solved the problem. All questions,

whether they received yes or no answers, were recorded in the first category. Questions which were asked a second time were not recorded. In the second category, questions which sought to establish facts were not tallied. For example, questions such as, "Is the can full of water?", "Does the same water that you put in come out?", and "Did more water come out than you put in?" are not considered explanations. On the other hand, questions such as, "Is there a chemical in the can which changes the pink liquid to blue?", "Are the funnel and glass tube connected together by a rubber tube?", and "Does the blue water keep coming out because the glass tube is a siphon?" were considered as either explanations which were offered or tested. All questions were answered "yes" or "no" in order that the examiner could not give additional information to the examinee. In the third category, tally marks were recorded when a child asked specifically for a hint. The child was then offered one of six hints, depending on the amount of information he had already determined by questioning.

When the examinee ceased to ask questions, became disinterested, or said that he had no more questions to ask, he was then asked to summarize the things he knew about the problem. The examiner recorded the quality of explanation offered by the student. The student was then excused. (A more extensive description of the test along with the form for recording data is given in the Appendix, page 36-40.

Analyzing Results

The results of the pre- and post-tests for independence and for academic achievement for the three groups were compared through an analysis of covariance. This treatment was employed in order to adjust for differences which were present in the groups prior to instruction and to indicate whether additional differences appear during the period of instruction.

The results of the test of inquiry were analyzed by a one-way analysis of variance. This analysis was utilized in order to determine whether the groups differed from one another in their scores of inquiry.

Instructional Procedures

Teachers of the control and the experimental groups were instructed to conduct their classes in the manner in which they regularly conducted classes. Additionally, the teachers of the experimental groups used the Inquiry Development Program. These materials were incorporated into the school day in such a manner that the other subjects were not altered significantly. These instructional procedures are described more specifically in the Appendix, page 33-35.

CHAPTER THREE

Analysis of Data

Two similar forms of statistical analysis produced the results reported in this chapter.

When it was possible to administer both pre-tests and post-tests, the differences which were present between the groups prior to the instruction were controlled while changes which came about during the period of instruction were identified.

Analysis of the Science STEP Test

It was possible to pre-test and post-test using both the Science STEP Test and IAR Questionnaire.

The scores of the Pre-test and Post-test Science STEP Tests were compared for all three groups by analysis of covariance. A summary of this comparison is given in Table 3.1. The comparison failed to reveal a significant difference between the experimental and the control group in their STEP Science Achievement Test scores.

TABLE 3.1

SUMMARY OF ANALYSIS OF COVARIANCE

(Science STEP Test)

Source of Variance	ΣX^2	Degree of Freedom	Variance	F-Test	Proba-bility
Among Group	78.276	2	39.138	.762	N.S.
Within Group	3438.953	67	51.327		
Total	3517.229	69			

Analysis of the IAR Questionnaire

A similar analysis was performed with the scores of the IAR Questionnaire (Table 3.2). Again, the analysis of covariance failed to identify significant differences among the scores of the three groups.

TABLE 3.2

SUMMARY OF ANALYSIS OF COVARIANCE

(Intellectual Achievement and Responsibility Questionnaire)

Source of Variance	$\sum X^2$	Degree of Freedom	Variance	F-Test	Probability
Among Group	4.858	2	2.429	.171	N.S.
Within Group	949.496	67	14.171		
Total	954.355	69			

Analysis of YIT

The nature of the Youngs Inquiry Test was such that it could not be administered as both a pre-test and a post-test. It was designed to be administered only after instruction had been offered or when it was desirable to obtain a performance level for a group of students.

Four aspects of the YIT were compared when the test data were analyzed. The four aspects were: 1) the total number of questions an examinee asked during the test session; 2) the number of explanations an examinee offered or tested; 3) the number of hints an examinee requested; and 4) the degree to which the examinee offered a complete explanation of the event.

Analysis of variance was employed to identify possible significant difference between the groups on the four variables.

