DOCUMENT RESUME

ED 041 744 | 24 | SE 009 013

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TITLE	Quantitative Measurement of the Effectiveness of a Science Course, Final Report.
INSTITUTION	Virginia Univ., Charlottesville, Bureau of Educational Research.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
BUREAU NO	BR-8-C-013
PUB DATE	Feb 70
GRANT	OEG-3-8-080013-0023-010
NOTE	127p.
EDRS PRICE	EDRS Price MF-$0.50 HC-$6.45
DESCRIPTORS	Academic Achievement, Course Evaluation, *Curriculum, *Evaluation, *Instructional Materials, Measurement, *Physical Sciences, *Secondary School Science
IDENTIFIERS	Introductory Physical Science

ABSTRACT

This is the report of a study designed to test a model for determining the effectiveness of sets of instructional materials which can be considered hierarchical and to derive a mathematical relationship by which such measures can be quantified. The model tested requires that the instructional materials be hierarchical in character. The Introductory Physical Science (IPS) course was used in the study. The public schools in a suburban county provided the instructional setting. The model for measuring effectiveness proved, within the constraints of the study, to be a valid one when applied to the performance of boys in the IPS course. It worked especially well for boys of high ability. The model was not applicable in the case of girls' performance in the IPS course. The report also contains the investigator's evaluation of the IPS course and materials, some of the evaluation instruments used, and a bibliography. (LC)

FINAL REPORT

Project No. 8-C-013
Grant No. OEG-3-8-080013-0023-010

Quantitative Measurement of the Effectiveness of a Science Course

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February, 1970

The research reported herein was performed pursuant to a grant with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

PREFACE

The author owes a large debt of gratitude to the administration and to the professional staff of The Fairfax County public schools. Without their cooperation and their dedication to improved instruction in their county's schools this study could not have been conducted. The results of this study should not be taken to mean that any school in the county was not doing a good job of teaching IPS. The models used to measure the effectiveness of the IPS course are empirical and, were they perfected, would provide only a small input to any evaluation of the effectiveness of a school's science course.

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SUMMARY

The difficulty of obtaining sound objective measures of the effectiveness of sequences of instructional materials is encountered by every evaluator who needs such measures as an aid in selecting materials for assignment to schools, to teachers, and to students. There has been enough research done on the effectiveness of sequences of instructional materials which are hierarchical in character to make it feasable to attempt a quantification of measures of effectiveness. This study represented one attempt to test or model for determining the effectiveness of sets of instructional materials which can be considered hierarchical and to derive a mathematical relationship by which such measures can be quantified.

The model tested requires that the instructional materials be hierarchical in character, not true hierarchies. The Introductory Physical Science course satisfied this requirement and was the one used in the study. The public schools in a suburban county provided the instructional setting and assured a severe test of The Model.

The model for determining effectiveness depended upon the untested assumption that the instructional materials used were indeed hierarchical in character. A model to test this assumption was also available, and that model too was to be tested in The Study. The model could be tested, however, only if at least some groups of IPS students completed the entire course.

The model for measuring effectiveness proved, within the constraints imposed by the study, to be a valid one when applied to the performance of boys in the IPS course. It worked especially well for boys of high ability. The model was not applicable in the case of girls' performance in the IPS course.

Because no class of students completed the entire IPS course, the model for testing the hierarchical character of the course could not be employed. Neither could there be a quantification of the measures of effectiveness of the IPS courses for such quantification depended on students making more progress than they actually made.

Further tests of the model should be done under carefully controlled situations. Although the model for determining effectiveness retained most of its promise, the requirement that it hold in a real school setting proved to severe. The model is so simple in concept that it would be extremely valuable to educational evaluators if its use could be clearly justified by experiment.

BACKGROUND OF THE STUDY

Introduction

The problem of determining the effectiveness of sets of instructional materials in promoting student learning is among the most important problems facing the educational evaluator. It is at the same time one of the most difficult problems and is perhaps the problem handled most carelessly by evaluators. Evaluation of sets of instructional materials have at their best consisted of deciding the relative merits of two alternative sets of instructional objectives. At their worst they have consisted of conjecture, innuendo, propaganda, and in some cases outright falsehood designed primarily to sell an instructional product in the educational marketplace. Methods which provide objective measures of the effectiveness of sets of instructional materials often end with the word counts and readability formulas, which are of limited value and which are appropriate for only a small number of materials. Beyond this, few objective methods for measuring effectiveness exist.

There are several reasons for the perplexing situation. The most important is that evaluation has been conceived in a very broad sense to include all the systematic efforts to assess the strengths and weaknesses of educational materials, (Grobman, 1968). The consequence of this concept being that evaluators have attacked their problems on too broad a front. While it is important to recognize that evaluation as a process in curriculum design is of broad scope, it is just as important to recognize that such a concept of evaluation is very seductive. It attracts to the field of evaluation many who are lured not by the satisfaction of performing useful evaluations and deriving productive methods but by the prestige to be had in becoming associated with a respected and burgeoning field of study.

As a consequence educational evaluators have not vigorously attacked the problems involved in adding to educational evaluation an element of empirical science. They have resisted the use of experimental methods in their search for factors influencing the effectiveness of instructional materials. They have not concerned themselves with such momentous problems as that of identifying the characteristics of instructional materials, characteristics of the learner, and teacher characteristics which go together to maximize learning. They have not, as Gagne (Gagne, 1967) has suggested, been concerned with determining what dimensions of curriculum may be systematically varied to determine their efforts on the learning accomplished by the student. And they have not, I might add, always systematically varied such dimensions as are already known.

Instead of attempting to devise and validate empirical methods of measuring such characteristics of instructional materials as their effectiveness, educational evaluators have too frequently taken the easier way, the descriptive approach to evaluation. Evaluations have as a result, often been highly opinionated descriptions which are more persuasive than convincing. Objective techniques for evaluation have become unnecessarily muddled because of too great a reliance on this approach. For whatever reasons; expediency, financial gain, personal gain, or whatever; the field of evaluation can no longer tolerate the consequences of taking the easy way out. If things are ever to become clearer, if the evaluator is ever to be able to identify and systematically vary the dimensions of curriculum which will yeild objective techniques for evaluation, then evaluators must face the task of devising empirical methods for accomplishing their work.

There is abundant evidence to support the contention that evaluation in education is in a state of confusion and that empirical techniques, while desperately needed, are not being desperately sought. Since the advent of the highly flattered curriculum study groups and their programs with new goals and new priorities, large sums of money and vast quantities of time and energy have been invested in the development of complete courses for the secondary schools and the elementary schools of the United States. The products of several curriculum study groups have been used extensively in other countries. Evaluation of the products of these study groups has been mostly a matter of informal feedback during the process of developing the curriculum materials. This process has usually consisted of the following steps:

1. Writing a preliminary set of materials.
2. Preliminary trial of this set of materials.
3. Revision of the set of materials using information from the preliminary trial.
4. Rewriting and second trial (repeated if necessary).
5. Production of a commercial set of materials.

Upon the completion of a saleable set of instructional materials, the products of the study group typically have been turned over to commercial publishing companies for distribution. While revisions do not cease to be made in many of the materials, evaluation, such as ever existed, in most instances ceases.

During the development of their products, the curriculum study groups did little to answer such relevant questions as:

1. To what extent do the instructional materials promote the learning claimed for them?

2. To what extent do the materials exhibit the structure (sequence) claimed for them?
3. Do the materials indeed teach new knowledge in a general way, as is often claimed?
4. Do the materials teach so that knowledge is more readily transferable?
5. Are the new materials more effective than the old?

These questions imply that underlying the development of the instructional materials produced by curriculum study groups were several untested assumptions basic and vital to successful evaluation of the materials. Furthermore, it may be inferred that these assumptions involve variables which have not been identified and properly treated in experimental development of the products of the curriculum groups. If so, it follows that evaluations of such materials have been at best less than adequate. Unfortunately, the evaluation carried out by the various curriculum study groups represent the best, not the worst evaluations of instructional materials. That there are untested assumptions underlying the new curriculum materials is in fact the case. Many of the assumptions, along with suggestions of numerous problems in need of experimental study, can be found in the publication which resulted from the Woods Hole Conference, called in September, 1959 by the Education Committee of the National Academy of Sciences, (Bruner, 1963) and attended by thirty-five scientists, scholars and educators. B.O. Smith (Ford and Pugno, 1964) has given a concise statement of some of the important assumptions underlying the development of many of the materials produced by curriculum study groups. These assumptions are (in part): (1) that "teaching will be more effective if it incorporates the ways elements of knowledge are related logically (structure), (2) what is learned will be retained longer if it is tied into a meaningful structure, (3) what is learned will be more readily transferred if it is tied into a system of knowledge, and (4) knowledge can be categorized in ways more conducive to learning..."

William W. Stokes (Stokes, 1964) studied the action taken on the recommendations of the Woods Hole Conference and concluded that the basic assumptions about the nature of knowledge and the nature of learning announced by the group that met there had not been carefully researched. He further concluded that the advantages claimed for teaching the structure of a discipline had not been researched and that research on the effectiveness of the curriculum projects based on disciplinary structure was so ambiguous that it was not possible to determine how effective the programs were. The situation has not changed much since Stokes' study, except that the impact of the curriculum studies on the public schools is now even more uncertain.

While numerous examples of poorly conducted evaluations, the most flagrant examples probably being evaluations of Title III (ESEA) Programs, could be mentioned, this is unnecessary at this point. The unknown impact of the instructional materials produced by the curriculum study groups is alone justification for concern about developing more objective techniques for evaluation than are now available. The materials produced by these groups are widely used in the public schools of the United States and they have had a great deal of influence on materials and programs which were already in use. It would be difficult, if not impossible, to measure the full impact of the materials produced by these groups. In many cases the materials themselves have been used exclusively; in other instances they have provided imputus for revisions and modifications in existing programs. There can be little doubt that the curriculum reform movement of the past decade has stimulated needed changes in school curricula. Given that the goals of the new curricula are new and that untested assumptions underlie them, however, it is safe to say that evaluation of the materials is perhaps the weakest flank of the new movement; yet it is probably at the same time the most vital. The problem of testing and developing empirical methods for assisting in the mammoth task of evaluating instructional programs is the problem to which this study addressed itself. In the belief that the problems of evaluation will best be solved by attempting to develop sound empirical methods to support a more comprehensive concept of evaluation, the study focused on a narrow problem in the field of evaluation. This is in no way intended to detract from the work of those who choose to treat evaluation in its broader context. In fact, it is hoped that the atomistic approach taken in this study will help to clarify some of the problems in the broader field of evaluation and thereby make some contribution to that broader field.

Review of Literature

If one looks closely at the assumptions listed by Smith, (Ford and Pugno, 1969) four dimensions of special concern for the evaluator of instructional sequences appear: effectiveness, structure, retention, and transfer. There was no attempt to deal in this study with all of them, but two of them were selected for study. They are closely related and, because I had previously dealt successfully with them in an earlier experiment, they lent themselves to further experimental study. The two dimensions are structure and effectiveness.

What follows is an attempt to review research which has dealt with these two dimensions and to describe two models, developed and tested in my previous study, for measuring the effectiveness and the structure of instructional materials. The models used are appropriate for materials which can be said to have structure, of which the best examples are in mathematics and science. While the models are not appropriate for all kinds of materials, they represent a great improvement over existing models for evaluating instructional sequences.

While research studies completed to date by no means answer all the important questions about the relationships among structure, effectiveness, and the learner, several studies have been reported which provided the groundwork for designing and conducting the study reported here. Since they are important to understanding the models used in this study to measure effectiveness and structure, a brief review of the important studies will be given at this point. The review is followed by a brief discription of the models employed in the study being reported.

J. Miller and S. Levine (1952) studied two different ways of using review sequences in films. They were concerned with the relative merits of (1) spacing the review sequences throughout the film after each major topic and (2) putting the entire review at the end of the film. The film used in the experiment was on Ohm's Law. In the first review condition, each of four sections of the film was shown and immediately reviewed; in the second review condition, the entire film was shown and then reviewed. The study revealed that the complete showing and review at the end was the superior of the two conditions. The experimentors also considered the problem of the effect of the frequent use of subtitles on the effectiveness of the film. The subtitles were used to identify and structure the several subtopics in the film on Ohm's Law. Two degrees of structuring were used, major subtitles only and complete subtitling, and a control, in which the material flowed without a break, was employed. Even though the different review conditions had significantly different effects, no significant differences were found among the three structuring treatments.

Wulff, and Stolurow (1967) did a study comparing two forms of organization for teaching aircraft rivet coding. The rivets were color coded for four properties: length, diameter, bead shape, and material. Two forms of organization were used. One form presented the material so that differentiating cues for each item could be learned by classes; the other form presented the same information, but presented all the information about a given item at one time so that it was unlikely that the learner could utilize cues learned by classes during learning in this form. As the experimentors had predicted, the method which utilized cues provided superior to the other method.

Gavurin and Donahue (1960) conducted a study using programmed materials in psychology given in an ordered sequence to one group of adults and in a random sequence to another group. They used a program with approximately ten-item blocks and required an errorless trial within a block before the subject could advance to the next block in the program. When an errorless trial was used as the criterion, the ordered sequence proved superior. A test on retention given one month later, however, revealed no significant differences between the group taking the ordered sequence and the group taking the random sequence.

Levine and Baker (1963) believing error rate not to be a satisfactory criterion to use in evaluating a program on retention and transfer, conducted a study to determine the importance of presenting items in a standard, logical sequence. They used a program of units in geometry with second graders and treated one unit of this program experimentally by randomizing the frames in that unit. The experimenters found no significant differences in (1) median number of errors, (2) mean working time, and (3) means on acquisition, retention and transfer measures. They indicated that individual differences might have obscured treatment effects, and, that on the basis of test scores, the program failed to teach the material effectively. They did not advocate giving up the idea that sequence is an important variable, but suggested examining the size of the divisions used in scrambling the sequence.

K. Roe, Case, and A. Roe (1962) examined the hypothesis that the mean performances for students who have studied a proper sequential ordering and students who have studied a random ordering of the same items will be significantly different. The items used in their experiment were on elementary probability, were related, and each item normally depended upon the preceeding one. Only the student's terminal performance was considered. The experimenters used a seventy-one-item program with two groups of eighteen psychology students each. One group was presented an ordered program and the other group a scrambled program. The experimenters found no significant differences in (1) time required for learning, (2) error score during learning, (3) criterion test score, and (4) time required for the criterion test. They suggested that sequence in an auto-instructional program may be a function of such variables as length of program, content of items, individual differences, and spacing of criterion measured.

Payne, Krathwohl, and Gordon (1967) investigated sequence in programmed instruction when the logical inter-relatedness of the material was varied. They hypothesized that the effect of scrambling would be greatest for the topics having the most internal logical development. The experiment involved 238 college sophomores in an elementary psychology course and eight combinations of linear and scrambled topics differing in logical interrelatedness of the material. The experimenters found (1) no significant differences between the means of the eight groups on an immediate and a delayed test, (2) no significant effect due to degree of dependence of content of learning sequence, and (3) no significant relation between performance and ability.

Gagne and Paradise (1961) have reported a study which gives much insight into the problem of testing a defined program for its sequence and for its effectiveness. These experimenters theorized that differences in the rate of acquisition of successive frames in a program depend upon the amount and kinds of knowledge that the learner brings to the learning task and not in as great a way on general intelligence. They conceived a hierarchy of learning sets at the bottom of which are very general sets and at the top of which is a final learning set. The general sets at the bottom of the hierarchy are called relevant basic abilities and are considered essential to the successful completion of the final learning set. Positive transfer is effected from set to set throughout the hierarchy, with attainment of the final set considered to be a matter of the successive attainment and assimilation of the sequence of lower sets, beginning with the lowest learning set already available to the individual.

According to hypotheses based upon this theoretical position, individual differences can be independently measured as differences in (1) general intelligence, (2) relevant basic abilities, and (3) number and pattern of relevant learning sets. Furthermore, an ideally effective program, a program in which all learning sets are achieved by every subject, should reduce the variance attributable to number and pattern of relevant learning sets to zero. If the program is not ideally effective, an increasing number of subjects will "drop out" as higher levels of the hierarchy are reached. Those who "drop out" will tend to be subjects of low basic ability. The "dropping out" of subjects as higher levels are reached will be indicated by increasing correlations of relevant basic abilities with achievement at progressively higher levels in the hierarchy. These correlations and the rate at which they change can be used to measure the effectiveness of the program.

On the basis of their experiment, the authors reported that correlations between basic ability and achievement confirmed predicitons based on the theory and that correlations between learning rate and relevant and irrelevant abilities also were in agreement with predictions based on theory. Transfer among learning sets was reported to be high, and a prediction that rate of learning depends decreasingly upon relevant basic abilities as learning progresses upwards in the hierarchy was confirmed. The authors indicated, however, that the learning program used in this study was only moderately successful.

Believing that the inconclusiveness of findings when studying the effects of sequence changes in instructional materials, whether they be programmed materials or not, was due to the failure to specify clearly what an ordered sequence of materials was to be and to test that sequence, I developed and tested models for measuring the structure (sequence) and the effectiveness of programmed instructional materials having a specified sequence, called structure. The models were based on a theoretical rationale, and since they are being used in the study being reported here, I elect to briefly describe them before reviewing the research study which reports their test.

Theoretical Basis for Models On Structure and Effectiveness

The results of reported research and the ideas upon which this research has been based provided the basis for a theoretical framework which served as a foundation for designing and conducting the study reported here. A brief discussion of this theoretical framework is given at this point, since the data analysis takes on its significance within that framework.

In a program which is one-hundred-percent effective, all the students can be expected to achieve all the intended elements in the program. In a program that is less than one-hundred-percent effective, the students who will achieve least are those who score lowest on tests used to measure certain relevant basic abilities necessary for successful achievement of the total program. Therefore, correlations between the scores on tests which measure basic abilities and achievement at successive points in a hierarchical program provide a measure of the effectiveness of the program. A set of high but rapidly increasing correlations of initial relevant basic ability with achievement at successive points, indicating that students of low basic ability are not achieving at the higher points, will be an indication of an ineffective program. A set of high but rapidly decreasing correlations, indicating that most students are "over-achieving" at the higher points, will be an indication of an effective but an inefficient program. A set of high correlations of close to zero slope, when plotted against distance in the hierarchical program, will indicate an effective program. A slight positive slope would also be indicative of a structured (hierarchical) unit.

If a program is hierarchical, achievement at successive points is dependent upon the achievement up to and including each previous point. As a consequence, the scores on achievement tests to a point should be good predictors of achievement at the next point in the hierarchy. If a program were one-hundred-percent effective, that is, if everyone achieved everything intended in the program, it would be difficult to determine whether the program actually constituted a hierarchy without readministering it omitting certain parts. No program, however, is ideally effective, and thus regression analysis can be used as a tool to examine the hierarchy of a program. The assumption underlying this as a technique for deciding the question of hierarchy is that, in a hierarchy, each point provides positive transfer to the next point in the hierarchy. The extent to which this positive transfer is acting within the program can be used to check to extent to which the program can be considered hierarchical. In a set of partial regression coefficients using achievement at several points in a hierarchy to predict final achievement of the hierarchy, each predictor should carry a significant weight with the weights showing a tendency to decrease because of the increasing uncertainty of predicting the subsequent score of one who achieves at a given point. One who fails would almost certainly continue to fail in a true hierarchy. If this is indeed the case, correlations of final achievement scores with achievement scores upward through the hierarchy should exhibit the same decreasing pattern. If basic ability alone accounted for this decrease in correlation coefficients, correlations with basic ability held constant would not be expected to exhibit this decreasing pattern; in fact the pattern could conceivably be reversed.

Basic ability would be expected to be most important in predicting achievement at the beginning of the hierarchy. Because achievement at later points in the hierarchy comes to depend more on achievement at preceding points and less on basic ability, the importance of basic ability as a predictor of final achievement should decrease as one goes upwards in the hierarchy (Gagne and Paradise, 1961). The intercorrelations of the successive tests in the hierarchy might be expected to increase because of the factor giving rise to the decreasing correlations of final achievement with achievement upwards through the hierarchy.

Experimental Test of the Models

The study which provided a test for the models (Pyatte, 1969) used a programmed unit or measurement written to conform to a definition of structure. The criteria for a structured unit were derived from the criteria for structured courses in science, recently produced by the various curriculum groups, as follows:

1. The course is developed around certain ideas or concepts which provide a logical and integrated picture of science and the science course.
2. The course has a central theme which helps to hold the development of the concepts together.

3. The various parts of the course (text, lab, etc.) are closely related.
4. The course emphasizes knowledge and understanding.
5. The course provides for the active involvement of the student in science-like problem situations.
6. The course is developed so as to lead the student through an increasingly complex and elaborate understanding of the concepts included, toward an ultimate understanding of the desired structure of the course. (This type of development can be considered hierarchical in that more elaborate understandings depend upon less elaborate understandings.)
7. The course provides periodic reviews of the concepts provided.

The unit used in the test study was written as a hierarchy consisting of four steps. Achievement tests were administered at each of the four steps, and a transfer test was administered along with the fourth achievement test. These two measures were used as criterion measures for another part of the study, which does not require explanation here.

One version of the measurement unit was used as it was written. A second version consisted of the four steps -- scrambled so that the order was one, four, three, two. Both versions of the unit were bound as a part of the larger course and were completed by 172 students in fourth, fifth and sixth grades. The Arithmetic Skills test of the Iowa Tests of Basic Skills were used as a measure of basic arithmetical ability in the measurement of effectiveness of the two versions of the measurement unit.

When the data were analyzed, the sets of correlation coefficients revealed that the structured version of the measurement unit was effective and indicated that it was in fact structured as intended. The sets of correlation coefficients for the unstructured unit did not exhibit the expected pattern, so it was assumed that at least some of the structure had been lost in scrambling.

The success of the two models developed and studies experimentally prompted the study which is being reported here. The intent of this study was to further test the model for measuring effectiveness and, providing it was successful, to attempt to arrive at a mathematical expression for determining the effectiveness of sets of instructional materials which could be considered structured. At the same time it was hoped that the data gathered would shed some light on the problem of measuring the extent of structure in such materials.

Since the measurement unit on which the models were originally tested was written to conform to a set of crieteria for a structured science course, it seemed logical to search for a science course which satisfied that set of criteria as nearly as possible for use in the study reported here. Furthermore, it was decided that an actual public school situation rather than a controlled experimental situation would provide a more rigorous test of the models.[1]

The course selected for study was the Introductory Physical Science Course. A detailed description of this course appears in Appendix A of this report, so no further description will be needed at this point.

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[1]The original tests were performed in the public schools but in a situation more carefully controlled than was the case in this study.

THE STUDY

Problem

Is this set of instructional materials effective? How effective is this set of instructional materials? Is this set of instructional materials more effective than that set? For which students is this set of instructional materials effective and for which is it not effective?

Such questions about the effectiveness of sets of instructional materials are of very great importance to the evaluator as well as to the user of instructional materials designed for use in the classrooms of our schools, but they have not been given the attention by educational researchers which questions of such importance demand. The major purpose of this study was to examine a prototype model for measuring the effectiveness of a set of instructional materials which could be said to be structured and which was being used in a real school situation. It was hoped that a mathematical expression could be derived which could be used as a means of quantatively measuring the effectiveness of such sets of instructional materials. If successfully developed and tested, such a model would obviously be of great practical value to the evaluator of such instructional sequences.

Is a structured set of instructional materials more effective than an unstructured set? Is this sequence of materials more effective than that one? These are questions which are closely related to the problems of measuring the effectiveness of sets of instructional materials and which will deserve much of the attention of future researchers in methods of evaluating instructional materials. A secondary objective of this study was the testing of a prototype model for measuring the extent to which a given set of instructional materials is structured.

These are essential steps if comparisons are ever to be legitimately made among various instructional sequences and if the relationships among the variables relevant to learning styles, teaching styles, and modes of instruction are ever to become clear.

The theoretical basis for the prototype models has already been explained, and no further attention will be devoted to it here. It might be said at this point, however, that the study was intended to test models already in a primitive state of development. The test was intended to require that the models stand up under a real school situation. As will be pointed out, when the results are discussed, this was perhaps an unrealistic demand. Nevertheless, lessons of considerable importance were learned from the study, and, although the data were not as revealing as it had been hoped, the study was not without some success. The problems being considered in this study are of such great importance, and so little is known about them at this time, that the results of this study deserve the careful attention of anyone who is involved in the evaluation of instructional programs designed for use in the schools.

Method

Subjects

Seven schools in Fairfax County, Virginia, were selected to participate in the data collection for this study. One eighth grade teacher was selected from each of the seven schools. These teachers were chosen for their exceptional talent and experience with the IPS course so that the course would have a fair chance to do what it was designed to do. The teachers taught five classes each, giving a total of thirty-five classes involved in the study. The total number of students involved during the entire project in all the classes was '31. One hundred and forty students were excluded from this total because they had incomplete data records which could not be completed.[2] The records were incomplete because the students either transfered out of the system before completing the course, failed to complete the course, or missed large numbers of tests. Most of the 140 were transfer students.

Materials

The materials used in this study were: (1) The Introductory Physical Science Course with its accompanying materials and (2) The Differential Aptitude Tests, Form L. Some data were recorded using the cumulative records of the students. The data recorded from cumulative folders was intended to be used mainly to categorize students. The information considered important enough to be recorded was (1) age, (2) sex, (3) IQ, and (4) reading ability (as measured by the IOWA Silent Reading Test, total score). In addition to information useful in categorizing students, IQ and reading scores were expected to be helpful in verifying expected relevant basic abilities. The DAT is widely used as an instrument for measuring aptitudes in one of several categories. It was used in this study to measure basic abilities relevant to the hierarchical science course as well as to provide some verification that abilities expected to be relevant basic behaved differently than those expected to be irrelevant or general abilities. The IPS course is described in detail in Appendix A, but a brief description will be given here.

The Introductory Physical Science (IPS) course consists of a textbook, a Teacher's Guide, Laboratory Equipment, Achievement Tests, and films. The textbook is written to sequentially develop, repeatedly using as much material as possible, a concept of the atomic model of matter, and it has laboratory experiments placed throughout to enhance

[2] See Incomplete Data, page 23

the total development of the concept. The Teacher's Guide is written to assist the teacher in conducting a course as it was intended and is very detailed in its descriptions and directions. The Laboratory equipment is especially designed for IPS and is packaged in kit-form for easy distribution and use in schools. There are three series of IPS Achievement Tests: Series A, Series B, and Series C. Series A was used in this study. The films are designed to supplement the course materials, but they were not systematically used in this study because they are in an early stage development.

The IPS course is designed to:

(1) provide a foundation in subject matter and develop the appropriate attitudes of inquiry, coupled with the necessary experimental and mathematical skills, needed for non advanced study in science.
(2) to serve as a terminal course for the student who will take few or no more science courses.

The IPS course satisfied the criteria for a structured science course and can be considered hierarchical, as was required of the course to be used in this study.

Procedure

The seven classes, selected for this study, were chosen during the summer preceding the school year during which the IPS course was taught. The teachers were selected because they had taught IPS in the two preceding years, and they can be considered about equal in experience with IPS. A meeting was held during the summer to acquaint the teachers, and the principals of the schools in which they taught, with the purposes of the study and the mechanics of collecting the data. The items discussed at this meeting were:

1.) Purpose of the study.
2.) Administering of the tests.
3.) Recording of the data.
4.) Grading.
5.) Visitation by project director.
6.) Dissemination of results.

In examining the purpose of the study, care was taken to convince the teachers that no evaluation of their work was intended. The techniques being applied, they were told, were designed to measure the effectiveness of the course materials. They were told, however, that teacher differences could not be overlooked in the treatment of data.

The school counseling departments took charge of administering the DAT tests, both the pretest and the posttest. While the pretests were not administered on the same day in each school, they were administered during the first week of school so that the measures of relevant basic abilities could be considered to be those with which the students began the course. The posttest of the DAT was administered during the last week of school. The project director provided whatever assistance was needed for recording scores, provision of answer sheets for post testing, and posttest scoring service.

The teachers administered all the IPS tests, as well as all teacher-made tests, and recorded all data. The project director provided supervision, checks on the accuracy of data, and resource information about the course, the tests, and problems encountered in the conduct of the course.

The teachers were told how to record the data on the data form[3], and were told of the importance of each item to the total project. They were instructed to record data for transfer students separately and to record all the information available for each student. They were encouraged to get complete data on each student whenever possible, but that only data which was available should be reported.

The age, sex, intelligence quotient, and reading score were to come from the cumulative records of the students. IQ was the score on the California Test of Mental Maturity, administered the previous year, and the reading score was the total score on the Iowa Silent Reading Test, also administered during the previous year. The DAT pretest scores were raw scores on the sub-tests of the Differential Aptitude Test, Form L, administered during the first week of the study. The IPS test scores were the raw scores on the IPS Achievement Test, Series A, administered during the execution of the course, and the grades were letter grades (A,B,C,D, or F) assigned by the teachers at nine-week intervals. The final grade was the letter grade assigned by the teacher. The DAT posttest scores were the raw scores on the post administration of the DAT tests.

The teachers were told to assign grades in their usual manner, but were warned not to use the IPS Achievement Test scores in the same way that they used the scores from their own tests. The elements of

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[3]A copy of the data form can be found in Appendix F. The items were: age, sex, IQ, reading level, pretest DAT subtest scores, IPS Achievement test scores, teacher's grades, and posttest DAT subtest scores.

standardized testing were briefly explained to them. All teachers assigned grades on an A,B,C,D,F scale.

The teachers were told that frequent visits would be made by the project staff. The purpose of these visits were (1) to become acquainted with the school situation and the teachers, (2) to get a description of the classes which would help in classifying the data for analysis, (3) to observe problems that arose in connection with the IPS course, (4) to assist the teachers whenever they wished it, and (5) to answer questions about the project. Each class was visited at least three times during the study, and recorded observations were made in a survey form prepared for this purpose.[4]

The teachers and the administrators of Fairfax County accepted the study with interest and enthusiasm. They were eager to have some help in answering questions that they had asked themselves about the effectiveness of IPS.

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[4]A copy of the survey form as well as a description of the classes can be found in Appendix E of this report.

RESULTS

Incomplete Data

There were 931 students involved in the IPS course and included in this study. On each student, thirty-three items of information were recorded. One hundred forty records had to be deleted from the study because they contained too few items of information to be of value in the data analysis, the decision to exclude a record being made if there were missing more than four of the thirty-three items of information. One hundred forty-eight of the remaining 791 records were also incomplete, but these records each had no more than four items missing with almost all of them having only one missing. Also, some items were missing with high frequencies.

A count of the number of items missing and the number of points missing for each item was made. Then, for each item having a sufficiently large number of missing points, a regression equation was computed.[5] The regression equations were then used to fill in the missing points.

Whenever a record was missing only one item, the point was filled with the score predicted on the basis of other information available from the record. For a record that had two missing items, the mean for one item was substituted to compute the second item. Then the computed item was substituted to recompute a value for the item for which the mean had been used. This procedure was used for items up to four in number. If a record had more than four missing items, it will be recalled, it was not used in the analysis.

When there was a missing item for which no regression equation had been computed, the mean for that item was substituted. Out of the 148 incomplete records used, each having thirty-three items, the mean for a given item was substituted as a point only seven times. For all other substitutions, the prediction based on the regression equation was used.

While the regression equation varied in the worth of the predictions they produced, comparisons of records having similar scores on each item revealed that the predicted scores were always more in line with the "expected" scores than would the means have been. Since no regression involved more than three means and most involved

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[5]See Appendix G for regression equations.

none, the 148 incomplete records used in the data analysis were, after completion, a valuable addition to the total data used in the analysis.

Identification of Relevant Basic Abilities

Relevant basic abilities are those abilities with which the student must be equipped when he begins an instructional sequence — if he is to successfully cope with the sequence. According to the theory, correlations of measures of relevant basic abilities with measures of achievement at successive points in a hierarchical sequence will be high. They will increase sharply for an ineffective course, they will remain about the same for an effective course, and if they decrease the course is likely to be effective but inefficient. Correlations of measures of general abilities and abilities not relevant to the course, with achievement will be lower and they will be expected to remain somewhat stable (Gagne, 1961) with the exception that irrelevant abilities may behave erratically.

Inasmuch as the IPS course demands systematic observation and reasoning, careful correlation and proof of ideas, and extensive computation, Verbal Reasoning, Abstract Reasoning and Numerical Ability would be expected to be relevant basic abilities for the IPS course. If this is so, analysis of the actual correlations found in the study should confirm the fact.

Clerical speed and accuracy having little or nothing to do with success in the IPS course, should behave as an irrelevant ability would be expected to behave. And, IQ being a measure of general ability, should behave so. If this is so, analysis of the actual correlations should confirm the fact and in so doing support the confirmation of the relevant basic abilities.

Since other measured abilities cannot be categorized on the basis of what is known about the behavior of relevant basic, general, and irrelevant abilities, and what is known about the IPS course, the analysis of their correlations with achievement might be expected to indicate the appropriate category.

Following is a list of the abilities measured in this study and their predicted behabior.

1. Verbal Reasoning: relevant basic ability.
2. Abstract Reasoning: relevant basic ability.
3. Numerical Ability: relevant basic ability.
4. IQ: general ability.
5. Clerical Speed and Accuracy: irrelevant ability.
6. Reading: uncertain.
7. Space Relations: uncertain
8. Language Usage (spelling): uncertain.

9. Language Usage (sentences): uncertain.
10. Mechanical Reasoning: uncertain.

The data were divided into twenty-eight groups for this analysis. Classifications, based on the success of the regression models in predicting missing points, was by sex, ability (measured by IQ), and school. There were two categories each for sex and ability, the dividing point for ability being the mean IQ, and seven categories of school. Correlation coefficients were computed for each of the ten measures of ability with scores on Achievement Test I, Achievement Test II, and Achievement Test III (when available). The patterns of correlations were examined to determine whether the abilities expected to be relevant basic behaved as relevant basic abilities were expected to behave and to see if additional measured abilities might be called relevant basic. The patterns were also examined to see how expected general and irrelevant abilities behaved.

In twenty-six of the twenty-eight cases, the correlations of clerical speed and accuracy with Achievement Tests I, II, and III were low in magnitude. One of the two exceptions was a group of low IQ girls in school number seven which had only five students. This can be discounted because of the small number. The other was a group of high IQ girls in school number 1 which had nineteen students, but the high correlation for this group was only .55. All other correlations were considerably lower, most being nearly zero in magnitude. This was in accordance with predictions based on theory.

Only two other measured abilities exhibited similar patterns in every group. These were Language Usage (spelling) and Language Usage (sentences). Only occasionally did these correlations excede .50, and they were usually considerably lower. Of the correlation coefficients resulting from correlations of Language Usage with achievement, the highest were found in two groups of high ability boys and high ability girls from the same school when the correlations involved Language Usage (sentences).

On the basis of these results it was concluded that Clerical Speed and Accuracy as expected, was an irrelevant ability for the IPS course and that Language Usage (spelling) was also an irrelevant ability. Language Usage (sentences) was probably an irrelevant ability, but the evidence was not conclusive.

The correlation coefficients for these three abilities, using only high ability students appear in Table 1.

TABLE 1

CORRELATION COEFFICIENTS FOR SCORES ON ABILITIES NOT RELEVANT TO THE IPS COURSE WITH SCORES ON ACHIEVEMENT FOR HIGH ABILITY STUDENTS

		Ach. Tst. I	Ach. Tst. II	Ach. Tst III
High IQM1[a] (IQ=125;n=32)	CSA[b]	.42	.43	-
	LUsp[c]	.57	.65	-
	LUse[d]	.65	.68	-
High IQF1 (IQ=127;n=19)	CSA	.31	.55	-
	LUsp	.64	.60	-
	LUse	.80	.75	-
High IQM2 (IQ=126;n=38)	CSA	.20	.12	-
	LUsp	.20	.30	-
	LUse	.05	- .05	-
High IQF2 (IQ=124;n=37)	CSA	.43	.18	-
	LUsp	.52	.28	-
	LUse	.75	.51	-
High IPM3 (IQ=124;n=23)	CSA	- .35	- .04	-
	LUsp	.24	.25	-
	LUse	.43	.50	-
High IQF3 (IQ=124;n=40)	CSA	.23	.25	-
	LUsp	.43	.29	-
	LUse	.66	.55	-
High IQM4 (IQ=124;n=32)	CSA	.20	- .04	-
	LUsp	.30	.19	-
	LUse	.37	.20	-

TABLE I CONTINUED

		Ach. Tst. I	Ach. Tst. II	Ach. Tst III
High IQF4 (IQ=126;n=37)	CSA	.15	.18	-
	LUsp	.40	.08	-
	LUse	.40	.22	-
High IQM5 (IQ=125;n=20)	CSA	- .08	- .14	-
	LUsp	.22	.15	-
	LUse	.20	.25	-
High IQF5 (IQ=129;n=18)	CSA	- .12	- .08	-
	LUsp	.50	.32	-
	LUse	.42	.37	-
High IQM6 (IQ=124;n=26)	CSA	.08	.04	-
	LUsp	.41	.24	-
	LUse	.33	.26	-
High IQF6 (IQ=124;n=20)	CSA	.25	- .08	-
	LSUsp	.16	- .08	-
	LUse	.28	.23	-
High IQM7 (IQ=132;n=25)	CSA	.13	- .09	.08
	LUsp	.37	.18	.41
	LUse	.35	.59	.69
High IQF7 (IQ=125;n=42)	CSA	- .12	- .07	.00
	LUsp	- .04	.15	.08
	LUse	.53	.38	.19

TABLE I CONTINUED

[a]High IQ Males from school number 1.
[b]Clerical Speed and Accuracy
[c]Language Usage (spelling)
[d]Language Usage (sentences)

The correlation coefficients for the irrelevant abilities using only data from the low ability students appear in Table 2.

TABLE 2
CORRELATION COEFFICIENTS FOR SCORES ON ABILITIES NOT RELEVANT TO THE IPS COURSE AND SCORES ON ACHIEVEMENT FOR LOW ABILITY STUDENTS

		Ach. Tst. I	Ach. Tst. II	Ach. Tst III
Low IQ M1[a] ($\bar{IQ}$=99;n=26)	CSA[b]	.37	- .18	-
	LUsp[c]	.23	.05	-
	Luse[d]	.30	.18	-
Low IQF1 ($\bar{IQ}$=100;n=32)	CSA	.10	.24	-
	LUsp	.32	.24	-
	LUse	.37	.49	-
Low IQM2 ($\bar{IQ}$=100;n=27)	CSA	.31	.40	-
	LUsp	.06	.05	-
	LUse	.37	.16	-
Low IQF2 ($\bar{IQ}$=100;n=33)	CSA	.11	- .18	-
	LUsp	.30	.12	-
	LUse	.22	.34	-
Low IQM3 ($\bar{IQ}$=100;n=33)	CSA	.14	.10	-
	Lusp	- .10	.02	-
	LUse	.43	.37	-
Low IQF3 ($\bar{IQ}$=97;n=38)	CSA	.40	.22	-
	LUsp	.27	.22	-
	LUse	.24	.50	-

TABLE 2 CONTINUED

		Ach. Tst. I	Ach. Tst. II	Ach. Tst III
Low IQM4 (IQ=96;n=31)	CSA LUsp LUse	.34 - .12 .13	.04 .03 .25	- - -
Low IQF4 (IQ=94;n=29)	CSA LUsp LUse	.27 .16 .24	.06 - .14 .00	- - -
Low IQM5 (IQ=91;n=33)	CSA LUsp LUse	.30 .41 .50	.13 .28 .54	- - -
Low IQF5 (IQ=89;n=29)	CSA LUsp LUse	.11 .35 .45	.17 .19 .28	- - -
Low IQM6 (IQ=100;n=29)	CSA LUsp LUse	.01 - .18 .29	.24 - .08 .44	- - -
Low IQF6 (IQ=101;n=34)	CSA LUsp LUse	.16 .03 .24	- .07 .13 .12	- - -
Low IQM7[e] (IQ=108;n=3)	- - -	- - -	- - -	- - -
Low IQF7[e] (IQ=110;n=5)	- - -	- - -	- - -	- - -

TABLE 2 CONTINUED

[a]High IQ Males from school number 1.

[b]Clerical Speed and Accuracy

[c]Language Usage (spelling)

[d]Language Usage (sentences)

[e]The numbers in these groups are so small that the correlation coefficients are not meaningful.

No measured ability behaved clearly in every instance as a general ability would be expected to behave. Patterns of correlation coefficients of measures of IQ with measures of achievement exhibited wide variations when classified by sex, by school, or by ability level. The widest variation was found among girls of high ability where correlation coefficients ranged from near zero to about .80. Figure 1 illustrates this wide variation. The patterns were scattered, although not over as wide a range for low ability girls. The patterns of correlations of measures of IQ with achievement for boys were clustered most and behaved more nearly as they would be expected to behave if IQ were a general ability. In the case of boys of low ability, the patterns were very nearly what would be expected of a general ability. Patterns for high ability boys and patterns for low ability boys appear in Figures 2 and 3, respectively. The correlations were higher among the high ability boys than they were among the low ability boys. This difference in the magnitudes of the correlation coefficients was not evidenced among the girls.

IQ, then, was found to behave as a general ability would be expected to behave when patterns of correlation coefficients for low ability boys were examined. While the behavior of IQ when all boys were considered was not entirely clear, the patterns examined were not such that the assumption that IQ was a general ability in the case of boys could be easily refuted. This was not so with girls. Either there was a source of considerable variance which was uncontrolled in the data analysis, or IQ was not a general ability for the IPS course when only girls were considered.