The Number of Questions

The analysis of the data (Table 3.3) was derived from the first question of the YIT (the number of questions an examinee asked). Although the results of this analysis did not demonstrate a significant difference between the group at the .05 level of confidence, the obtained probability of .09 suggested the possibility that significance might be observed with a more refined measure of the dependent variable.

TABLE 3.3

SUMMARY OF ANALYSIS OF VARIANCE

(YOUNGS INQUIRY TEST)

Number of Questions

Source	Sums of Squares	Degrees of Freedom	Mean Squares	F-Ratio	P.
Among groups	240.8407	2	120.4203	2.482	N.S.
Within groups	3298.3424	68	48.5050		
Total	3539.1531	70			

The Number of Explanations

The second measure on the YIT identified the number of explanations which were offered. Table 3.4 summarizes the analysis of the data of this measure.

TABLE 3.4

SUMMARY OF ANALYSIS OF VARIANCE

(YOUNGS INQUIRY TEST)

Number of Explanations

Source	Sums of Squares	Degrees of Freedom	Mean Squares	F-ratio	P
Among Groups	20.8721	2	10.4360	4.120	.05>P>.02
Within Groups	172.2264	68	2.5327		
Total	193.0986	70	-	-	-

Analysis of variance in Table 3.4 revealed a significant difference between the groups on this variable.

Mean scores were then compared. This analysis (summarized in Table 3.5) demonstrated that the difference between the groups occurs between the control group (4A) and the experimental group (4C). Student's t-ratio (Walker and Lev 1953) was used to test this difference. This difference was significant at the .01 level.

TABLE 3.5

SUMMARY OF ANALYSIS OF VARIANCE

(YOUNGS INQUIRY TEST)

Arithmetic Mean for Group 4A	1.2608
Arithmetic Mean for Group 4B	1.7961
Arithmetic Mean for Group 4C	2.5833
Mean (4A) vs. (4C) (Student's t)	-2.8477 with Probability of .0058

Number of Hints and Quality of Explanation

Tables 3.6 and 3.7 summarize the results of the analysis for the last two parts of the YIT; the number of hints asked for and the quality of the final explanation of the problem. For each part, the scores of the experimental groups did not differ significantly from the scores of the control group.

TABLE 3.6

SUMMARY OF ANALYSIS OF VARIANCE

(YOUNGS INQUIRY TEST)

Number of Hints

Source	Sums of Squares	Degrees of Freedom	Mean Squares	F-Ratio	P.
Among Group	1.5601	2	.7800	.855	N.S.
Within Group	61.9891	68	.9116		
Total	63.5492	70	-	-	-

TABLE 3.7

SUMMARY OF ANALYSIS OF VARIANCE

(YOUNGS INQUIRY TEST)

Quality of Explanations

Source	Sums of Squares	Degrees of Freedom	Mean Squares	F-Ratio	P.
Among Group	3.2230	2	1.6115	2.096	N.S.
Within Group	50.2699	68	.7686		
Total	55.4929	70			

Summary

Analysis of covariance failed to reveal significant differences between the groups on measures of science achievement and achievement responsibility. On measures of inquiry compared by an analysis of variance, only the number of explanations offered by one experimental group was found to differ significantly from the control group. (Original test data is given in the Appendix, page 45-51)

CHAPTER FOUR

Results and Conclusions

This study attempted to answer three questions: 1) Do children who are exposed to the Inquiry Development Program score higher on a test of academic achievement in science than do students who have not been similarly exposed? The results of this study did not demonstrate that children who have been exposed to the Inquiry Development Program had a higher level of academic achievement in science than those children who were not similarly exposed. (The null H_2 was accepted.) 2) Do children who have been exposed to the Inquiry Development Program score higher on a test that measures academic autonomy than do children who have not been similarly exposed? The results of this study did not demonstrate that children who had received the Inquiry training were more autonomous than the children in the control group. (The null H_3 was accepted.) 3) Are children who have been exposed to the Inquiry Development Program more able to inquire? The results of this study appeared to demonstrate children who have been exposed to Inquiry Development materials offer and test more explanations to a problem situation than those children who have not been exposed to the Inquiry Development material. On three other measures of Inquiry, the number of questions, the number of hints, and the quality of explanation, the children exposed to the Inquiry Development materials

did not perform significantly better than did those children who were not similarly exposed. (The null H_1 was rejected.)