When the patterns of correlations of measures on reading ability with measures of achievement were examined it was found that reading behaved more as a general ability would be expected to behave than did IQ. The patterns for reading ability using low ability girls appear in Figure 4. This is the pattern that was most nearly what was expected of a general ability on the basis of the theory. It is included here for this and for an additional reason, the behavior of coefficients of correlation for school number 4 to which attention will again be called in the discussion on measures of effectiveness.

Although the patterns of coefficients of correlation of measures on reading ability with measures on achievement were somewhat variable, though less variable than those for IQ, the data analysis indicated that reading ability was a general ability. The differences by sex found in the behavior of patterns of correlations when IQ was examined were not in evidence in the patterns exhibited when reading ability was examined.

Of the other abilities measured, only Space Relations ability exhibited patterns of correlation which were indicative of a general ability. Although there were small differences by ability level, patterns of correlation coefficients of measures on Space Relations ability with measures on achievement behaved more consistently as a general ability would be expected to behave than any other measured ability. Patterns found for high ability boys and for low ability boys appear in Figures 5 and 6, respectively.

The behavior of correlations of Space Relations ability with achievement indicated that it was a general ability for the IPS course. Since there were no large differences in the patterns for boys and those for girls, this ability was a general ability for both.

Of the measured abilities expected to behave as relevant basic abilities none did so consistently. Abstract Reasoning ability exhibited no discernable pattern and could not, on the basis of the data analysis, be called a relevant ability. Numerical Ability and Verbal Reasoning Ability, however, exhibited the expected behavior but only when the data were grouped by sex, and then the expected behavior was found only among boys.

The best example of the behavior of an ability expected to be relevant basic was found among boys of high ability when patterns of correlations of measures on Verbal Reasoning ability with measures on achievement were examined. These patterns appear in Figure 7. From Figure 7 it is easily determined that the correlations are high, that they cluster about the same point for Achievement Test I, and that they branch from that point for Achievement Test II.

It is this kind of branching that can be useful in measuring the effectiveness of instructional sequences and in making comparisons of the effectiveness of a sequence in different instructional settings.

While in no other instances were the patterns of correlations as clearly what was expected of relevant basic abilities as they were in this group of high ability boys where Verbal Reasoning Ability was correlated with achievement, Verbal Reasoning ability and Numerical Ability exhibited patterns which indicated strongly that they were relevant basic abilities for the IPS course when only boys were considered. These abilities were not found to be relevant basic for girls.

The data analysis revealed no patterns of correlations of Mechanical Reasoning ability with achievement from whihh it could be decided whether Mechanical Reasoning ability was irrelevant, general, or relevant basic.

In summary, the data analysis revealed that Clerical Speed and Accuracy, which was expected to be an irrelevant ability for the IPS course, exhibited the expected patterns of correlation with achievement. Language Usage (spelling) also exhibited the patterns expected for an irrelevant ability, and Language Usage (sentences) exhibited similar patterns. It was concluded, then, that Clerical Speed and Accuracy was in fact an irrelevant ability and that Language Usage (spelling) was also. The analysis did not clearly indicate whether Language Usage (sentences) was an ability not relevant to the IPS course.

IQ, expected to behave as a general ability, was found to behave as expected only for boys and even then not too nearly. The expected patterns were most nearly represented in boys of low ability. Patterns for girls were extremely erratic.

Patterns of correlations of reading ability with achievement were more in accordance with the behavior predicted for general abilities than were those of IQ. The patterns most nearly like those expected were found among low ability girls. Patterns of correlations of Space Relations ability with achievement were like those expected of a general ability. It was concluded, then, that reading ability and Space Relations ability were general abilities for the IPS course and that IQ was a general ability for the course only for boys.

Of the three measured abilities expected to behave as relevant basic abilities, only Numerical Ability and Verbal Reasoning ability did so with any regularity. The data clearly revealed that Abstract Reasoning ability was not an ability relevant to the IPS course. Patterns of correlation of Verbal Reasoning ability with achievement were most nearly in agreement with predictions in the case of high ability boys. Patterns of correlations of Verbal Reasoning ability and Numerical Ability with achievement were generally what was expected of relevant basic abilities but only for the boys. Patterns among girls were quite variable. It was concluded, then, that Verbal Reasoning ability and Numerical Ability were relevant basic abilities for the IPS course only when boys were considered.

Mechanical Reasoning ability, the remaining measured ability, exhibited no clearly discernable patterns of correlations with achievement. Its status remained uncertain.

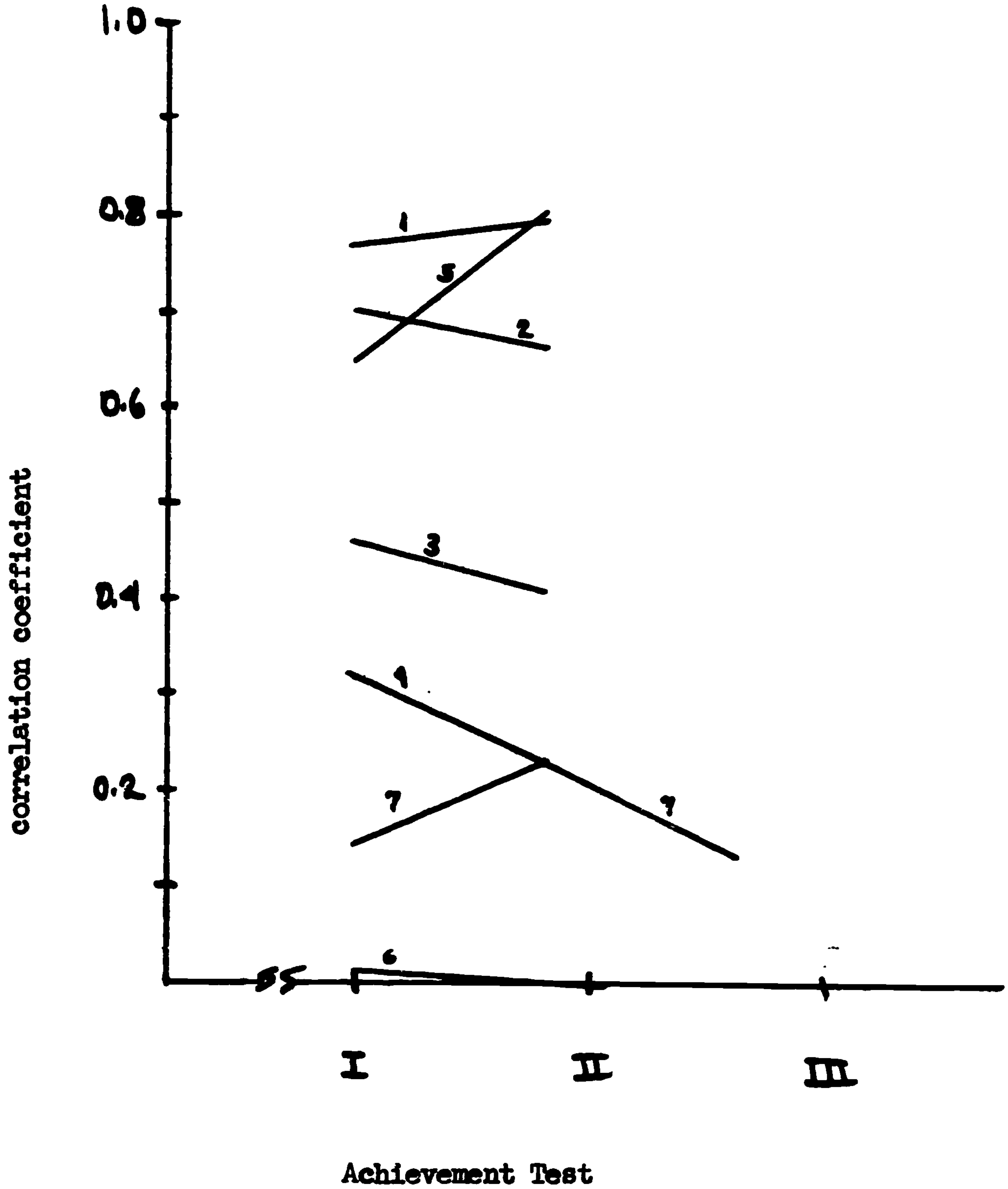
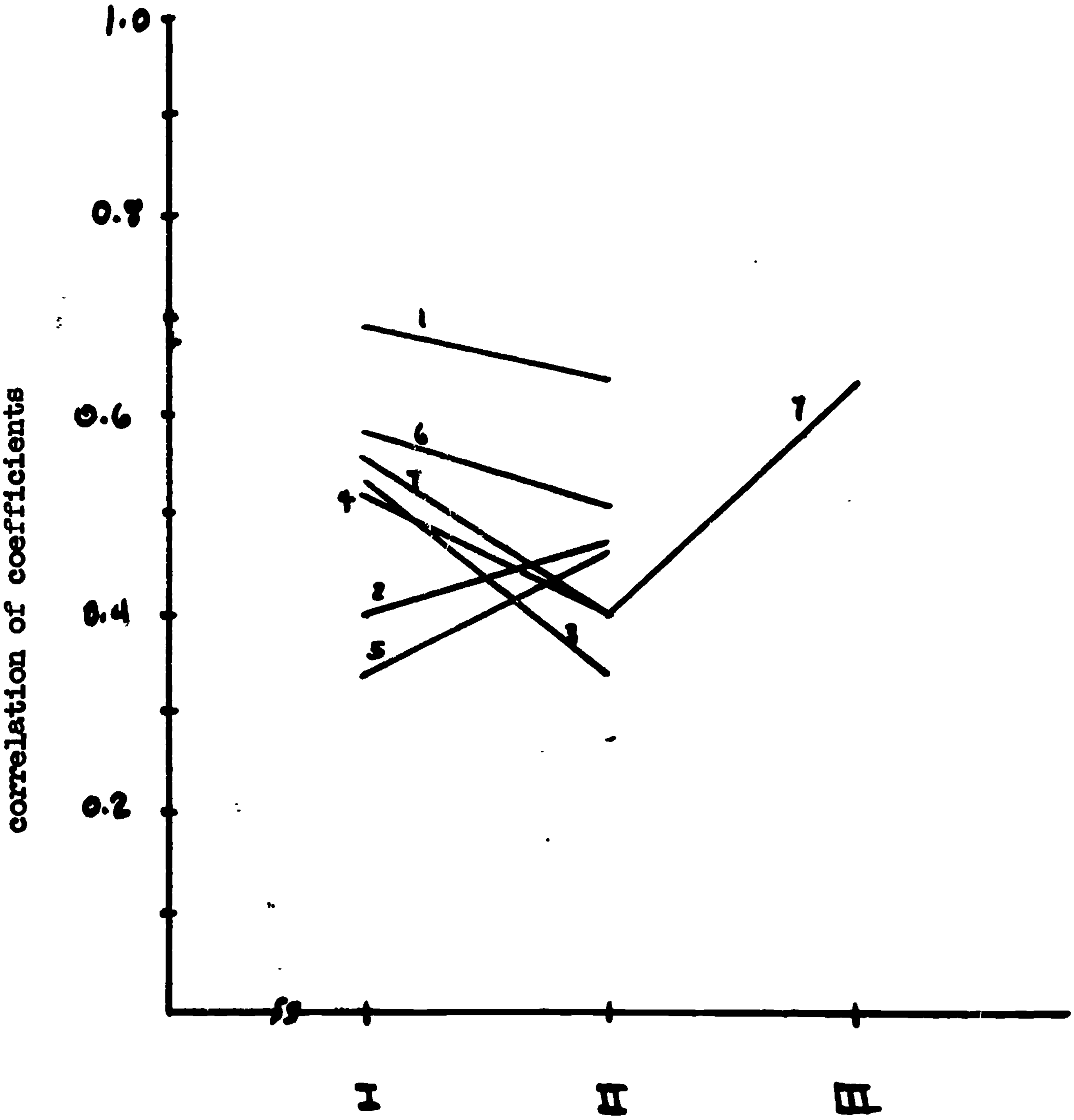


Fig. 1. - Patterns of coefficients of correlation of IQ with achievement for high ability girls. Data in Table 3.

TABLE 3

COEFFICIENTS OF CORRELATION OF IQ
WITH ACHIEVEMENT FOR HIGH AND
LOW ABILITY GIRLS

School	Ability Level (n)	Ach.Test I	Ach.Test II	Ach.Test III
1	High (19) Low	.77 .48	.79 .48	- -
2	High Low	.70 - .10	.67 .39	- -
3	High Low	.46 .24	.41 .44	- -
4	High Low	.32 .64	.23 .00	- -
5	High Low	.65 .39	.80 .29	- -
6	High Low	.09 .23	- .01 .36	- -
7	High Low	.15 .15	.23 .50	.14 .51



Achievement Tests

Fig. 2. - Patterns of coefficients of correlation of IQ with achievement for high ability boys. Data in Table 4.

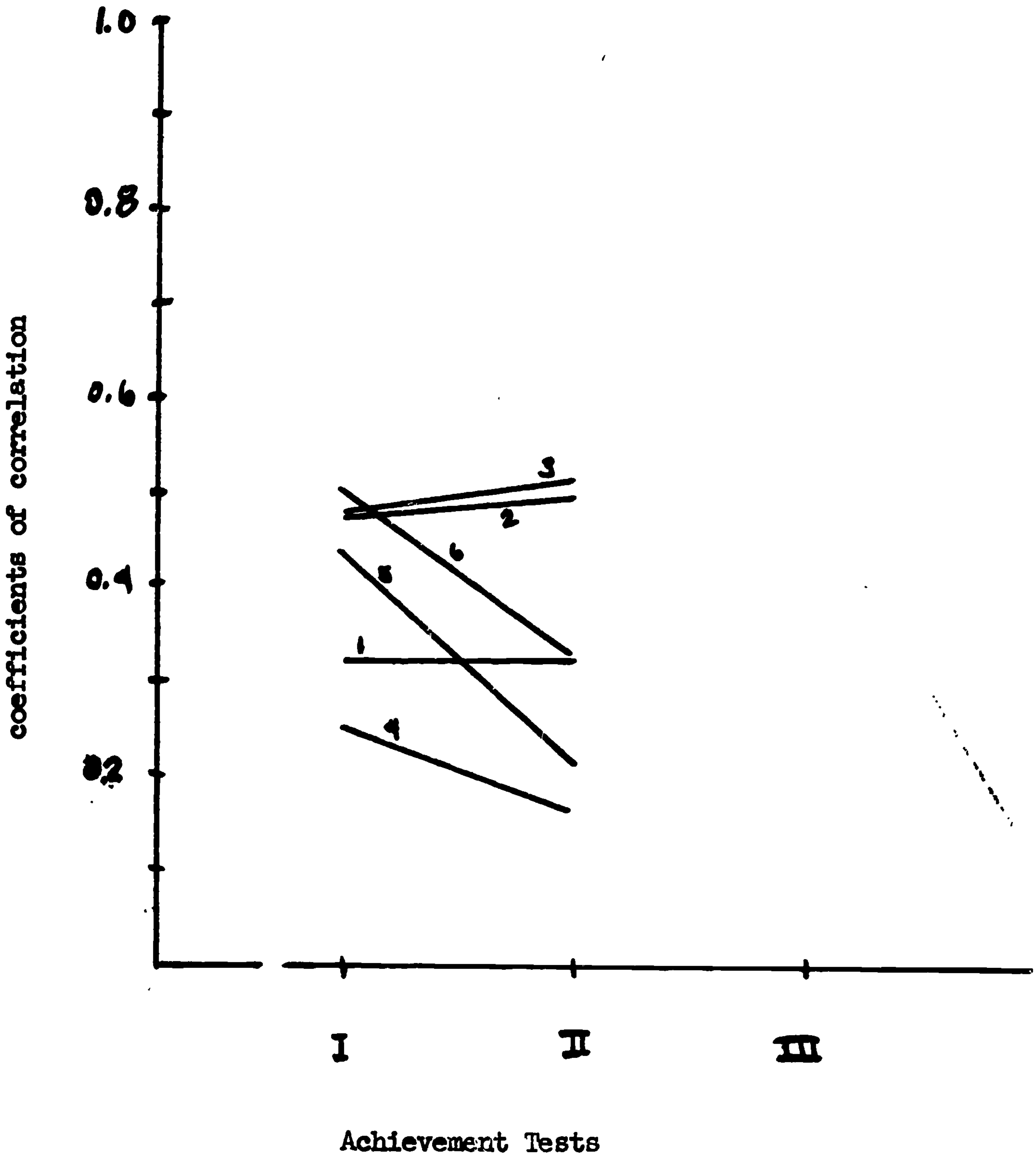


Fig. 3. - Patterns of coefficients of correlation of IQ with achievement for low ability boys. Data in Table 4.

TABLE 4

COEFFICIENTS OF CORRELATION OF IQ
WITH ACHIEVEMENT FOR HIGH AND
LOW ABILITY BOYS

School	Ability Level (n)	Ach. Test I	Ach. Test II	Ach. Test III
1	High (32) Low (26)	.69 .32	.64 .32	- -
2	High (38) Low (27)	.40 .48	.47 .52	- -
3	High (23) Low (33)	.53 .47	.34 .50	- -
4	High (32) Low (31)	.52 .25	.40 .17	- -
5	High (20) Low (33)	.34 .44	.46 .21	- -
6	High (26) Low (29)	.58 .50	.52 .33	- -
7	High (25) Low (3)	.56 .23[a]	.40 .97[a]	.63 - .27[a]

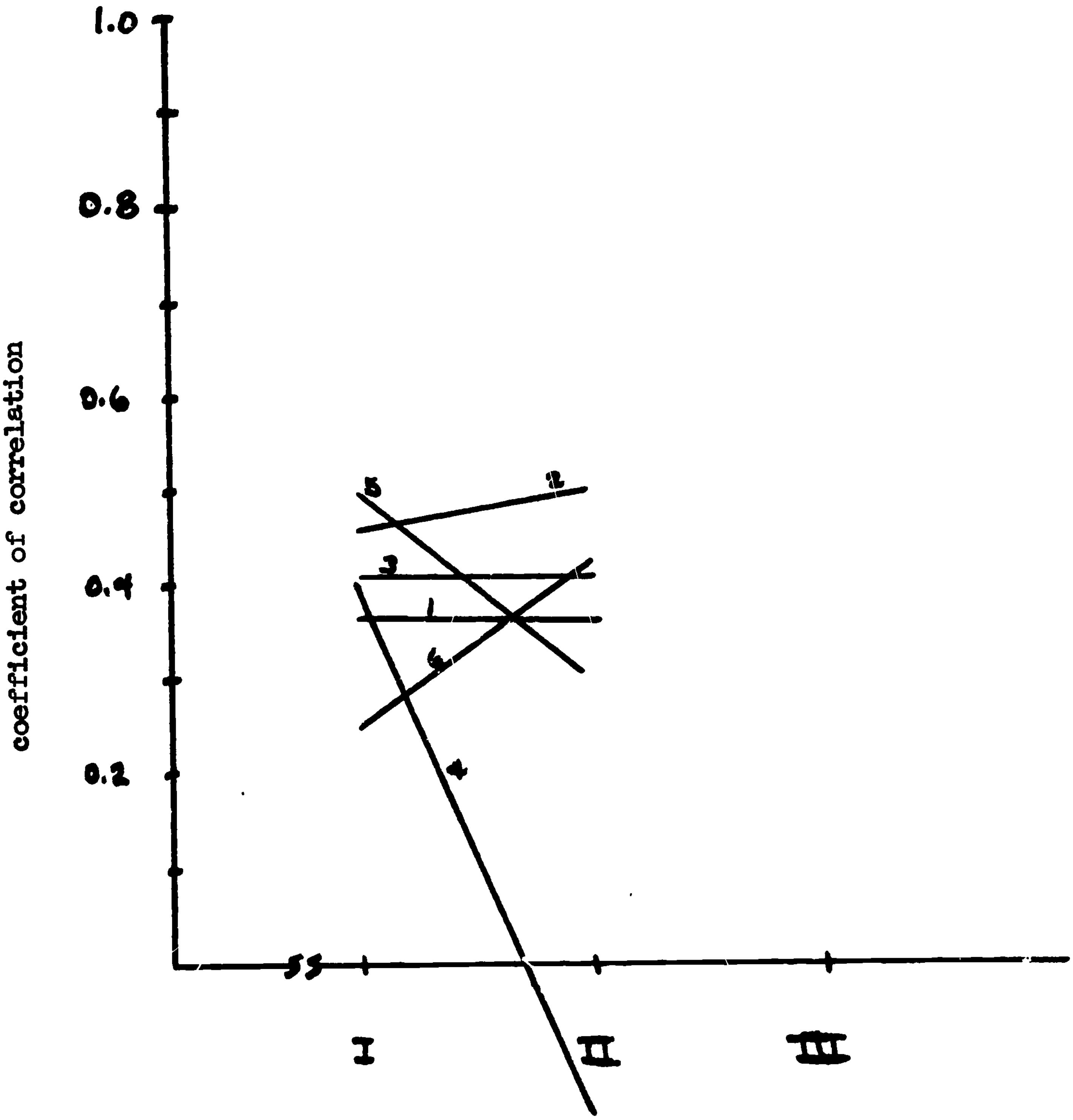


Fig. 4. - Patterns of coefficients of correlation of reading ability with achievement for low ability girls. Data in Table 5.

TABLE 5

COEFFICIENTS OF CORRELATION OF READING ABILITY WITH ACHIEVEMENT FOR LOW ABILITY GIRLS

School	(n)	Ach. Test I	Ach. Test II	Ach. Test III
1	(32)	.37	.36	-
2	(33)	.46	.50	-
3	(38)	.41	.41	-
4	(29)	.40	- .16	-
5	(29)	.50	.30	-
6	(34)	.25	.42	-
7	(5)	- .37[a]	- .47[a]	- .39[a]

[a]Based on n = s; not plotted in Figure 4

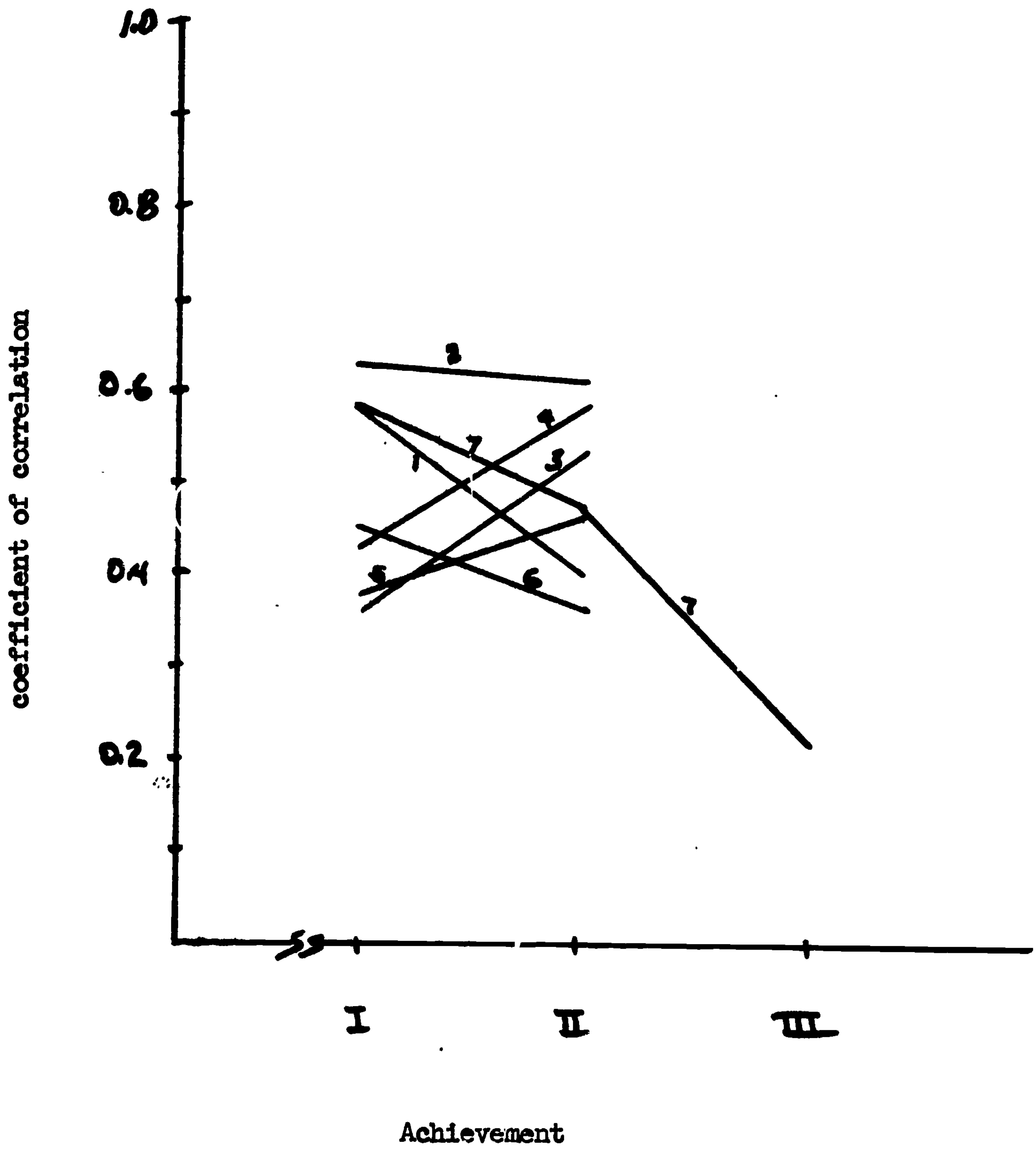


Fig. 5. - Patterns of coefficients of correlation of Space Relations ability with achievement for high ability boys. Data in Table 6.

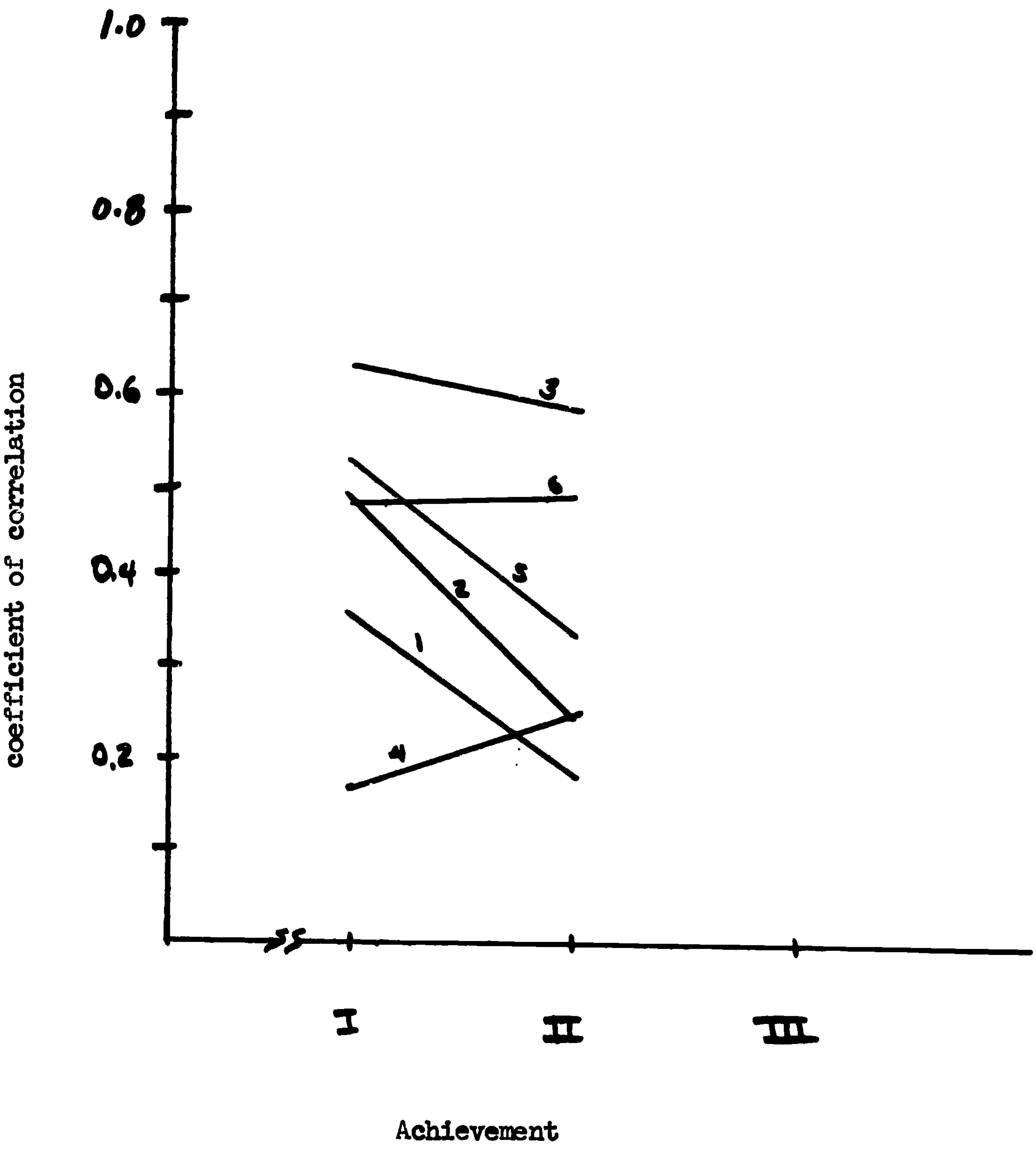


Fig. 6. - Patterns of coefficients of correlation of Space Relations ability with achievement for low ability boys. Data in Table 6.

TABLE 6

COEFFICIENTS OF CORRELATION OF
SPACE RELATIONS ABILITY WITH
ACHIEVEMENT FOR HIGH AND
LOW ABILITY BOYS

School	Ability Level (n)	Ach. Test I	Ach. Test II	Ach. Test III
1	High (32)	.58	.40	-
	Low (26)	.36	.18	-
2	High (38)	.64	.62	-
	Low (27)	.48	.25	-
3	High (23)	.36	.54	-
	Low (33)	.64	.59	-
4	High (32)	.44	.58	-
	Low (31)	.17	.25	-
5	High (20)	.38	.46	-
	Low (33)	.53	.35	-
6	High (26)	.45	.36	-
	Low (29)	.48	.49	-
7	High (25)	.58	.47	-
	Low (3)	.76[a]	.63[a]	- .78[a]

[a]Based on n = 3; not plotted

Table 8 is a summary of the changes in the predicted results as a consequence of data analysis.

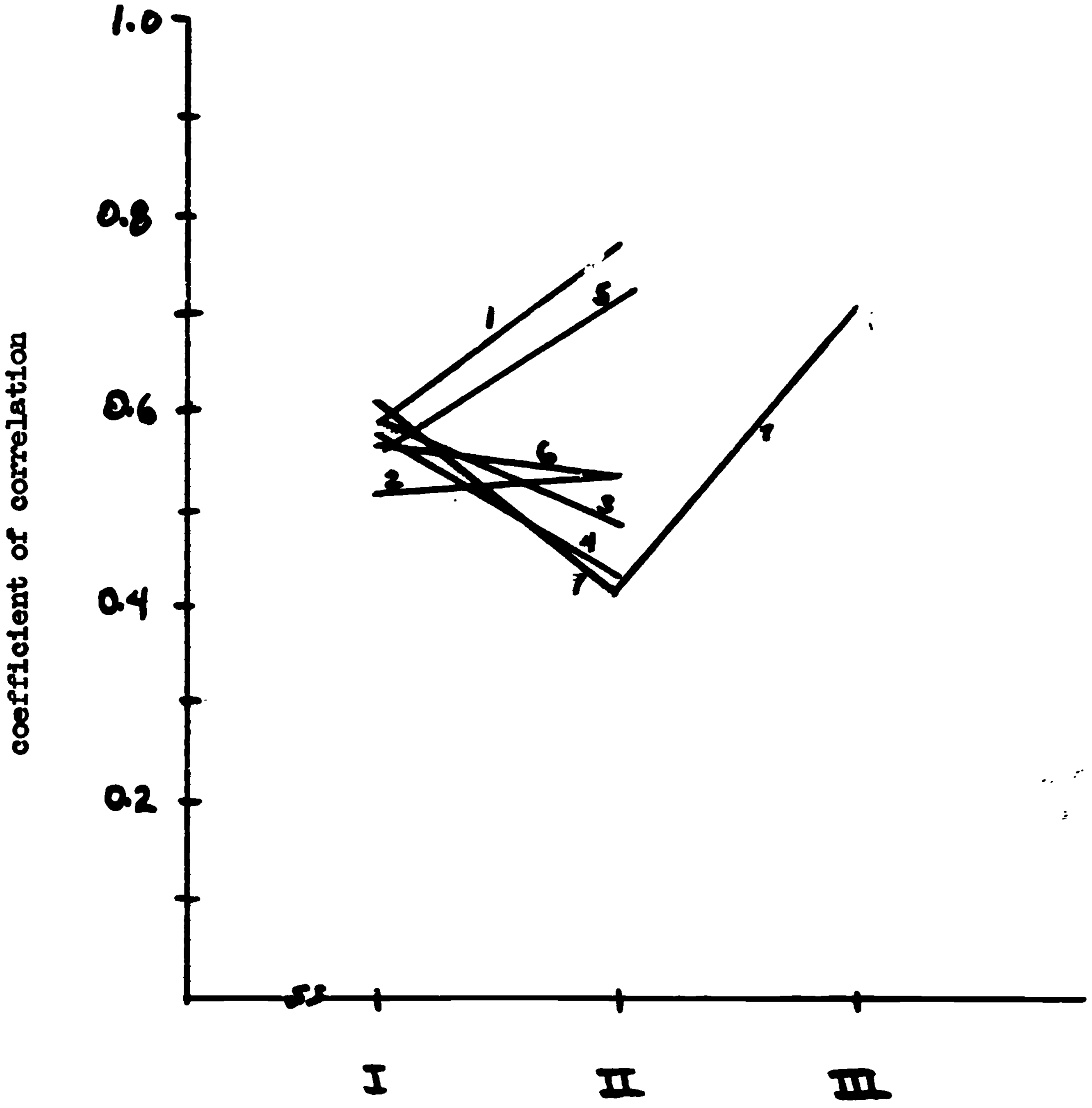


Fig. 7 - Patterns of coefficients of correlations of Verbal Reasoning ability with achievement for high ability boys. Data in Table 7.

TABLE 7

COEFFICIENTS OF CORRELATION OF VERBAL REASONING ABILITY WITH ACHIEVEMENT FOR HIGH AND LOW ABILITY BOYS

School	Ability Level (n)	Ach. Test I	Ach. Test II	Ach. Test III
1	High (32) Low (26)	.59 .30	.77 .56	- -
2	High (38) Low (27)	52 .19	.54 .44	- -
3	High (23) Low (33)	.59 .64	.49 .50	- -
4	High (32) Low (31)	.58 .42	.43 .36	- -
5	High (20) Low (33)	.56 .54	.71 .53	- -
6	High (26) Low (29)	.56 .63	.54 .50	- -
7	High (25) Low (3)	.61 1.00[a]	.42 - .03[a]	.71 -1.00[a]

[a]Based on n = 3; not plotted

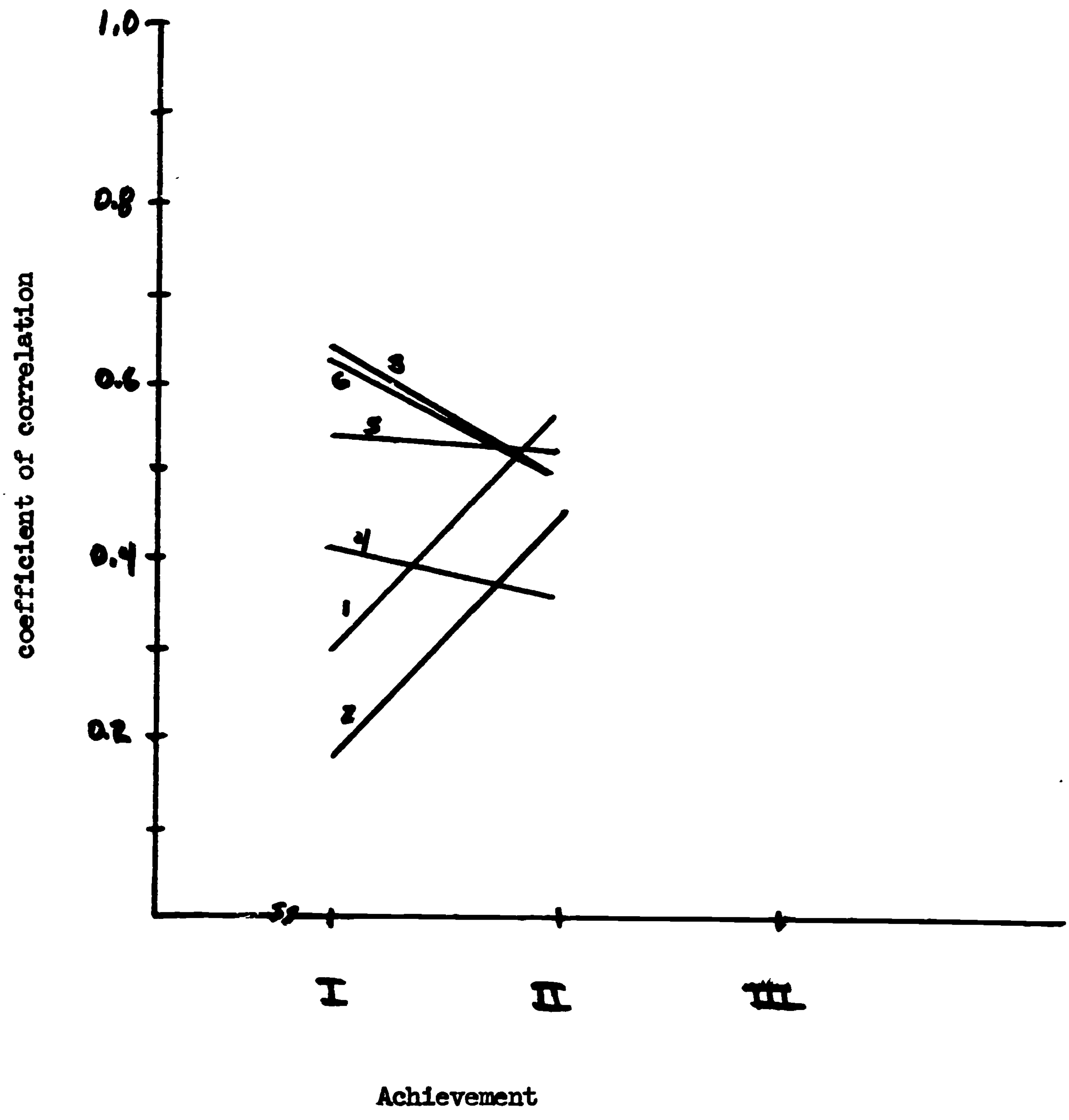


Fig. 8 - Patterns of coefficients of correlation of Verbal Reasoning ability with achievement for low ability boys. Data in Table 1.

TABLE 8

SUMMARY OF THE TEST OF PREDICTED BEHAVIORS OF MEASURED ABILITIES

ABILITY	PREDICTED BEHAVIOR	ACTUAL BEHAVIOR
1. Verbal Reasoning	relevant basic	relevant basic (boys only)
2. Numerical Ability	relevant basic	relevant basic (boys only)
3. Abstract Reasoning	relevant basic	uncertain
4. IQ	general	general (boys only)
5. Clerical Speed and Accuracy	irrelevant	irrelevant
6. Reading	uncertain	general
7. Space Relations	uncertain	general
8. Language Usage (spelling)	uncertain	irrelevant
9. Language Usage (sentences)	uncertain	uncertain
10. Mechanical Reasoning	uncertain	uncertain

Measures of Effectiveness

According to the theory, a set of rapidly increasing coefficients of correlation of a relevant basic ability with achievement in a structured program will reflect "drop out" among students of low basic ability and will be indicative of an ineffective course. A set of rapidly decreasing coefficients of correlation will reflect "over achievement" and will be indicative of an effective but inefficient course. A set of high correlations of close to zero slope will indicate an effective course.

After the relevant basic abilities for the IPS course had been identified, predictions of achievement based on the theory were made in cases where the abilities were behaving as the theory predicted they should. These predictions were then checked against what actually happened in the classes to provide a check on the ability of the theory to detect effectively taught courses.

Verbal Reasoning ability was found to be a relevant basic ability for boys, and its behavior most nearly conformed to theoretical predictions for boys of high ability. The relative achievement of classes of high ability boys, then, can easily be predicted using Figure 7. Since the lines drawn for schools numbered 1 and 5 increase sharply from Test I to Test II, a large drop in the achievement on Test II relative to Test I can be predicted for both these groups of boys. The lines drawn for schools numbered 2 and 6 have near zero slope. It can be predicted that there will be little or no difference in the achievement on Test II relative to that on Test I for these two groups. Since the lines drawn for schools numbered 3, 4 and 7 drop, it cannot be predicted with assurance what will happen. Such a drop is indicative of "over achievement" and one would expect the achievement on Test II relative to Test I to be higher. This would certainly be expected to be the case for school number 4, in which it was known from visits to the classes in that school that the teacher coached the students for the IPS achievement tests. This effect was dramatic in the case of low ability girls in that school. Attention was called to the marked behavior of correlations among low ability girls when Figure 4 was discussed. But this differential could go either way, depending on which test was better coached. From the direction of line number 4 in Figure 7, an increase in achievement on Test II relative to Test I would be expected. The marked drop in correlations from Test I to Test II in school 4 was found in every pattern in which low ability girls were studied. The effect was evident, although not always as pronounced, in groups of high ability girls. Large changes were evidenced in groups of boys, but there was not always a sharp drop.