Limitations of the Materials

The Inquiry Development Program in its present form appeared to be, in part, unsuitable for average and bright fourth grade children. The reading level of the Resource Book was well beyond the capability of most fourth grade students. The Dale-Chall (1948) Readability Formula showed it to be approximately eighth grade level. Several of the discrepant events were either beyond the comprehension of fourth grade children or did not interest them sufficiently to provide the necessary motivation.

It should be pointed out that the publisher of these materials recommended them primarily for use with junior high children. Further, in fairness to the material, the researcher has had considerable success in the use of these materials at the junior high grade level.

Teacher Limitations

The teachers of the experimental classes agreed that the science background necessary to conduct the inquiry sessions successfully exceeded the science background of well-prepared elementary teachers. A lack of thorough understanding on the part of the teachers made

it difficult for them to maintain the free and permissive atmosphere which was a necessary condition of the program. It was also difficult for the teachers with their limited science background to answer the students' questions effectively.

Insufficient Exposure to the Material

A question could be raised as to whether or not the children were exposed to the Inquiry Development Materials for a sufficient period of time. The test results seemed to indicate that at least one experimental group began to demonstrate some changes as a result of the Inquiry Development Program. Further studies might indicate that the changes which are claimed for the program will, in fact, come about when the program is maintained for a longer period of time or at a more intense level than was done within the limitations of this study.

Further Research

This study indicates that additional studies which examine the relationship between Inquiry Development materials and changes in student behavior are indicated. Studies which examine the appropriateness of the current materials for elementary grade levels are particularly desirable. A revision of the materials employed would be a valuable contribution to elementary science. Such a revision might have the effect of making the materials more appropriate for

children in the lower grades. In addition, a study which considered the minimal qualifications of an inquiry leading teacher might provide valuable information to those who would consider the use of the Inquiry Development Program. A study which would reveal the elements of the mode of inquiry, if such modes exist, and the knowledge, skills, attitudes and physical development which might be necessary to inquiry would be valuable also.

Summary

The children using the Inquiry Development materials met with only moderate success. Several factors may have contributed to the minimal success. Portions of the Inquiry Development material appeared to be beyond the comprehension of average fourth grade children, as well as many of the gifted fourth graders. The science background necessary to conduct inquiry sessions successfully exceeded the science background commonly found in well-prepared elementary teachers. Lastly, the children may have not been exposed to the materials for a sufficient period of time to bring about a level of inquiry which would cause them to differ significantly from a control group.

Finally, additional research on this topic is indicated. Studies which are concerned with appropriate grade placement, revision of materials for lower grade levels, and minimal science background of inquiry conducting teachers are indicated as worthwhile avenues of investigation.

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APPENDIX

Description of the Inquiry Development Program

Philosophy of Inquiry Development Program

Fundamental to this program is the notion of Beller (1955) which suggests that all humans have a need to explore, manipulate, and control their environment. The author of these materials capitalizes on this need to "produce an autonomous student whose inquiry is developed largely by the motivation of curiosity." (Suchman, 1966)

While using the materials, the children are encouraged to experiment and to explore. The author of the Inquiry Development Program insists that an atmosphere of freedom be maintained in the classroom.

A Problem is Presented

Situations are presented to the students which have outcomes which run counter to the student's expectation. These are labeled discrepant events. They are contrary to the student's beliefs about reality. The student is motivated by curiosity to find an explanation which will explain the events in order that they can be reconciled with his expectations.

The discrepant events or problems are presented to the student in a variety of ways. Some of the problems are presented to the student by way of motion picture films. The motion pictures consist of 8mm silent film loops. The children are organized into small groups

of from 8 to 12 students. The group views the film completely and then asks questions about the film. They may also view the film a second time and stop its motion at critical places and view specific events.