A summary of the predictions based in the theory appears on Table 9. The relevant basic ability used was Verbal Reasoning ability and the comparisons were made for high ability boys. Comparisons were made by converting the deviations of the group means from the total mean for all groups on the given test to standard units.

The expected agreement of findings with predictions based on theory was found. There was some doubt about what happened to achievement when the pattern of correlations showed a drop, but little doubt about what achievement did when the pattern showed an increase or remained stable. Apparently, correlations can show a decrease while achievement remains relatively stable but an increase in correlations indicates a drop in achievement.

The theory would predict, as is evident from Figure 7, that the performance of group 7 on Test III would drop relative to the other two tests. A Z of .37 calculated using means and standard deviations from the standardizing data for the IPS tests, confirmed this prediction.

TABLE 9

SUMMARY OF COMPARISON OF PREDICTED CHANGES IN ACHIEVEMENT WITH ACTUAL CHANGES FOR HIGH ABILITY BOYS USING VERBAL REASONING ABILITY AS RELEVANT BASIC

Group	Mean Test I	Mean Test II	Z I	Z II	Predicted Change	Actual Change ZI - Z2
1	14.13	15.22	.51	.20	Large drop	- .31
2	13.74	12.08	.42	.53	no change	+ .11
3	16.22	18.87	.97	.86	increase	- .11
4	13.94	17.22	.47	.38	increase	- .09
5	17.40	19.30	1.23	.94	large drop	- .29
6	12.88	14.96	0.24	.15	no change	- .09
7	17.08	19.24	1.16	.93	increase	- .23

A summary of predicitions based on the theory for the low ability boys appears in Table 10. Verbal Reasoning ability was again used as the relevant basic ability. The predictions were derived from the patterns of correlations in Figure 8. The theory does not hold up quite as well for this group, but it should be noted that the patterns of correlation coefficients in this group is not as close to that required by the theory as was the case with the group of high ability boys. It is of interest to note that the coaching in school number 4 is in this case revealed in the expected increase in achievement on Test II relative to Test I. This, coupled with the sharply decreasing patterns among low ability girls suggests that the effect is more difficult to detect among students of high ability.

Patterns of correlation coefficients of Numerical Ability with achievement for high ability boys and for low ability boys appear in Figures 9 and 10, respectively. If Numerical Ability is considered relevant basic and these patterns are used to predict changes in achievement, agreement with the predictions made using Verbal Reasoning ability as relevant basic, while not perfect, is nevertheless good. Predictions, or measures, of effectiveness which be essentially the same in the two cases. The most notable exceptions are predictions for high ability boys in schools 5 and 6. If the variability of the initial correlations, those of the relevant basic ability with achievement Test I, could be carefully controlled, there is strong evidence that measures of effectiveness based on the theory and using either relevant basic ability could be corroborated almost completely by using the other.

In summary, both the correlation patterns and the changes in achievement between Test I and Test II indicated that school number 2 and, probably school number 6 were teaching an effective course for high ability boys. The patterns of correlations indicated that schools 3, 4, and 7 were teaching an effective but inefficient IPS course for boys of high ability. The changes in achievement between Test I and Test II however, indicated that school number 7 was teaching an ineffective course. Both the correlation patterns and the changes in achievement indicated that schools number 1 and 5 were teaching an ineffective IPS course for high ability boys. School number 4, which had been suspect because it was known that the teacher in that school "taught for" the IPS achievement tests, had patterns of correlations which confirmed the suspicion.

The correlation patterns and the changes in achievement indicated that school number 5 was teaching an effective IPS course for low ability boys. The correlation patterns for schools 3 and 6 indicated that they were teaching an effective but inefficient course. Changes in achievement did not confirm this in both cases. The correlation patterns indicated that schools 1 and 2 were teaching an ineffective IPS course for low ability boys, but changes in achievement failed to confirm this in both cases. Suspicions about school 4 were again confirmed by the correlation patterns. In the case of low ability boys, the changes in achievement between Test I and Test II strongly supported the suspicious correlation patterns. There were not enough students in the low ability group in school 7 to make a judgment about the effectiveness of the IPS course advisable in that situation.

A summary of the determination of the effectiveness of the IPS course is given in Table 12.

These results were in good agreement with the results of observations made on visits to the IPS classes.* On the basis of these observations, one would have expected the teacher in school 2 to be effective with both high and low ability students. It would also be expected that the teacher in school 3 would have been effective with at least one group.

*See Appendix E

TABLE 10
SUMMARY OF COMPARISON OF PREDICTED CHANGES
IN ACHIEVEMENT WITH ACTUAL
CHANGES FOR LOW ABILITY
BOYS USING VERBAL REASONING
ABILITY AS RELEVANT BASIC

Group	Mean Test I	Mean Test II	Z I	Z II	Predicted Change	Actual Change
1	9.35	10.42	- .54	- .68	Large drop	- .14
2	8.63	10.59	- .69	- .65	Large drop	+ .04
3	10.48	12.30	- .29	- .34	Increase	- .05
4	11.35	15.10	- .10	+ .17	No change	+ .27
5	7.76	10.00	- .91	- .76	No change	+ .15
6	9.76	10.62	- .45	- .65	Increase	- .20

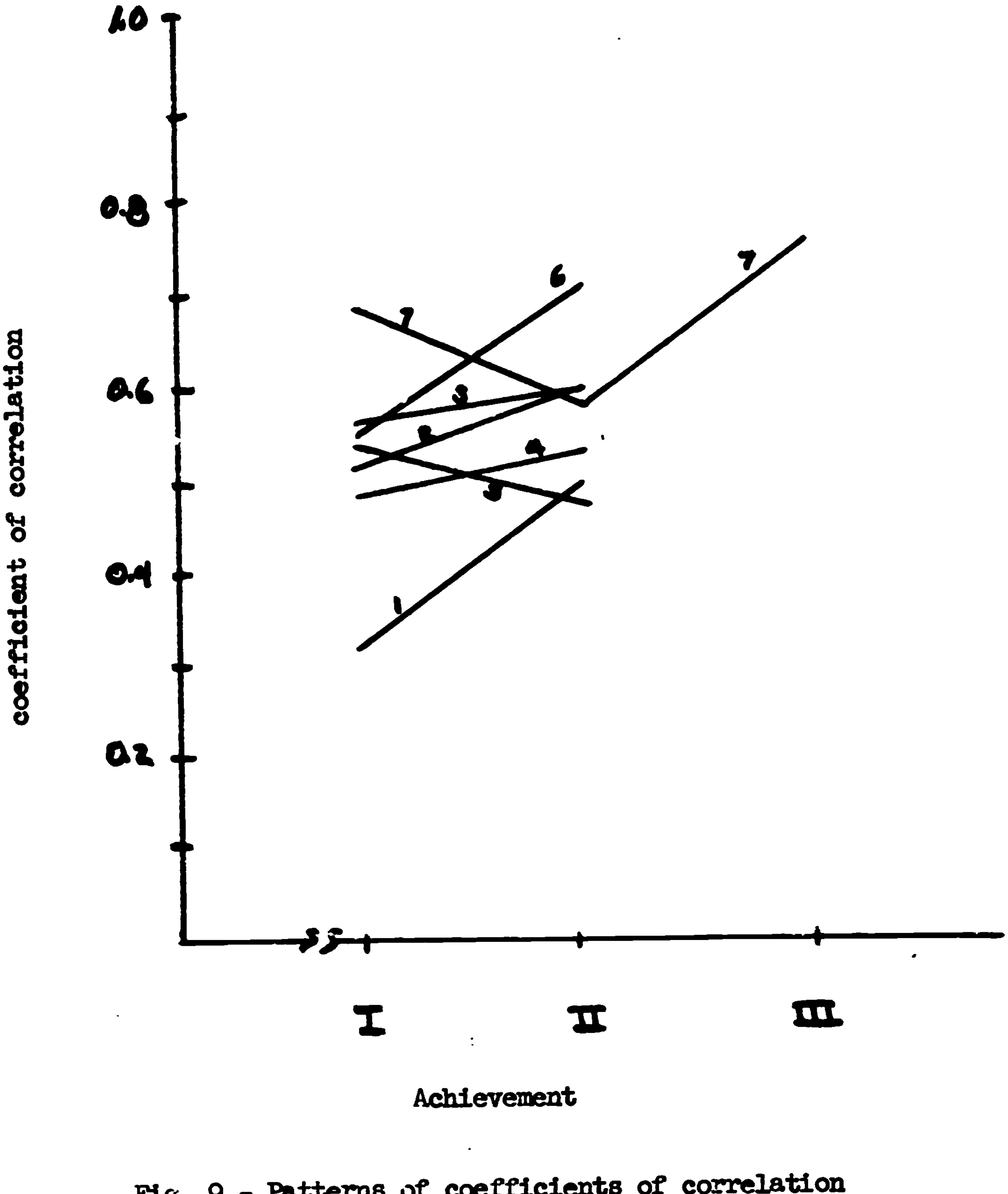


Fig. 9 - Patterns of coefficients of correlation of Numerical Ability with achievement for high ability boys. Data in Table 11.

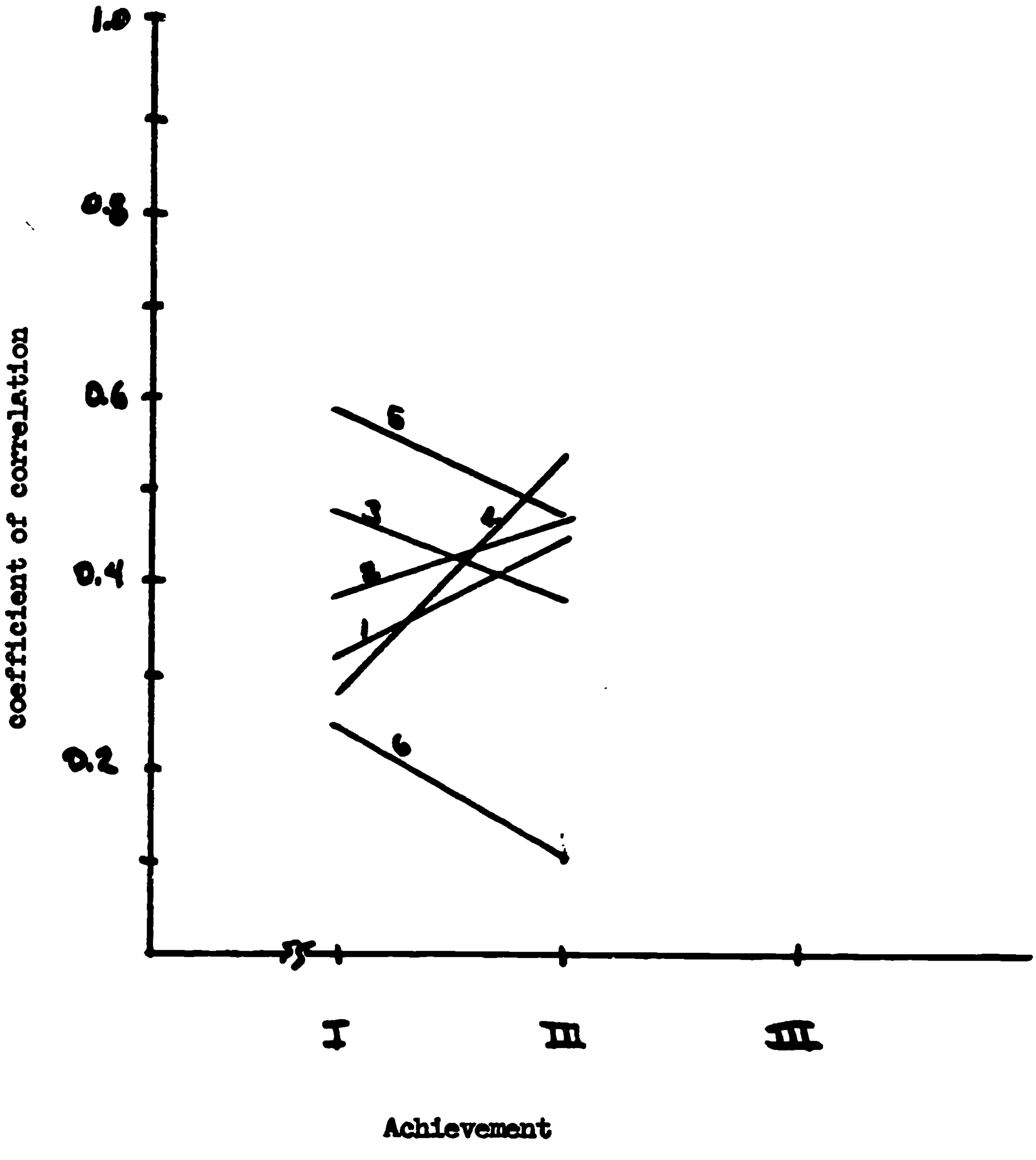


Fig. 10 - Patterns of coefficients of correlation of Numerical Ability with achievement for Low ability boys. Data in Table 11.

TABLE 11

COEFFICIENTS OF CORRELATION OF NUMERICAL ABILITY WITH ACHIEVEMENT FOR HIGH AND LOW ABILITY BOYS

School	Ability Level (n)	Ach. Test I	Ach. Test II	Ach. Test III
1	High (32) Low (26)	.32 .32	.50 .45	- -
2	High (38) Low (27)	.52 .39	.60 .46	- -
3	High (23) Low (33)	.56 .48	.60 .38	- -
4	High (32) Low (31)	.48 .29	.53 .53	- -
5	High (20) Low (33)	.53 .58	.43 .47	- -
6	High (26) Low (29)	.55 .25	.71 .11	- -
7	High (25) Low (3)	.69 .07[a]	.58 .99	.76 - .11

[a]Based on n = 3; not plotted

TABLE 12
SUMMARY OF MEASURES OF THE
EFFECTIVENESS OF THE IPS
COURSE FOR HIGH AND
LOW ABILITY BOYS

		Effectiveness		
School	(Ability)	Effective	Effective but Inefficient	Ineffective
1	High	-	-	1,2,3
	Low	-	-	1,2,3
2	High	1,2,3	-	
	Low	-	-	1,2
3	High	-	1,2	-
	Low	-	1,2	-
4	High	-	1,2,3	-
	Low	1	-	2
5	High	-	-	1,2,3
	Low	1	2	-
6	High	1,3	-	-
	Low	-	1,2	-
7	High	-	1,2	-
	Low	not determined		

Code: 1 - confirmed using Verbal Reasoning as a relevant basic ability
2 - confirmed using Numerical Ability as a relevant basic ability
3 - confirmed using Achievement changes

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The study reported here had as its primary objective the testing of a prototype model for determining the effectiveness of structed instructional materials. The test of the model was to be a severe one. The model was required to hold up in a real school situation and for a course in introductory physical science (IPS). If the prototype model held up under this test, a mathematical expression was to be derived which could be used to add an element of quantity to measures of the effectiveness of such instructional materials.

The prototype model was based on a theoretical foundation. The theory predictions of the effectiveness of structured instructional materials based on patterns of correlation coefficients of measures of basic abilities relevant to the materials with measures of achievement at successive points in the structured sequence of materials. There were several questions that had to be satisfactorily answered, however, before the model could be put to a test. These questions were:

1. What measured abilities were relevant to the IPS course?
2. What patterns of correlation coefficients indicate an effective course?
3. What unit should be used to divide the course when the coefficients are plotted to give a pattern?
4. How can these patterns be mathematically described so that they will provide a quantitative measure of effectiveness?

The study was successful in dealing with the first two questions. Patterns predicted on the basis of theory were found among the patterns plotted from the data, and there was good agreement between the expected behavior of measured abilities of a specified type and the behavior these abilities actually exhibited. Agreement of predicted patterns and actual patterns, however, was in most instances found to be a function of ability (as measured by IQ tests) and of sex.

Abilities which were expected to be irrelevant to the IPS course were found to exhibit the predicted patterns independent of ability and of sex. Abilities expected to be general with regard to the IPS course were found to exhibit mixed patterns. IQ was found to behave as a general ability for boys only while reading ability and Space Relations ability were found to behave as general abilities for all students. Abilities expected to be relevant and basic to the IPS course were found to exhibit the predicted patterns only for boys, the patterns most nearly what were expected being found among high ability boys.

In the cases where an ability relevant to the IPS course could be identified the patterns of correlation coefficients were used to make predictions of the effectiveness of the IPS course for the groups of students for which the relevant basic ability could be identified. When these predictions were compared with changes in achievement which would be expected for effective and ineffective courses, the results were very good.

On the basis of the theory and the data analysis of the study the following things were concluded:

1. Relevant basic abilities as measured for the IPS course were not independent of the level of general intelligence.
2. Relevant basic abilities as measured for the IPS course were not independent of sex.
3. Irrelevant abilities as measured for the IPS course were independent of the level of general intelligence as well as of sex.
4. The concept of general ability as measured for the IPS course was open to serious doubt.
5. The model used for measuring the effectiveness of the IPS course retained much of its original promise.
6. Verbal Reasoning ability and Numerical Ability were relevant basic abilities for the IPS course.
7. The IPS course was effective in some but not all situations.

Measures of the effectiveness of the IPS course, and thus the test of the prototype model, were severely limited because of the failure of any class to complete the IPS course and to take all four achievement tests. Two points in the correlation patterns is far too small a number to make determinations of effectiveness by the technique used in this study and sure procedure. Yet it was found that, as far as the data could test it, the model was a sound one.

With regard to questions 3 and 4, the fact that no class completed the IPS course and took all four tests precluded the possibility of attacking the problem of quantifying measures of achievement. The only relationship possible when only two points are available is a line or one. Although a detailed analysis of the IPS textbook was conducted, dividing the course into units for the data analysis was not attempted due to the limited number of IPS achievement test scores available for the data analysis.

In addition to the test of a prototype model for determining effectiveness, it was hoped at the outset of this study that a model for determining whether the IPS course could be considered structured could also be subjected to a test. The test of this model depended upon the studen'ts completing the IPS course and a measure of their final achievement. Since no class finished the course, the model could not be tested.

Recommendations

On the basis of the experiences of this study and the results obtained from it, several recommendations can be made:

1. The study revealed that patterns of correlations which showed a sharply increasing trend were indeed useful in spotting situations in which the IPS course was ineffective. Further study is needed on what is indicated by patterns which show a sharp decrease. As was indicated by the patterns for a situation where coaching was known to be going on, sharply decreasing patterns may be indicative of the best or most effective course, assuming, of course, that the tests of achievement have not been invalidated because of coaching.
2. The erratic behavior of general abilities measured in this study suggests that the concept of general ability and its theoretically predicted behavior should be given further attention. The fact that both measures of IQ and of reading ability in this study were composite scores might suggest that correlations of general abilities from point to point in a structured sequence might remain stable because the effects of more specific abilities are masked when they are combined into a composit score. This idea was supported in this study by the behavior of correlations involving Verbal Reasoning ability, but it was not supported by the behavior of correlations involving Space Relations ability, which itself behaved as a general ability would be expected to behave. The concept of general ability needs further study.

3. Future studies using the models tested in this study should be done in a carefully controlled "laboratory" setting using programmed or program-like instructional sequences. Division of the instructional sequences into the appropriate units probably should be accomplished by determining average equal times for completing blocks of the instructional sequence. In addition to the carefully controlled environmental setting, the important variables, ability and sex, should be controlled.
4. Some method of determining relevant basic abilities for the IPS course when girls take it should be sought. This problem of differences by sex should be studied further.

REFERENCES

Bruner, Jerome S. The Process of Education, Cambridge, Mass.: Harvard University Press, 1963.

Ford, G.W., and Lawrence Pugno (editors) The Structure of Knowledge and The Curriculum, Chicago: Rand McNally and Co., 1964, "Introduction" by B.O. Smith.

Gagne, Robert. "Curriculum Research and the Promotion of Learning," Perspectives of Curriculum Evaluation AERA Monograph Series on Curriculum Evaluation, No. 1, Chicago: Rand McNally and Co., 1967, p. 19.

Gagne, Robert M., and Noel E. Paradise. "Abilities and Learning Sets in Knowledge Acquisition." Psychological Monographs: General and Applied, LXXV (Whole No. 518,1961), 1-23.

Gavurin, Edward L., and Virginia M. Donahue. Logical Sequence and Random Sequence in Teaching Machine Programs, Burlington, Mass.: Radio Corporation of American, 1960. 16pp.