Others are demonstrated by the teacher while some of the problems are found in the Idea Book. The children have an opportunity to examine the apparatus closely and conduct the demonstration themselves. The Idea Book poses problems, and the students may ponder these problems at their leisure.

The Solution of the Problem

Several avenues are available to the child for the solution of the problem. He may be part of a group which questions the teacher: the teacher serves as a resource person. The questions posed by students need to be answerable by yes or no. This requirement insures that ideas for the solution of the problem originate with the student. A student is permitted to ask a series of questions before relinquishing the floor to another student. His curiosity or the drive to manipulate and to explore the problem provides the motivation. The student may experiment with the Experimental Kit which may assist him in verifying or in demonstrating the explanations he has created. The Idea Book provides another source of information which will assist the child in formulating explanations of phenomena. A Resource Book is provided which also can contribute to the student's fund of knowledge so that he is better able to pursue the problem and offer solutions to it.

To summarize, four types of materials are available to the student. The films present the majority of the major problems or discrepant events which are shown to the child. The remainder of the discrepant events are demonstrated to the child by the teacher or are illustrated in the Idea Book. The child gains information for the solution of the problem by asking the teacher an appropriate sequence of questions, by referring to appropriate sections of the Idea Book, by experimenting with the experimental kit, and/or relating the problem to stories in the Resource Book.

Description of the Youngs Inquiry Test

This test consists of a problem which is presented to the examinee and a method of analyzing the manner in which the examinee responds to the problem.

Description of Youngs Inquiry Test

The problem consists of a siphoning device which is constructed from a gallon can, funnel, rubber stopper, and glass tubing. (see figure A.1) The materials are assembled in such a manner that the funnel and the glass tubing are inserted into the rubber stopper. The stopper, in turn, is fitted into the top of a gallon can. The gallon can is filled with blue water. When a liquid, in this case pink water, is poured into the funnel, it forces the blue water through the glass tube and into a receptacle placed beside the apparatus. The blue water continues to siphon through the glass tube until the level in the can falls below the siphoning tube. This tube can be adjusted so that the water will stop siphoning when the receptacle collecting the water is full.

Initially, the problem appears to be a puzzling one. Pink water is poured into the funnel, and blue water begins flowing from the glass tube. The amount of water which comes out of the glass tube greatly exceeds the amount that was put in the funnel. The tube appears to stop supplying water when the collecting receptacle is full.

Each student is examined individually. The examinee is seated across from the examiner, and the apparatus for posing the problem is placed between them. The examiner provides these instructions in a friendly and casual manner. "I am going to show you a science puzzle. You may ask questions about it, but I can answer only yes or no questions. You may not touch the puzzle." At this point the examiner picks up a small beaker of pink-colored water. The pink water is then poured into the funnel, and blue water begins to emerge from the end of the glass tube and fall into the receptacle. The beaker of water which was used to start the siphon is placed beside the large receptacle with a small amount of the pink water still in it. The examinee may then ask questions or simply observe the problem. After approximately one minute has elapsed, the examiner mentions that he can give hints if the student asks for them. Shortly, the receptacle receiving water from the glass tube will be filled and "automatically" the water stops coming from the tube.

The examiner records four types of information on a tally sheet: 1) the number of questions the examinee asks; 2) the number of explanations offered or tested; 3) the number of hints asked for; 4) the degree to which the examinee satisfactorily solves the problem. All questions, whether they receive right or wrong answers, are recorded in the first category. In the second category, questions such as, "Is

there a chemical in the can which changes the pink liquid to blue?", "Are the funnel and glass tube connected together by a rubber tube?", and "Does the blue water keep coming out because the glass tube is a siphon?" are considered as explanations which are offered or tested.

In the third category, tally marks are recorded here when a child asks specifically for a hint. He is offered one of six hints depending on the amount of information he has already collected by his questioning.

When the examinee ceases to ask questions, becomes disinterested, or says that he has no more questions to ask, he is asked to summarize the things he does know about the problem. Three levels of explanation are recorded: 1) the lowest level, acknowledgement that the pink water caused the blue water to overflow through the glass tube; 2) the next higher level solution to the problem recognizes that the water is kept running because of a siphon system; and 3) the third level of understanding is indicated when the student recognizes that the siphon stops because the water level in the can falls below the bottom of the glass tube. The examiner records the quality of explanation offered by the student and excuses him. (Directions for the test and a copy of the form for recording this data along with the hints follow.)

DIRECTIONS FOR YOUNGS INQUIRY TEST

I am going to show you a science puzzle. You may ask questions about it, but, I can answer only yes or no questions. You may not touch the puzzle. (Start siphon.) When the puzzle stops you may ask questions about it, but I can answer only yes or no questions.

(After one minute) I can give you hints if you ask me to.

(After five minutes or when the questioning stops) Tel me what you can about this puzzle.

RECORD OF RESPONSES FOR YOUNGS INQUIRY TEST

NAME _____
DATE _____

1. Number of questions: _____

2. Number of explanations offered or tested: _____

3. Number of hints asked for: _____

    1. The liquid is colored water.
    2. The can was full of blue water.
    3. The pink water exerted a pressure on the blue water.
    4. The blue water was pushed through the glass tube by the pink water.
    5. The water in the tube kept running because it is a siphon.
    6. The tube goes down into the can only a short way.

4. Persistence time: _____ _____ _____*

5. Quality of explanation:

    1. Pink water caused the blue to overflow.
    2. Kept running because of siphon.
    3. Stopped when water level in can at bottom of tube.

*It was not possible to obtain this information for all children. Therefore, this was omitted from the analysis.

IAR SCALE*

Directions

At the top of the paper, please put your name.

I am going to ask you some questions to find out how certain important things affect different children. Each question has two parts lettered "a" or "b". Please pick the one part of each pair (and only one) which you more strongly believe to be true as far as you are concerned. Then put a circle around the letter "a" or "b". Be sure to pick the one you <u>really</u> believe to be more true, not the one you think you should choose or the one you would like to be true. There are no right or wrong answers. You are just saying what you think is true.

Please answer these questions very carefully but do not spend too much time on any one question. Sometimes you may believe both parts; sometimes you may not believe either part. When this happens, mark the one you most strongly believe to be true as far as <u>you</u> are concerned. Please answer every question.

* Intellectual Achievement Responsibility Questionnaire by V. C. Crandall, W. Katkovsky, and V. J. Crandall.

NAME_____

THE IAR SCALE

1. If a teacher passes you to the next grade, would it probably be

   a. because she liked you, or

   b. because of the work you did?

2. When you do well on a test at school, it is more likely to be

   a. because you studied for it, or

   b. because the test was especially easy?

3. When you have trouble understanding something in school, it is usually

   a. because the teacher didn't explain it clearly, or

   b. because you didn't listen carefully?

4. When you read a story and can't remember much of it, it is usually

   a. because the story wasn't well written, or

   b. because you weren't interested in the story?

5. Suppose your parents say you are doing well in school. Is this likely to happen

   a. because your school work is good, or

   b. because they are in a good mood?

NAME _____

6. Suppose you did better than usual in a subject at school. Would it probably happen

   a. because you tried harder, or

   b. because someone helped you?

7. When you lose at a game of cards or checkers, does it usually happen

   a. because the other player is good at the game, or

   b. because you don't play well?

8. Suppose a person doesn't think that you are very bright or clever,

   a. can you make him change his mind if you try to, or

   b. are there some people who will think you're not very bright no matter what you do?

9. If you solve a puzzle quickly, is it

   a. because it wasn't a very hard puzzle, or

   b. because you worked on it carefully?

10. If a boy or girl tells you that you are dumb, is it more likely that they say that

   a. because they are mad at you, or

   b. because what you did really wasn't very bright?