Grobman, Hulda. Evaluation Activities of Curriculum Projects AERA Monograph Series on Curriculum Evaluation, No. 2, Chicago: Rand McNally and Co., 1968, pp. 1-2.

Levine, Gerald R., and Bruce L. Babov. "Item Scrambling in a Self-Instructional Program." Journal of Educational Psychology, LIV, (June, 1963), pp. 138-143.

Miller, J. and S. Levine. A Study of the Effects of Different Types of Review and of "Structuring" Subtitles on the Amount Learned from a Training Film, Washington, D.C.: USAF Human Factors Research Laboratory, March, 1952. Cited by A.A. Lumsdaine. "Experimental Research on Instructional Devices and Materials," Training Research and Education, Robert Glaser (ed.), University of Pittsburgh Press, 1962.

Payne, David A., David R. Krathwohl, and John Gordon. "The Effect of Sequence on Programmed Instruction." American Educational Research Journal, IV (March, 1967), pp. 125-132.

Pyatte, Jeff A. "Some Effects of Unit Structure on Achievement and Transfer," American Educational Research Journal, VI (March, 1969), pp. 241-260.

REFERENCES CONTINUED

Roe, J. Vlachouli, H.W. Case, and A. Rose. "Scrambled Versus Ordered Sequence in Auto Instructional Programs." Journal of Educational Psychology, LIII (April, 1962), pp. 101-104.

Stokes, William Wood. "An Analysis and Evaluation of Current Efforts to Improve the Curriculum by Emphasis on Disciplinary Structure and Learning by Discovery," Dissertation Abstracts, XXV (July, 1964).

Wuff, J.J. and L. M. Sturlow. "The Role of Class Descriptive Cues in Paived-Associates Learning," Journal of Experimental Psychology, XLIII (January, 1957), pp.199-206.

APPENDIX A

THE IPS COURSE

INTRODUCTORY PHYSICAL SCIENCE: THE COURSE, ITS CONSTRAINTS, ADVANTAGES AND PROBLEMS, AND SOME RECOMMENDATIONS

The Introductory Physical Science Course (IPS)

The public schools are rapidly adopting curriculum materials in science which are the products of the prolific "curriculum study groups", which are beginning to become, in many cases, development specialists. There are numerous problems in the adoption of these materials. One such problem arises because the new science courses (PSSC, CBA, CHEMS, and BSCS, etc.) take an approach to science which is foreign to the majority of students of science. This approach emphasizes observation and reasoning and makes heavy demands on the students' ability to perform laboratory experiements and to use the evidence gathered to correlate, reason, and conclude. It requires, in addition to these laboratory skills, considerable facility with mathematics, some feeling for approximations and errors, and no small amount of common sense.

The IPS course exists primarily because its developers sought to devise a course which would give the high school student some experience in dealing first hand with the problems of experimental science before he faced the high school science courses.

Objectives and Approach of IPS

The Introductory Physical Science Course (IPS) was developed by Educational Services Incorporated.[1] The work on IPS was begun in the summer of 1963 with the support of the National Science Foundation. About two-thirds of the course was completed and tried in a few schools during the 1963-1964 school year. The following academic year found an expanded, and lengthened, version of the IPS course in about fifty schools on a trial basis.[2] The IPS course materials have now been developed, and the IPS Group is concerning itself with implementing

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[1] Educational Services Incorporated is now Education Development Center, 55 Chapel Street, Newton, Mass. 02160.

[2] ESI Quarterly Report Summer-Fall 1965, (Watertown, Mass.: Educational Services Incorporated, 1965), p. 45.

the course in the public schools and in developing a second course in physical science.[3]

IPS was designed to be an introductory physical science course taking one academic year to complete. The course had as its over-all purposes:

1. to provide a foundation in subject matter and develop the appropriate attitudes of inquiry, coupled with the necessary experimental and mathematical skills needed for more advanced work in science;
2. to serve as a terminal course for the student who will take few or no more science courses.

The approach that the developers of IPS have chosen takes a narrow, well-defined path toward a broad content objective -- the development of evidence for an atomic model of matter-- rather than a broad survey of the entire field of science. The means through which the concept is developed, and also the means of achieving the overall purpose of the IPS course, is one of student experimentation with carefully guided reasoning. The laboratory, then, is a vital part of the IPS course, and it is incorporated directly into the textbook.[5]

A concise statement of the specific objectives and approach of the IPS course, beyond the very general statements just reviewed, has not appeared in the publications of the developers of IPS. The specific objectives and approach are, however, implicit in statements made about the IPS course and in directions given to students and teachers of the course.

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[3] Uri Haber-Schaim, "Introductory Physical Science Accent on Implementation", Introductory Physical Science, Physical Science II: A Progress Report, Newton, Mass.: EDC (Undated Preliminary edition), p.1. (Although this report is not dated, the IPS Group must have been in this study of implementation at least four years before now, 1969).

[4] Educational Services Incorporated, A Review of Current Programs, 1965, p.25. See also: ESI Quarterly Report, Summer-Fall 1965, p.47-48, or A Progress Report, EDC (Preliminary edition) pp. 2-3 for the article "Objectives and Content of the Introductory Physical Science Course," by Uri Haber-Schaim.

[5] See, A Review of Current Programs, p. 25.

Objectives are difficult to separate from approach, since both are often so much the same that they appear to be one. For example, IPS is intended to teach the student to find out for himself through experimental work in the laboratory. But the experimental approach is "finding out for oneself" -- with some guidance. As a consequence of this difficulty of separating objectives and approach, a summary of the statements about what IPS is supposed to do and how one should go about doing it has been compiled from several sources.[6] Generally, the summary consists of (1) expected teacher behaviors and (2) expected student behaviors, but it has been compiled under the following outline:

I. Teacher Practices in the classroom.

   A. General Practices
   B. Laboratory Practices
      1) Pre-lab
      2) Lab
      3) Post-lab
      4) Lab notebooks

II. Student Behaviors.

   A. In the classroom
   B. Outside the classroom

III. Use of the Textbook

IV. Use of the HDL problems

V. Testing and evaluating

VI. Use of Reference materials

These will now be discussed briefly.

Teacher practices in the Classroom

The IPS course is a laboratory course which encourages the student to find out things for himself by making systematic observations

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[6] The sources of information for this summary are: Teacher's Guide to Introductory Physical Science, Prentice-Hall, Inc., 1967; Introductory Physical Science, Prentice-Hall, Inc., 1967; Introductory Physical Science and Physical Science II: A Progress Report", Educational Development Center (undated).

on things as they really are. There are several behaviors expected of the teacher under ideal conditions. These behaviors fall into the two broad categories of general practices and laboratory practices.

General Practices -- The teacher of IPS should:

1. Encourage the student to think for himself. Instead of giving an answer to students' questions, he should use such responses as "How can you find out," "Try it," "Look it up," "You have to decide," and "Are you satisfied with your data"?
2. Encourage students to investigate on their own outside of class. Students who want to build laboratory equipment at home should be encouraged to do so.
3. Suggest a general format for reports and help students learn to organize their data. A rigid format should not be required.
4. Perform demonstrations of the complicated experiments for which data are provided in the textbook, but which are not appropriate for the students at this level.
5. Not be too hasty to judge a student's answers as "right" or "wrong". It is better to ask the student for his reasons for giving an answer.
6. Adjust the pace of the course to the ability of the particular class to do the work.
7. Convey to the student the idea that science is a human endeavor, not a monstrous thing.
8. Encourage the student to construct and test models and theories to explain phenomena.
9. Have the students conduct the experiments as they are encountered in the text.
10. Handle makeup laboratory by allowing the students to discuss experiments with their partners.

Laboratory Practices -- Laboratory practices fall into four categories: (1) pre-lab, (2) lab, (3) post-lab, and (4) lab notebook.

Pre-lab - The teacher should:

1. See that equipment and materials needed for the experiment are prepared and ready when the students need them.
2. Take a few minutes before each lab to review with the students the purpose of the experiment.
3. Be careful not to give away the expected result of the experiment.
4. Conduct a thorough discussion of every experiment before the students are allowed to perform them. Discuss:

purposes, procedures, special precautions, data collection, etc.
5. Whenever desirable, vary the way students perform an experiment to systematically observe the effects of variables on the outcomes.

Lab - The teacher should:

1. Assign two students to a lab team for most of the experiments.
2. See that students observe the simple rules of the laboratory:

    a) wear safety glasses when doing an experiment involving heating, corrosive substances, or gas pressure.
    b) dispose of unused chemicals.
    c) use boiling chips for boiling.
    d) taste or smell only when instructed to do so.
    e) report all inquiries.
    f) not point a boiling test tube at a fellow student.
    g) know how to use fire extinguisher.
    h) use only specified quantities of materials.
3. Ask a few questions about the experiment to check for unprepared students.
4. Not give the students too much direction. Allow them to find out for themselves.
5. Not answer too many of the students' questions.

Post-lab - The teacher should:

1. Pool the data from the whole class for discussion of averages, errors, and effects of manipulative variables.
2. Have the class repeat an experiment when probable errors are discovered in post-lab discussions.
3. Always conduct a post-lab discussion of the data, the analysis, and the conclusions from the experiment.

Lab Notebooks - The teachers should:

1. Insist that a notebook of the experiments be kept. This should be a neat record of what the student does, when he does it, and how it came out.
2. Check the student's notebook occasionally while he is recording his experiment.
3. Discourage the use of sloppy notes and scratch paper.
4. Insist on self-contained, gramatically correct answers to questions about the experiment.

5. Make sure each student records the conclusions in his laboratory notebook -- his own and those arrived at in post-lab discussions.
6. Give an occasional open-book quiz on the materials to impress upon the student its value as a record.

Student Behaviors

The expected behaviors of the students fall into two classes: (1) classroom behaviors and (2) behaviors outside classroom.

Student behaviors in the classroom -- Obviously, the student is expected to support the teacher in his objectives and support the general approach of the IPS course. The student, then should:

1. Demonstrate his ability to make his own observations, organize his own data, and form his own conclusions.
2. Keep a neat and accurate record of his work.
3. Demonstrate a positive attitude towards the experimental method of science.
4. Demonstrate the knowledge that science is a human endeavor carried out by humane scientists.
5. Show that he knows that answers can be found by observation.
6. Demonstrate the ability to formulate and check hypotheses.
7. Show that he knows when one experimental result is significantly different from another and when the difference can be attributed to experimental error.
8. Observe safety precautions in the laboratory.

Student behaviors outside the classroom -- The student should:

1. Exhibit an interest in investigating problems outside the classroom.
2. Come to the laboratory prepared to perform the experiment of the day.

Use of the textbook material

The IPS textbook is the most important piece of material the student has to work with. It contains his textual material, his laboratory instructions, and the problems he will be assigned. The textbook is designed to lead the student through the IPS course in a way which will allow him to build for himself a concept of the atomic model for matter. It has been written to fulfill the overall purposes for the IPS course. The teacher should use the IPS textbook:

1. For regular and scheduled assignments of text material, laboratory assignments, and Home, Desk and Lab problems.
2. To lay the groundwork for the concepts developed step-by-step throughout the IPS course.
3. As a source of reading material for classroom reading and exercises -- reading with the class important sections of the text.

Use of the HDL Problems.

An important part of the IPS course is the exercises included in the textbook labelled "Home, Desk, and Lab" Problems. These are designed to serve several functions. The teacher should:

1. Use the HDL problems when the subject with which they deal is being learned in class.
2. Realize that it is not necessary to assign all the HDL problems.
3. Realize that it is not necessary to assign the same HDL problems to all students.
4. Use the HDL problems to send some students into material at a greater depth.
5. Realize that it is better to treat a few problems in depth than to treat all problems superficially.
6. Assign problems from earlier portions of the text as a review and whenever they fit into the material being learned.
7. Encourage students to consider their answers -- avoid "right" or "wrong" evaluations of answers.

Testing and Evaluating

The objectives and approach of the IPS course are broader than can easily be measured with objective-type tests, although these are very important and have been provided with the course. In evaluating the student in IPS the teacher should:

1. Use the IPS Achievement tests.
2. Make some effort to measure the student's progress in gaining independence in the laboratory.
3. Use tests to point out areas of weakness in teaching the material.
4. Write tests which emphasize the broad topics stressed in the text and lab, and deemphasize memory and recall that will encourage the student to cram for tests.
5. Observe and make a few simple notes on the students' performance in the laboratory.

6. Make some notation of the students' participation in class discussion.
7. Inspect the solutions to the assigned problems in the "Home, Desk, and Lab" section at the end of each chapter.
8. Inspect from time to time the laboratory notebooks for completeness, accuracy, readability, and clarity.
9. Give short quizzes (5-10 minutes) on advance reading assignments or on material just completed.
10. Give laboratory tests.
11. Give chapter quizzes as suggested in Teacher's Guide.
12. Use no more than two days per thirty-days for formal testing.

Course Content of IPS

The two pervading purposes of the IPS course have been stated rather broadly as (1) to develop a foundation for the student who will continue in the study of science and (2) to provide a physical science course for the terminal science student. These broad objectives were no doubt of little value in coping with the practical problem of selecting content for the IPS course. Since it has not been clearly stated how course content was selected for IPS, one must infer from scattered statements of specific objectives and approach, and explicit directions to students and teachers, what the criteria and methods of content selection were.

When the content of the IPS course is being considered two facts must be kept in mind. First, the developers of IPS have taken but one of the many possible approaches to physical science -- a narrow path to atomic model of matter. Secondly, they have taken an approach which places emphasis on the laboratory, and, largely through the laboratory, they have attempted to develop an atomic model which "evolves" in the student's mind. Every element of content in the IPS course is useful in the final development of the atomic model of matter, and almost always each element is repeatedly used in the total development.[7] Consequently, to one accustomed to surveying content in general science courses, the course content of IPS will very likely seem too narrow and repetitive.

Based on the overall purposes of the IPS course and the approach taken in the development of an atomic model for matter, one might reasonably infer that the criteria for selection of content which

[7] Uri Haber-Schaim, "Objectives and Content of the Introductory Physical Science Course", ESI Quarterly Report Summer-Fall, 1965 (Watertown, Mass.: ESI, 1965), p. 48.

had the greatest influence on the final choice of content in the IPS course were the following:

1. Each item of content selected must contribute to the development of an atomic model of matter.
2. Each item of content selected must lend itself to repeated use in the story of matter.
3. The total effect of all content must be (1) a science course which will serve as a foundation for the student who will continue in the study of science and (2) a science course which can be considered adequate preparation in science for the student who will not continue to study science.

The more specific objectives of IPS, which no doubt also had some influence on the content selected, are found in the direction to students and teachers, as well as in scattered comments about IPS made by the people associated with its development. These have been summarized in the section on "Objectives and Approach of IPS" and will not be repeated here.

The course content of IPS can be catalogued under five headings: (1) Characteristic Properties, (2) Mixtures, Pure Substances, and Elements, (3) Radioactivity, (4) The Atomic Model, and (5) The Kinetic Picture of Heat.[8]

Characteristic Properties -- The part of the IPS course which comes under the heading "Characteristic Properties" begins with the idea of purposely doing things to the objects of scientific inquiry and develops the idea of doing the same things to two objects to see if they are different. The concept of "mass" is then developed as a means of comparing quantities of the same or different materials. Then density is introduced as a property that is independent of the amount and shape of an object -- a characteristic property. Other characteristic properties are discussed -- soluability, boiling point, and freezing point -- which are useful in building an atomic model of matter. These are chosen to explain some of the properties of liquids, gases, and solids.

In the textbook, this section of content takes up chapters one through four: "Introduction", "Quantity of Matter: Mass", "Characteristic Properties", and "Soluability and Solvents". Numerous laboratory experiments are woven into the textual material for these four chapters. Each student performs the experiments, usually with the help of one other student.

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[8] Ibid. pp. 48-53.

Mixtures, Pure Substances, and Elements -- The idea of characteristic properties is put to use to separate mixtures into their component parts. The idea of a pure substance is thereby introduced. By applying the characteristic properties the student learns that he cannot separate a pure substance into additional components. He also learns that, if he can list the characteristic properties of a substance, he can probably identify it.

More harsh treatment is given to substances than can be given using the simple characteristic properties of density, boiling point, freezing point and solvability to show that some substances cannot be broken down into components. The idea of element is thus introduced.

All the while, the student is told that people applied these procedures long before there was a chemical theory. The names of chemicals and the chemical reactions are not emphasized. It is the phenomena that are important.

The material in this section covers chapters five and six: "The Separation of Substances" and "Compounds and Elements". The student continues to work extensively in the laboratory and conducts an exhaustive laboratory test on the separation of a sludge into its component pure substances.

Radioactivity -- Because radioactivity is one phenomenon which shows rather vividly the discreteness implied in an atomic model of matter, it is chosen as the means of leading up to an atomic picture. Exposure of the grains of a photographic film and the train of a particle in a cloud chamber are used as laboratory demonstrations of radioactivity. The material on radioactivity constitutes chapter seven in the text and is called "Radioactivity".

The Atomic Model -- The background information for constructing an atomic model of matter is built up from chapter one through chapter seven. Chapter eight, "The Atomic Model", builds the model on the basis of what has already been developed. The idea that atoms are small particles which are different for each element and are chemically grouped in molecules is developed. This conceptualization explains much of what has been observed -- the conservation of mass, pure substances, compounds, and so forth.

Different densities of different substances are reasoned to be the result of their having atoms that are different or that are grouped differently. The different range of densities for gases, liquids, and solids then are explainable with the model.

In the laboratory, the student uses rings and fasteners to construct molecules, studies the laws of multiple proportions and more about radioactivity.

Chapter nine deals with sizes and masses of atoms. The student does a measure of the size of a molecule using the thin-film method and studies about the masses of other atoms.

The Kinetic Picture of Heat -- The atoms conceived in chapters eight and nine are now put into motion, and the atomic model becomes more versatile. When the particles are allowed to move, much more of what has been observed can be explained. Moving molecules are used to explain heat and the differences between solids, liquids, and gases. Much is made of the "moving molecule". But the particle model is not forgot. An experiment with crystal growth is a vivid reminder that matter is particulate.

The course concludes with quantitative measures for heat. This covers, in a short space, several of the natural heat phenomena: heat loss, heat of reaction, heat of solution, heat of vaporization, etc. The concluding chapters are chapter ten and chapter eleven.

Description of IPS Materials

Textbook

The eleven chapters of the text are designed to guide the student's reasoning in performing laboratory experiments which develop evidence for an atomic model of matter. Thus, the laboratory experiments are contained in the body of the text. Photographs often accompany the experiments in demonstrating the proper arrangement of laboratory equipment.

Chapters two through eleven contain Home, Desk and Lab (H,D,L's) problems which are extensions of the experiments and reading assignments. The HDL's are designed for various levels of difficulty in order to meet the needs and interests of the students.

The text may be purchased in either hardback or paperback form. The paperback has the advantage of low cost, which allows the student to retain his copy upon completion of the course. Thus, notes can be made in the text, and the student can use the text as a reference in future courses.

Teacher's Guide

The purpose of the Guide is to help the teacher in providing an effective IPS program. Nevertheless, the Guide is not designed to replace a teacher-training workshop.

The Guide contains suggestions related to such topics as: proper use of the text, pre and post laboratory discussions, proper laboratory techniques, solutions to HDL's, judging achievement, and scheduling the course. A description of the purpose, materials, and method of each experiment is provided, as well as answers to the suggested questions. Realistic, sample data is often provided as a basis for evaluating class data.

Laboratory Equipment and Apparatus

Apparatus for use in IPS is developed in the laboratories of the Physical Science Group of Education Development Center and is produced by independent manufacturers. Experiments as described in the IPS text can be performed with the special materials designed at EDC.

The apparatus designed for use in the experiments is available in kit form and can be easily assembled. Minimum room facilities need include only flat-top desks or tables, one sink, and storage space for the peg boards, chemicals, and demonstration apparatus. No electrical or gas outlets are needed at the student's t[illegible]

Achievement Tests

There are three series of IPS Achievement Tests designated A, B, and C. The tests in series A and B are intended for the typical student in IPS, and are at the same level of difficulty.

The tests in series C are easier than those in series A and B. In series A and B there are four unit tests; each test is based on about three chapters of the IPS course and contains approximately 30 objective questions. Series C contains five tests, each dealing with about two chapters.

Little use is made of questions designed only to test a student's memory. Most of the test items present situations in which there is some element slightly different from those in the laboratory or in the textbook. Thus, some judgment is usually required of the student, based on his understanding of principles and procedures.

Films

One new film was produced for the IPS course and four PSSC films have been recommended for use with the course. These films are avilable for purchase or rental.