NAME _____

11. Suppose you study to become a teacher, scientist, or doctor and you fail. Do you think this would happen

    a. because you didn't work hard enough, or

    b. because you needed some help, and other people didn't give it to you?

12. When you learn something quickly in school, is it usually

    a. because you paid close attention, or

    b. because the teacher explained it clearly?

13. If a teacher says to you, "Your work is fine." is it

    a. something teachers usually say to encourage pupils, or

    b. because you did a good job?

14. When you find it hard to work arithmetic or math problems at school, is it

    a. because you didn't study well enough before you tried them, or

    b. because the teacher gave problems that were too hard?

15. When you forget something you heard in class, is it

    a. because the teacher didn't explain it very well, or

    b. because you didn't try very hard to remember?

NAME_____

16. Suppose you weren't sure about the answer to a question your teacher asked you, but your answer turned out to be right. Is it likely to happen

    a. because she wasn't as particular as usual, or

    b. because you gave the best answer you could think of?

17. When you read a story and remember most of it, is it usually

    a. because you were interested in the story, or

    b. because the story was well written?

18. If you parents tell you you're acting silly and not thinking clearly, is it more likely to be

    a. because of something you did, or

    b. because they happen to be feeling cranky?

19. When you don't do well on a test at school, is it

    a. because the test was especially hard, or

    b. because you didn't study for it?

20. When you win at a game of cards or checkers, does it happen

    a. because you play well, or

    b. because the other person doesn't play well?

21. If people think you're bright or clever, is it

    a. because they happen to like you, or

    b. because you usually act that way?

NAME_____

22. If a teacher didn't pass you to the next grade, would it probably be

    a. because she "had it in for you," or

    b. because your school work wasn't good enough?

23. Suppose you don't do as well as usual in a subject at school. Would this probably happen

    a. because you weren't as careful as usual, or

    b. because somebody bothered you and kept you from working?

24. If a boy or girl tells you that you are bright, is it usually

    a. because you thought up a good idea, or

    b. because they like you?

25. Suppose you became a famous teacher, scientist or doctor. Do you think this would happen

    a. because other peopled helped you when you needed it, or

    b. because you worked very hard?

26. Suppose your parents say you aren't doing well in your school work. Is this likely to happen more

    a. because your work isn't very good, or

    b. because they are feeling cranky?

NAME_____

27. Suppose you are showing a friend how to play a game and he has trouble with it. Would that happen

    a. because he wasn't able to understand how to play, or

    b. because you couldn't explain it well?

28. When you find it easy to work an arithmetic or math problem at school, is it usually

    a. because the teacher gave you especially easy problems, or

    b. because you studied your book well before you tried them?

29. When you remember something you heard in class, is it usually

    a. because you tried hard to remember, or

    b. because the teacher explained it well?

30. If you can't work a puzzle, is it more likely to happen

    a. because you are not especially good at working puzzles, or

    b. because the instructions weren't written clearly enough?

31. If your parents tell you that you are bright or clever, is it more likely to be

    a. because they are feeling good, or

    b. because of something you did?

32. Suppose you are explaining how to play a game to a friend and he learns quickly. Would that happen more often

    a. because you explained it so well, or

    b. because he was able to understand it?

NAME _____

33. Suppose you're not sure about the answer to a question your teacher asks you and the answer you give turns out to be wrong. Is it likely to happen

    a. because she was more particular than usual, or

    b. because you answered too quickly?

34. If a teacher says to you, "Try to do better," would it be

    a. because this is something she might say to get pupils to try harder, or

    b. because your work wasn't as good as usual?