The films and their recommended use are:

"Elements, Compounds and Mixtures" (PSSC) -- Chapter 6
"Definite and Multiple Proportions" (PSSC) -- Chapter 8
"Crystals" (PSSC) -- Chapter 10
"Behavior of Gases" (PSSC) -- Chapter 10
"Mass of Atoms" (IPS) -- Chapter 11

Constraints, Advantages, and Problems of the IPS Course in Fairfax County

Evaluations of curriculum materials, whether they are formal evaluations or whether they are informal, ought to be done with a clear statement of the objectives of the materials as one of the guides to evaluation. It will be recalled that there are two broad purposes of the IPS course. These purposes are:

1. To provide a foundation in subject matter and develop the appropriate attitudes of inquiry, coupled with the necessary experimental and mathematical skills, needed for more advanced work in science.
2. To serve as a terminal course for the student who will take few or no more science courses.

In addition to the objectives of instructional materials, there is an approach to teaching which often is characteristic of a given set of materials and which needs to be taken into account in evaluating the materials. In the IPS course, the means of accomplishing the objectives is student experimentation with guided reasoning. The approach taken is one which encourages the student to become independent of the teacher -- to learn to make observations, record and analyze data, and draw conclusions on his own.

Finally, there are usually a number of constraints operating when the instructional materials being evaluated are instituted in a school or are tried out in a classroom. Since these do not always work in favor of the set of instructional materials being evaluated, they need to be considered in evaluations of the materials.

In order to get some indication of how successful and how effective the IPS course was in the school systems being used in this study, extensive interviewing and discussions were conducted in the schools. Those interviewed included teachers, principals, directors of instruction, and students. The results of these interviews provided much of the information for judging whether the formal evaluations, based on the models for evaluating used in this study, were in fact valid. In addition, they pointed to the constraints which were operating to reduce the effectiveness of the IPS course.

There were, in addition to the interviews, numerous comments gathered from teachers in a workshop being conducted in the Fairfax school system. These teachers were all teaching IPS, were familiar with the objectives and approach of IPS, and were very much aware of the problems as well as the successes of IPS. The results of these informal observations will be discussed under the general headings of Constraints, Advantages, and Disadvantages.

Constraints

While the IPS program was generally operating successfully in Fairfax County, and had been operating for three years, there were two facts about the way the program was operating which are important in the determination of its effectiveness.

1. The IPS program was intended mainly for ninth graders. In Fairfax County, IPS was the only science program available to eighth graders and was required of all eighth grade students. This presented two major difficulties: (1) reading the text was hard for many students and (2) reaching the high levels of abstraction demanded in IPS was hard for almost all students and impossible for many.

2. The classes in many cases were homogeneous. They were grouped on the basis of their ability to read. This caused serious problems in classes where students of low ability were required to do the IPS course without extensive modification of the materials and the approach.

Advantages of Introductory Physical Science

The advantages of the IPS course, based on interviews and workshops with teachers, over the courses offered in past years are three, and these indicate that some of the objectives of the developers of IPS are being achieved in the classroom. Teachers indicated that the students did develop self-confidence and self-direction in their science work. They felt that the sequential development of the course material, with frequent repitition of concepts and information, was very desirable and that it was successful. And they felt that the course was successful in achieving the goal of giving the students the laboratory skills necessary for further work in science.

The teachers as a whole felt that science courses taught in years past either did not do these three things as well as did IPS or that they did not do them at all. Comments from teachers which indicate how they felt about the three advantages are given here.

Development of Self Confidence in Science

"Students develop a great deal of confidence in themselves and their ability to perform as an individual or as a team. At the beginning of the year, students appeared hesitant to begin on their own in lab. Now (Jan.13), I find that they will come in without any hesitation and have their lab set up ready to work, with a minimum of guidance by the teacher. I have also found that the slower students are more willing to participate in class and are not afraid to give their data and conclusions along with the rest of the class."

"All students enjoy the personal involvement in doing the experiments. All enjoy the stimulation and excitement of 'making' things happen. All enjoy the thrill of discovery when nature proceeds to reveal her secrets to them."

"I feel the main strength in the IPS program is the actual student involvement. They learn by doing and therefore their science has a meaning and not just something to memorize."

Sequential Development of the Course With Repitition of Concepts and Information

"One good point (of the IPS course) is the logical development and the success of the criteria for selection of content -- 'We feel that a topic that appears in our outline only once should not appear at all'."

"The strengths I have found so far (with IPS) are (1) it is laboratory oriented and (2) it is well designed to get step by step (with repitition) to building the atomic model."

Introduction to Laboratory Methods

"In my experience with the course the strength of the program appears to be the experience students can gain in using lab equipment, utilizing achieved math skills, and expanding them and development of or training in reasoning, deducing and concluding."

"All students gain in manipulative skills and all so learn some communication skills because it is always easier to communicate about something you do yourself."

Problems with the Introductory Physical Science Course

The interviews and discussions in the workshop also provided information about the problems encountered with the IPS course in the schools used in the study. Obviously, different teachers encountered different problems when teaching a course. The difficulties encountered with IPS were many, but, even so, the prevailing feeling was the IPS was a better science course than what had previously been offered.

Problems encountered fall under four headings: (1) problems related to the objectives of the IPS course, (2) problems related to the approach of the IPS course, (3) problems related to the content of the IPS course, and (4) problems in general. Two will be considered here.

Problems related to the objectives of the IPS course

The prevailing feeling of those who expressed opinions about the IPS course was that the course was a good science course, but that there were two very serious weaknesses in this course. First, those who were interviewed felt very strongly that the course failed to achieve the objective of providing a good science course for the terminal student. Secondly, and relatedly, they felt that the course leaves serious gaps in the training of all students.

IPS not suitable for the Terminal Student

It will be recalled that one of the broad purposes of IPS was to provide a terminal course for the student who will take no more science. It is reasonable to require that this course be a good course. If the IPS course could achieve the objective of giving the student who will take no more science a "way of learning", if it could teach him to observe, record, analyze, and conclude, then it might be strongly argued that IPS is a good course for the terminal student. But the feeling among those interviewed was that IPS did not accomplish this objective. The terminal student did not learn to learn, nor did he learn much physical science from IPS.

The reasons offered for the failure of IPS to be successful with the terminal student were essentially: (1) the terminal student is normally a student of low ability and cannot grasp enough of the abstract ideas in IPS to understand the course, and (2) the terminal student is behind his grade in reading ability and cannot comprehend what he reads in the textbook.

Typical comments were:

"The major weakness I find in the IPS course is the fact that it is not geared to the below-average student. The instructor has to 'tear her hair out' trying to revise the content of the course in order to make it simpler for these students."

"The IPS course accomplishes its objectives with most of the average and above-average students, which is an excellent recommendation in itself... However, I feel that the main weakness of the IPS program is with the below-average student... A course should be designed which contains the strengths of the IPS course and which benefits the low-ability student."

IPS Leaves Serious Gaps in the Student's science Training

It will be recalled that the developers of the IPS chose a narrow path to the atomic model. They admitted that there are other paths and that other courses could be devised. Nevertheless, the narrow approach taken by the IPS Group omits much of physical science. Those interviewed felt that the narrow approach to physical science left serious gaps in the student's science preparation. The teachers felt that more attention should be given to additional topics in physical science and that more factual information be included in the course. Administrators, as well as teachers, felt that the course was too inflexible to permit remedial or enrichment materials to be used. And students felt the need to know not just about what they were working with but what they were working with too -- names, formulas, etc.

Typical comments were:

"A lot of material involved in physical science is left out using just an approach to the atomic model of matter. I feel that sound, light, electricity, machines and many forces in nature are bypassed in this approach."

"One shortcoming, as I see it, may be that the scope of material presented may be too narrow for a terminal course."

Student - "We work with these materials, but we never know what they are. I would like to know the names of the chemicals."

Problems Related to the Approach of IPS

The course, it will be recalled, attempts to achieve its aims through student experimentation with minimum of direction. The over-arching content aim of the course is the development of the atomic model matter. The approach to this is a step-by-step building of evidence to support the model.

There were two major problems related to the approach of IPS. These were (1) A student who fails at any point in the sequence is hopelessly lost thereafter in the course, and (2) the amount of abstraction required of the student in understanding of the atomic model is more than he can do at this age level.

Typical comments were:

"The students often seem to lose track of the continuity in the course -- they forget important facts that are taught and then later required."

"If a student fails to understand at one point, then more than likely he is lost."

"The major weakness of the course is that it requires some students, who are not yet capable, to think abstractly. To force this upon them can cause them to rebel."

APPENDIX B

DEVELOPMENT OF AN IPS STUDENT CHECKLIST

The IPS Student Checklist was written, validated, and revised for use as a part of this study. Serious misgivings expressed by the county personnel, however, made it unwise to use the checklist for its intended purpose. It is included here because it provides a useful and convenient means, for anyone wishing to use it, of examining an IPS class to see if the course is being conducted as the developers intended that it be. Although the checklist was not used in the study, several teachers volunteered to use it in their classes. All commented that the students "really liked it."

Development of an IPS Student Checklist

Purpose of the IPS Student Checklist

Whenever any product or a developer of curriculum materials is evaluated, it is only fair to evaluate it in terms of the purposes for which it was intended and in the kind of environment conceived for it. The quantitative measures applied to the IPS course in this study can only have meaning if the course was taught the way it is supposed to be taught. Several informal observations were made to determine whether the "spirit" of the IPS was being upheld in the classrooms of the teachers whose classes were used in this study. Some of these were guaranteed in the recording of the data itself. The teacher had to give the IPS Achievement Tests, for instance, and she had to record the students' scores on these tests. Most of these observations, however, were based on visits to the classrooms. During these visits, the teachers and the students discussed their opinions of IPS, its worth, and its effectiveness. The results of these visits have been discussed in Appendix A of this report.

The IPS Student Checklist was devised (1) as a means of getting a better idea of the extent to which the objectives and the approach, as advocated by the developers of the IPS course, were being practiced in the classroom and (2) to provide a means for checking the validity of the informal observations. It is important to note that the Checklist was designed to elicit from the student answers which would indicate how closely the teacher was following the IPS approach.

There were several problems with the IPS course. These have already been discussed in Appendix A of this report. Quite obviously, teachers cannot be expected to follow an approach to teaching which simply does not work. Nevertheless, in developing and validating the Checklist, it was the guiding principles of IPS, as published by its developers, that determined what questions the students would be asked.

Writing Questions for the IPS Checklist

In the section of this report entitled "Objectives and Approach of IPS", the behaviors expected of students and teachers in the course have been documented in detail. The summary which appears there was taken from publications of the IPS Group, and each statement takes the form of what should go on in the various segments of the IPS course.

On the basis of this summary, ninety-one questions with "yes" or "no" answers were written to represent all the divisions and subdivisions of the summary.* Following is a list of the divisions and subdivisions and the number of questions written for each.

	Number of Questions	
Teacher Practices in the Classroom - 47		
General Practices	25	
Pre-lab	2	
Lab	8	
Post-lab	4	
Lab Notebooks	8	- 47
Student Behavior - 19		
Classroom behaviors	17	
Outside behaviors	2	- 19
Use of Textbook Material -	3	- 3
Use of HDL Problems	9	- 9
Testing and Evaluation	13	- 13
		91

Validation of questions for the IPS Checklist

To provide data for determining the validity of the Checklist, the ninety-one questions were given to sixteen teachers in an IPS workshop being conducted during the study but involving no teachers participating in the study. These teachers had spent one and one-half semesters in the workshop studying the IPS course, the content as well as the objectives and approach. They ranged in teaching experienee from one-half year to three years teaching IPS. Some had previous work in either IPS institutes or workshops. The teachers were instructed to answer the questions, not as they would approach IPS, but as they believed the developers of the course would have them approach it.

The questions were also given to two Instructors of workshops in IPS in order to provide a check on the answers given by the teachers. The data collected from the administration of the ninety-one questions appears in the following table.

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*A copy of the ninety-one questions is included in Appendix C of this report.

TABLE 1

FREQUENCIES OF RESPONSE OF TEACHERS AND INSTRUCTORS TO THE NINETY-ONE QUESTIONS FOR THE IPS STUDENT CHECKLIST

Question Number	Teachers Yes	Teachers No	Instructors Yes	Instructors No
1	1	15	0	2
2	14	2	2	0
3	4	12	0	2
4	5	11	1	1
5	4	12	0	2
6	4	12	0	2
7	14	2	2	0
8	0	16	0	2
9	6	10	0	2
10	13	3	2	0
11	1	15	0	2
12	14	2	2	0
13	5	11	0	2
14	9	7	0	2
15	3	13	1	1
16	1	15	0	2
17	1	15	0	2

TABLE 1 CONTINUED

Question Number	Teachers Yes	Teachers No	Instructors Yes	Instructors No
18	1	14*	1	1
19	2	14	0	2
20	0	16	0	2
21	1	15	0	2
22	8	8	1	1
23	15	1	2	0
24	16	0	2	0
25	2	14	0	2
26	16	0	1	1
27	16	0	2	0
28	16	0	2	0
29	15	1	2	0
30	15	1	2	0
31	1	15	0	2
32	13	3	2	0
33	2	14	0	2
34	9	7	2	0
35	3	13	0	2
36	14	2	2	0
37	15	1	2	0

TABLE 1 CONTINUED

Question Number	Teachers Yes	Teachers No	Instructors Yes	Instructors No
38	6	8	1	1
39	16	0	2	2
40	2	14	0	0
41	1	15	0	2
42	14	2	2	0
43	11	5	2	0
44	11	5	2	0
45	12	4	2	0
46	16	0	2	0
47	15	1	2	0
48	13	3	2	0
49	16	0	2	0
50	16	0	2	0
51	2	14	0	2
52	16	0	2	0
53*	4	11*	2	0
54	11	5	2	0
55	16	0	2	0
56	1	15	0	2
57	16	0	2	0

TABLE 1 CONTINUED

Question Number	Teachers Yes	Teachers No	Instructors Yes	Instructors No
58	16	0	2	0
59	16	0	2	0
60	9	7	1	1
61	3	13	0	2
62	16	0	2	2
63	12	4	2	0
64	15	1	2	0
65	15	1	2	0
66	15	1	2	0
67	5	11	1	1
68	10	6	2	2
69	15	1	2	0
70	3	13	0	2
71	2	14	0	2
72	12	4	2	0
73	9	7	1	1
74	3	13	0	2
75	4	12	0	2
76	6	10	2	0
77	1	15	0	2

TABLE 1 CONTINUED

Question Number	Teachers Yes	Teachers No	Instructors Yes	Instructors No
78	13	3	2	0
79	11	5	2	0
80	16	0	1	1
81	14	2	2	0
82	9	7	1	1
83	5	11	1	1
84	12	4	2	0
85	13	3	2	0
86	16	0	2	0
87	0	16	0	2
88	0	16	0	2
89	0	16	0	2
90	1	15	0	2
91	16	0	2	0

*A copy of the IPS Student Checklist is included in Appendix D of this report

Questions on which there was strong disagreement among the teachers and the instructors were discarded. Questions which were unclear were revised. From the remaining questions, seventy-five were selected for the IPS Student Checklist.* The answers were given as a "True" (T) or "False" (F) choice to make it less confusing to the students completing the Checklist.

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*A copy of the IPS Student Checklist is included in Appendix D of this report.

APPENDIX C

IPS STUDENT CHECKLIST
PRELIMINARY VERSION

Introductory Physical Science Student Checklist

Instructions to Workshop Teachers

The following questions have been written to reflect the objectives and approach the developers of Introductory Physical Science have adopted. This is not to say that their approach is the most desirable, or that you, as an IPS teacher, should adhere strictly to the approach. A careful effort has been made to reflect the IPS approach in these questions, however, so that students' opinions can be used as an indicator of how closely their teacher follows the objectives and approach advocated by the IPS Group.

You have spent several months studying the IPS course content, and the objectives and approach as well. Please answer each of the questions with a "yes" or a "no". Answer according to the published wishes of the IPS Group not according to what you believe or what you do. This might be contrary to the intentions of the IPS Group - which is, of course, acceptable!

Instructions to Students

Here are 91 very simple questions about your IPS science course. Answer the questions by blacking a circle on either "yes" or "no". Be sure to read the questions carefully. They can be misleading if you do not.

There are no "right" or "wrong" answers. The way you answer can in no way affect your grade. It is important that you be as sincere as you possibly can.

There is no time limit. Answer as quickly as you can. A sample question has been answered for you.

Sample

The IPS textbook is blue. ~~Yes~~ No

Proceed

TEACHER PRACTICES IN THE CLASSROOM

General Practices

My teacher always gives me answers to my questions.	yes no
My teacher often says, "You must find out for yourself."	yes no
My teacher will accept only one way of writing my lab report.	yes no
My teacher only does the experiments which are too hard for us to do.	yes no
My teacher goes too fast for the class.	yes no
My teacher tells us that scientists are really something special.	yes no
My teacher makes me guess what will happen in an experiment and try it out to see.	yes no
We often skip experiments and come back to them later.	yes no
When I miss a day of school, I have to stay after school and do any experiments I have missed.	yes no
When I want to, I am told that I can do experimenting at home.	
Once a chapter is completed, we do not go back to it.	yes no
My teacher often asks students to explain certain sections of the textbook.	yes no
We often use other textbooks instead of our IPS textbook.	yes no
Our teacher often gives the right answer to questions being discussed in the class.	yes no
We are told not to guess the answer to a question before running an experiment.	yes no
Our teacher often lectures on an experiment and then does the experiment for the class.	yes no
In grading our written assignments, our teacher does not require correct English.	yes no
We do not often discuss questions other than those in the textbook.	yes no
Our teacher told us that the math in IPS was pretty difficult .	yes no
My teacher does not like for students to disagree with him (her).	yes no
We are required to be very quiet while conducting experiments.	yes no
Often, different pairs of students are doing different experiments.	yes no
We usually discuss the purpose of the experiment before every lab.	yes no
Histograms are often used in analyzing class data.	yes no
Before we do an experiment, the teacher often tells the class what to expect.	yes no

Laboratory Practices

Pre-lab

When I come to class to do an experiment, all the materials I need are ready for me.	yes	no
My teacher always discusses the experiment before we do it (Pre-lab).	yes	no

Lab

Two students work together for most experiments.	yes	no
My teacher makes us observe a set of rules for the laboratory	yes	no
We always have to wear safety goggles when we are doing an experiment with heat, chemicals, or gas pressure.	yes	no
To save chemicals, we have to put what we do not use back into the storage jars.	yes	no
My teacher comes around to ask me questions about the experiment while I am doing it.	yes	no
My teacher tells us exactly what to do in the laboratory	yes	no
My teacher lets us decide what to do for ourselves in the laboratory	yes	no
When I ask my teacher a question I always get the right answer to it.	yes	no

Post-lab

My teacher always discusses the experiment the day after we have finished it.	yes	no
When the teacher discusses the experiment he (she) uses the data from the whole class.	yes	no
When we think there has been an error in the experiment, our teacher has us do it over.	yes	no
We have conclusions about our own experiments and also conclusions from the class discussion.	yes	no

Lab Notebooks

Our lab notebook is seldom used in answering questions in the text.	yes	no
We do not often put graphs in our notebook to help us interpret the data.	yes	no
My teacher makes us keep a lab notebook	yes	no
My teacher checks my lab notebook while I am doing the experiment to see if I am recording my observations	yes	no

My teacher will not let us use scratch paper to record our observations.	yes	no
My teacher always checks my laboratory report to see that it is neat and accurate.	yes	no
My teacher makes us write down our conclusions in our lab notebooks.	yes	no
We sometimes have tests on our lab notebooks.	yes	no

Student Behaviors

Classroom behaviors

I do my own work when we do an experiment.	yes	no
I keep a neat and accurate record of what I do in the laboratory.	yes	no
I like to do the experiments.	yes	no
I think scientists possess magical powers.	yes	no
When I do not know much about something, I can learn about it by observing it.	yes	no
When I guess what will happen in an experiment, I try it and it usually does happen.	yes	no
I sometimes get results for my experiment that are different from the other students. When I do, I can almost always explain them.	yes	no
I am always careful when I do an experiment so that I will not get hurt or hurt someone else.	yes	no
Science deals with absolute truths -- right answers.	yes	no
I ask for evidence to support what I read and hear.	yes	no
This course has helped me become a better thinker.	yes	no
Students are curious about the results other students get in experiments.	yes	no
Students do not go to work as soon as they enter the IPS classroom.	yes	no
We find very few answers in our IPS course.	yes	no
Most of the people in my class are interested in this course.	yes	no
This course has helped improve my reading.	yes	no
I believe that my math has been improved by this course	yes	no

Outside behaviors

I like to work in science projects at home.	yes	no
I always come to class ready to do my experiments.	yes	no

Use of the Textbook Material

My teacher assigns me work in my textbook about every day.	yes	no
We never skip over part of the textbook.	yes	no
Sometimes my teacher reads the textbook aloud with us.	yes	no

Use of H,D,L Problems

The HDL problems do not cover the same material we are doing in class.	yes	no
We have to do all of the HDL problems in the textbook.	yes	no
We always go over the HDL problems in class and discuss them.	yes	no
My teacher always tells us if our HDL problems are right or wrong.	yes	no
Most of the HDL's are difficult.	yes	no
All students are assigned the same HDL's for homework.	yes	no
We do not spend much class time on HDL's.	yes	no
All HDL's are assigned when we finish a chapter in the text.	yes	no
I work some of the HDL's for fun.	yes	no

Testing and Evaluation

We have to take the IPS Achievement Tests.	yes	no
My teacher makes notes on our behavior in the laboratory	yes	no
We always go over the tests in class and learn what we missed.	yes	no
My teacher makes easier tests than the IPS Achievement Tests.	yes	no
My teacher always checks our HDL problems.	yes	no
My teacher always checks our lab notebooks.	yes	no
We often have short quizzes on the classwork or the laboratory work.	yes	no
We have laboratory tests.	yes	no
We have long tests about once a week.	yes	no
Our teacher often gives us a list of words and their definitions to be memorized.	yes	no
I believe that the major part of my total class grade is determined by grades on tests.	yes	no
It is difficult to get a good grade in IPS.	yes	no
The grades I receive in this course are fair.	yes	no

APPENDIX D

IPS STUDENT CHECKLIST
REVISED FORM

Introductory Physical Science Student Checklist

Here are 75 very simple questions about your IPS science course. Answer the questions by blacking either True, "T" or False, "F". Be sure to read the questions carefully. They can be misleading if you do not.