TEST DATA FOR GROUP 4A
(Control)

Student	STEP Pre-test Nov. 66	STEP Post-test May 67	IAR Pre-test Jan. 67	IAR Post-test May 67	YIT Ques-tions	YIT Expla-nations May 67	YIT Hints	YIT Qual-ity
101	262	262	28	27	6	2	1	1
102	248	248	32	24	5	0	0	0
103	264	267	25	27	5	1	1	2
104	238	238	29	26	1	0	0	0
105	263	259	29	29	0	0	0	0
106	247	251	20	27	10	1	0	0
107	275	276	27	27	0	0	0	0
108	258	255	24	27	2	0	0	0
109	264	276	30	25	0	0	0	0
110	256	258	26	30	24	2	0	1
111	263	273	24	22	4	1	0	3
112	253	258	25	23	7	3	0	0
113	262	266	24	14	0	0	0	0
114	267	269	21	22	20	4	2	1
115	277	276	26	30	4	2	3	1
116	260	269	22	29	5	1	0	0
117	263	283	30	29	0	0	1	0
118	261	269	20	17	3	2	0	1
119	247	253	21	25	0	0	0	0
120	261	254	30	28	2	1	0	2
121	259	271	23	24	27	6	0	2
122	288	279	32	30	17	2	4	0
123	263	255	28	32	4	1	0	0
$\bar{X}$ =	260.8	263.7	25.9	25.8	6.3	1.3	.5	.67

TEST DATA FOR GROUP 4C
(Experimental)

Student	STEP Pre-test Nov. 66	STEP Post-test May 67	IAR Pre-test Jan. 67	IAR Post-test May 67	YIT Ques-tions	YIT Expla-nations May 67	YIT Hints	YIT Qual-ity
201	258	249	24	24	4	3	0	3
202	275	276	24	24	6	2	2	2
203	264	271	31	29	4	2	0	1
204	266	261	30	28	13	2	0	0
205	269	287	24	28	2	1	1	1
206	271	261	31	29	15	1	1	0
207	269	269	29	26	5	1	1	0
208	255	263	22	24	18	3	0	1
209	262	273	19	28	9	2	2	0
210	263	267	21	24	11	1	0	1
211	266	269	22	18	9	1	1	1
212	273	264	26	26	14	4	1	1
213	261	262	21	28	9	0	0	2
214	271	261	23	19	2	2	0	0
215	271	283	25	24	7	3	0	2
216	234	242	18	19	24	3	0	0
217	277	262	24	25	21	2	2	1
218	264	273	29	28	11	1	0	2
219	277	267	31	27	5	2	0	1
220	261	266	30	24	9	0	1	0
221	266	266	29	24	15	4	0	3
222	266	267	22	31	13	1	1	0
223	259	267	30	22	2	1	1	1
224	261	263	31	24	3	1	1	1
$\bar{X}$ =	264.95	266.2	25.6	25.1	10.9	1.8	.63	1.0

TEST DATA FOR GROUP 4C
(Experimental)

Student	STEP Pre-test Nov. 66	STEP Post-test May 67	IAR Pre-test Jan. 67	IAR Post-test May 67	YIT Ques-tions	YIT Expla-nations May 67	YIT Hints	YIT Qual-ity
301	262	279	26	29	2	4	1	3
302	258	264	30	32	10	0	2	1
303	267	267	27	23	11	2	1	1
304	264	258	23	22	5	2	0	1
305	223	231	16	23	11	5	[illegible]	1
306	264	266	27	27	8	3	[illegible]	1
307	252	255	26	24	10	1	3	1
308	250	258	30	31	12	5	1	1
309	264	263	29	29	8	2	1	0
310	264	264	21	23	20	3	1	2
311	264	273	24	27	10	6	0	1
312	254	257	28	28	14	2	0	0
313	284	269	29	23	2	2	0	2
314	269	264	27	25	5	1	0	1
315	256	255	32	29	5	1	0	0
316	280	259	21	29	4	2	2	1
317	269	276	20	18	3	1	0	3
318	267	260	31	14	14	0	1	0
319	254	255	20	23	4	0	0	0
320	263	262	27	24	12	8	4	1
321	252	261	30	31	20	5	1	2
322	261	256	22	24	0	3	1	1
323	280	273	28	31	12	2	1	1
324	247	252	18	24	8	2	0	1
$\bar{X}$ =	261.2	261.5	25.5	25.5	8.8	2.6	.88	1.1