There are no "right" or "wrong" answers. The way you answer can in no way affect your grade. It is important that you be as sincere as you possibly can.

There is no time limit. Answer as quickly as you can. A sample question has been answered for you.

Sample:

The IPS textbook is blue. T F

Proceed.

1. Our teacher often lectures on an experiment and then does the experiment for the class. T F
2. We use the IPS book as a textbook, although we may use other books for reading. T F
3. Often, different pairs of students are doing the same experiment in slightly different ways. T F
4. My teacher does not like for students to disagree with him (her). T F
5. Our teacher says that questions are either right or wrong and never in doubt. T F
6. My teacher often asks students to explain certain sections of the textbook. T F
7. In grading our written assignments, our teacher requires correct English. T F
8. We often skip experiments and come back to them later T F
9. My teacher tells us that scientists are geniuses with special powers. T F
10. My teacher sometimes says, "You must find out for yourself." T F
11. We are required to be very quiet while conducting experiments. T F
12. We are told to guess the answer to a question before running an experiment. T F
13. My teacher likes for me to guess what will happen in an experiment and try it out to see. T F
14. Once a chapter is completed, we do not go back to it. T F

15. I am told that I can do experiments at home, if I can find the equipment.	T	F
16. Histograms are often used in analyzing class data.	T	F
17. Before we do an experiment, the teacher tells the class what to expect.	T	F
18. My teacher likes for me to write any lab report the same way every time.	T	F
19. My teacher always gives me answers to my questions.	T	F
20. We often discuss questions other than those in the textbook.	T	F
21. My teacher checks my lab notebook while I am doing the experiment to see if I am recording my data	T	F
22. My teacher sometimes comes around to ask me questions about the experiment while I am doing it.	T	F
23. My teacher makes us write down our conclusions in our lab notebooks.	T	F
24. My teacher makes us observe a set of rules for the laboratory.	T	F
25. My teacher always discusses the experiment before we do it (Pre-lab).	T	F
26. Our lab notebook is seldom used in answering questions in the text.	T	F
27. My teacher has us keep a lab notebook.	T	F
28. To save chemicals, we have to put what we do not use back into the storage jars.	T	F
29. We often put graphs in our notebooks to help us interpret the data.	T	F
30. My teacher always discusses the experiment soon after we have finished it.	T	F
31. My teacher checks my laboratory report to see that it is neat and accurate.	T	F
32. When the teacher discusses the experiment he (she) uses the data from the whole class.	T	F
33. When the whole class "goofs" on an experiment, our teacher has us do it over.	T	F
34. When I come to class to do an experiment, all the materials I need are ready for me to get and use.	T	F
35. My teacher will not let us use scratch paper to record our observations.	T	F
36. My teacher tells us exactly what to do in the laboratory.	T	F
37. Two students work together for most experiments.	T	F
38. We have conclusions about our own experiments and also conclusions from the class discussion.	T	F
39. We always have to wear safety goggles when we are doing an experiment with heat, chemicals, or gas pressure.	T	F

40. We sometimes have tests on our lab notebooks. T F
41. Students come to class and start working on their experiments without having to be told to. T F
42. I am always careful when I do an experiment that is different from the other students. When I do, I try to explain them. T F
43. I always come to class ready to do my experiments. T F
44. This course has helped me become a better thinker. T F
45. I read my own data when we do an experiment. T F
46. I believe that my math has been improved by this course. T F
47. I like to do the experiments. T F
48. I like to work on science projects at home. T F
49. When I do not know much about something, I can learn about it by observing it. T F
50. Most of the people in my class are interested in this course. T F
51. I keep a neat and accurate record of what I do in the laboratory T F
52. I sometimes get results for my experiment that are different from the other students. When I do, I try to explain them. T F
53. Students are curious about the results other students get in experiments. T F
54. Science deals with absolute truths -- right answers. T F
55. I ask for evidence to support what I read and hear. T F
56. We always go over the assigned HDL problems in class and discuss them. T F
57. My teacher makes notes on our behavior in the laboratory. T F
58. My teacher assigns me a little work in my textbook regularly rather than a lot infrequently T F
59 All HDL's are assigned when we finish a chapter in the text. T F
60. The grades I receive in this course are fair. T F
61. We often have short quizzes on the classwork and the laboratory work. T F
62. Sometimes my teacher reads the textbook aloud with us. T F
63. Most of the HDL's are difficult. T F
64. We have long tests about once a week. T F
65. The HDL problems cover the same material we are doing in class. T F
66. We always go over tests in class and discuss what we missed. T F
67. All students are assigned the same HDL's for homework. T F
68. Our teacher often gives us a list of words and their definitions to be memorized. T F

69. We have to do all of the HDL problems in the textbook.	T	F
70. We spend a lot of time on HDL's in class.	T	F
71. I work some of the HDL's for fun.	T	F
72. My teacher makes easier tests than the IPS Achievement Tests.	T	F
73. I believe that the major part of my total class grade is determined by grades on tests.	T	F
74. We have laboratory tests.	T	F
75. My teacher always checks our lab notebooks.	T	F

APPENDIX E

CHARACTERISTICS OF PARTICIPATING SCHOOLS

SCHOOL SYSTEM: ______________________ DATE: ____________
SCHOOL: ______________________ OBSERVER: ____________
TEACHER: ______________________
PERIOD: ______________________

School:

Size ____________ Age ________ Economic Level H M L
Number of years IPS offered ________
Number of teachers teaching IPS ________
Number of students enrolled in IPS ________
Number of students enrolled in 8th grade ___
Special characteristics of the school ______________

____

Teacher:

Years of teaching experience ________
Type of certificate held ________
Years of experience in teaching IPS ________
Special preparation for teaching IPS -- Yes ______ No ______
If yes, explain ______________________

____

Teacher recommends IPS for the following type of student:
(1) Slow Learner ________ (2) Under-achiever ______ (3) Average ___
(4) Over-achiever ________ (5) Accelerated ________

Equipment:

Equipment available ______________ (Date)
Quantity available: (1) Not sufficient ________ (2) Barely adequate ___
(3) Adequate ________ (4) As recommended by IPS ____________

Class:

Size: 10-15 ______ 15-20 ______ 20-25 ______ 30-35 ______
Age Level: Low ______ Average ______ High ______
Ability Level: Low ______ Average ______ High ______
Reading Level: Low ______ Average ______ High ______
Sex ____________ % Girls ______ Boys
Homogeneous Grouping: Yes ____________ No ______
Type of Program: (1) Slow Learners ________ (2) Vocational ______
(3) College Prep ________
Progress as to time schedule of IPS course: Slow ___ Avr. ___ Fast ___
Special class characteristics: ______________

____

____

Attitude of teacher consistent with philosophy of IPS:
(1) Very low ____ (2) Low ____ (3) Average ____ (4) Good ________
(5) Excellent ________

Teacher's opinion as to the effectiveness of IPS with students.
(1) Very low____ (2) Low____ (3) Average____ (4) Good__________
(5) Excellent__________
Teacher would teach IPS again: Yes__________ No__________

Comment:__________

Schools Participating in the Evaluation of the IPS Course: General and Special Characteristics*

Fairfax County Schools

1. Bryant Intermediate — 6500 Quander Road, Alexandria, Virginia, 22307

I. School Characteristics

A. School size -- approximately 1000
B. School age -- nine years
C. Years of offering IPS -- three
D. Number of teachers teaching IPS - three
E. Number of students enrolled in IPS - approximately 400 eighth graders
F. Economic level of school population -- the students were distributed about evenly among high, middle, and low income families

II. Teacher characteristics (participating teacher)

A. Years teaching - ninetten
B. Certificate - Postgraduate Professional
C. Years teaching IPS - three
D. Special preparation for IPS - Institute at the University of Nebraska, Summer 1967
E. Observational Rating of Participating Teacher
I observed Mr. A in action in the IPS classroom four times during the course of the project. The students in his low ability classes showed great interest in the course and exhibited independence in their approach to learning. Mr. A presented the students with a well-ordered situation which encouraged their interest and their independence. In his high ability classes, the students, while a bit noisy, were well behaved and exceptionally mature in their approach to IPS. I would rate Mr. A about 4 on a scale from 1 to 5.

III. Special Constraining Characteristics of School or class

I noticed nothing about the school or the classes that I observed which would need special consideration in

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*Based on visits and interviews with teachers and school officials and summarized before the data analysis.

data analysis. The classes were, of course, grouped by ability, but the data for this consideration were being collected on the data form. If one can say that any school is typical, I suppose it could be said of this one. At least there was nothing obviously atypical about it.

2. Glasgo Intermediate   4101 Fairfax Parkway
Alexandria, Virginia, 22310

I. School Characteristics

A. School size -- 891
B. School age -- ten years
C. Years offering IPS -- three
D. Number of teachers teaching IPS -- three full time, one with one class
E. Number of students enrolled in IPS -- 458
F. Economic level of school population -- there was a concentration of families in high income and low income groups with not many in the middle income group

II. Teacher Characteristics (participating teacher)

A. Years teaching -- nine
B. Certificate -- Collegiate Professional
C. Years teaching IPS -- three
D. Special preparation for IPS -- First year in-service workshop in Fairfax County
E. Observational rating of teacher
I observed Mrs. B three times during the course of the project. She was a superb teacher during the times I saw her working. At times, however, she gave answers and directions when students could have been allowed to do for themselves. I would rate Mrs. B 4.5 on a five-point scale.

III. Special Constraining Characteristics of School or Class

Mrs. B was considered a superb teacher, but she was surrounded by IPS teachers and school officials who were more inclined to talking about problems than acting to solve them. The science department suffered from a high rate of teacher turnover. Two science teachers had to stop teaching on orders from their doctors last year. An additional science teacher had quit last year and another this year. Only Mrs. B remains with experience in teaching IPS. The other teachers were not familiar with IPS and were having a great deal of difficulty with it.

The assistant principal for administration and instruction complained bitterly about the problems with IPS -- notably the difficulty students were having reading the textbook -- but did not offer suggestions for solving any problems.

3. Luther Jackson Intermediate   3020 Gallows Road
Merrifield, Virginia, 22116

I. School Characteristics

A. School size -- approximately 1400
B. School age -- ten years
C. Years offering IPS -- three
D. Number of teachers teaching IPS -- four
E. Number of students enrolled in IPS -- approximately 400 eighth graders
F. Economic level of school population -- the school drew from predominantly high and middle income families

II. Teacher Characteristics -- (Participating teacher)

A. Years teaching - about ten
B. Certificate -- College Professional
C. Years teaching IPS -- two
D. Special preparation - Institute at the University of Nebraska, Summer 1968
E. Observational Rating of Participating teacher
I observed Mr. C in the classroom three times during the course of the project. I would describe his classes as excellently conducted. The students were well behaved, attentive, responsive and knowledgeable. Mr. C presented his classes with well planned experiences to which they responded with eagerness. I would rate Mr. C at about 5 on a scale of 1 to 5.

III. Special Constraining Characteristics of School or Class

One very obvious characteristic of this school I noticed, as I believe anyone would, on my first and all subsequent visits. The school was efficiently run. There was no running in the hallways, the building and its rooms were always quiet and clean, but yet the students showed a remarkable enthusiasm for school and for learning. They were alert, respectful and interested. Mr. C believed that you must win the confidence and faith of the student if you were to be successful in teaching IPS -- apparently, this attitude prevailed at the school.

4. Thoreau Intermediate   2505 Cedar Lane
Vienna, Virginia, 22180

I. School Characteristics

A. School size -- 1250
B. School age -- about ten years
C. Years offering IPS -- three
D. Number of teachers teaching IPS -- four
E. Number of students enrolled in IPS -- 650 eight graders
F. Economic level of school population -- the school drew from predominantly high and middle income families, tending toward high.

II. Teachers Characteristics (participating teacher)

A. Years teaching - seventeen
B. Certificate - Collegiate Professional
C. Years teaching IPS - three
D. Special preparation for teaching IPS - in-service workshop in Fairfax County first year
E. Observational Rating of Participating teacher
I observed Mrs. D three times during the project. She was an unusual teacher. I cannot tell how effective she was. With the slower classes she was deliberate and authoritative. She did not let the students do very much work on their own. With the more able classes she was quite the opposite. She emphasized the "correctness" of responses to questions, and what was correct was what she herself had in mind. Interest in IPS was high in low ability classes, but it waned as the period was about half finished. She admitted that she taught for the IPS tests, coaching the students on the "type of question to learn." I would rate Mrs. D 2 on a scale of 1 to 5.

III. Special Constraining Characteristics of School or Class

I noticed nothing unusual about the school or classes. If there is a typical school, I suppose this one would be typical.

5. Twain Intermediate — 4700 Franconia Road, Alexandria, Virginia, 22310

I. School Characteristics

A. School size -- 890
B. School age -- about ten years
C. Years offering IPS -- three
D. Number of teachers teaching IPS -- three
E. Number of students enrolled in IPS - 390 eighth graders
F. Economic level of school population -- the school drew students from middle to low income families; "pretty nearly normal."

II. Teacher Characteristics (participating teacher)

A. Years teaching - fifteen
B. Certificate - Postgraduate Professional
C. Years teaching IPS - three
D. Special preparation for IPS- First year in-service workshop in Fairfax County
E. Observational Rating of Participating teacher
I observed Mr. E three times during the project. His classes were conducted more in the manner of a military drill than a science class. He got good response from his classes, however, but it was not possible to tell whether this was for the benefit of the "visitor" or if it was the accustomed manner of the classes. Mr. E believed IPS could be taught in periods half the length of those he now had (about 50 minutes). He taught half the year on a split-shift in which the periods were about 30 minutes long. I would rate Mr. F about 2 on a scale of 1 to 5 points.

III. Special Constraining Characteristics of School or Class

For one semester, the school was run on a double-shift basis to handle students assigned to a new school which was late opening. According to Mr. E the half day with thirty-minute periods did not affect the students' performance on IPS.

6. Whittier Intermediate — Hillwood and Cherry Streets, Falls Church, Virginia, 22042

I. School Characteristics

A. School size -- approximately 1100
B. School age -- about nine years
C. Years offering IPS -- three
D. Number of teachers teaching IPS -- four
E. Number of students teaching IPS -- about 500 eight graders
F. Economic level of school population -- the school had no concentration of families in either the high or the low income groups.

II Teacher Characteristics - (Participating teacher)

A. Years teaching - six
B. Certificate - Postgraduate Professional
C. Years teaching IPS - three
D. Special Preparation for IPS - IPS workshop at Bethany College under Marvin Williams
E. Observational Rating of participating teacher
I observed Mr. F three times during the project. His classes were conducted in a way which encouraged students to participate, and they did. Students were very knowledgeable and enthusiastic about IPS. I would rate Mr. F 5 on a scale from 1 to 5

III. Special Constraining Characteristics of School or Class

The school was exceptionally well run. I would say that Whittier and Luther Jackson were the two best schools in the project -- from the standpoint of efficiency and smoothness of school operation. One thing that is worthy of note about Whittier is the fact that the administration expressed complete confidence in the school staff. They appeared to me to deserve that confidence, too, for each was exceptionally well prepared in science and each was a very good classroom teacher.

7. Poe Intermediate — 7000 Cindy Lane, Annandale, Virginia, 22003

I. School Characteristics

A. School size -- about 1000

B. School age -- about ten years
C. Years offering IPS -- three years
D. Number of teachers teaching IPS -- four
E. Number of students enrolled in IPS -- about 700
F. Economic level of school population -- students were distributed about evenly among high, middle, and low income families.

II. Teacher Characteristics

A. Years teaching -- about fifteen
B. Certificate - unknown
C. Years teaching IPS - three
D. Special preparation for IPS - in-service workshop
E. Observational Rating of participating teacher
I observed Miss G three times during the course of the project. Her classes were always efficiently run. She showed concern for the classes in her department and had made an obvious effort to provide them with the best equipment available. Students in her classes showed enthusiasm for IPS and other science topics as well. I would rate Miss G 4 on a scale of 1 to 5

III. Special Constraining Characteristics of School or Class

None noted

APPENDIX F

FORM FOR COLLECTING DATA

[illegible]OOL: ____________________ SCHOOL ADDRESS: ____________________ BEGINNING DATE OF COURSE: ____________

[illegible]: ____________________ [illegible]: ______ ____________________ [illegible]: ____________

Home Telephone No. of Teacher: ____________

STUDENT'S NAME	AGE	SEX	I.Q.	IOWA SILENT READING	PRE DAT TEST DATE OF: ______								IPS ACHIEVEMENT TEST				6 or 9 WEEKS GRADE						GRADE	POST DAT TEST DATE OF TEST: ______							
					Verbal Reasoning	Numerical Ability	Abstract Reasoning	Clerical Speed and Accuracy	Space Relations	Spell / Language Usage / Gram	Mechanical Reasoning	I DATE:	II DATE:	III DATE:	IV DATE:	1st	2nd	3rd	4th	5th	6th	FINAL	Verbal Reasoning	Numerical Ability	Abstract Reasoning	Clerical Speed and Accuracy	Space Relations	Spell / Language Usage / Gram	Mechanical Reasoning

APPENDIX G

REGRESSION EQUATIONS USED IN COMPLETING PARTIAL RECORDS

Regression Equations for Predicting Missing Data Points*

From cards containing the thirty-three items of information on the data form, the following is a summary of the imput used in the regression analysis:

Item	Code	Operation	Input Variable	Variable No.
2	1,2	generation	two categories for sex	1,2
3	None	transfer	continuous IQ vector	3
4	None	transfer	continuous reading score vector	4
5	None	transfer	continuous pre scoe Verbal Reasoning vector	5
6	None	transfer	continuous pre score Numerical Ability vector	6
7	None	transfer	continuous pre score Abstract Reasoning vector	7
8	None	transfer	continuous pre score Clerical Speed and Accuracy vector	8
9	None	transfer	continuous pre score Space Relations vector	9
10	None	transfer	continuous pre score Language Usage (spelling) vector	10
11	None	transfer	continuous pre score Language Usage (grammar) vector	11
12	None	transfer	continuous pre score Mechanical Reasoning vector	12
32	1 - 7	generate	seven categories for school	13 - 19
13	None	transfer	continuous Achievement Test I vector	20
14	None	transfer	continuous Achievement Test II	21
24	None	transfer	continuous post score Verbal Reasoning vector	22
25	None	transfer	continuous post score Numerical Ability vector	23
27	None	transfer	continuous post score Clerical Speed and Accuracy vector	24
28	None	transfer	continuous post score Space Relations vector	25
29	None	transfer	continuous post score Language Usage (spelling) vector	26
30	None	transfer	continuous post score Language Usage (grammar) vector	27

To predict IQ, variable numbers 1-2 and 4-19 were used and yielded an R^2 of .76.

To predict Reading scores, variable numbers 1-3 and 5-19 were used and yielded an R^2 of .86.

To predict pre scores on Space Relations, variable numbers 1-8 and 10-19 were used and yielded an R^2 of .56.

To predict pre scores on Language Usage (spelling), variable numbers 1-19 and 11-19 were used and yielded an R^2 of .54.

To predict Achievement Test I scores, variable numbers 1-19 were used and yielded an R^2 of .57.

To predict Achievement Test II scores, variable numbers 1-19 were used and yielded an R^2 of .65.

To predict post scores on Clerical Speed and Accuracy, variables numbers 1-19 were used and yielded an R^2 of .55.

To predict post scores on Space Relations, variable numbers 1-19 were used and yielded an R^2 of .71.

To predict post scores on Language Usage (spelling), variables 1-19 were used and yielded an R^2 of .75.

To predict post scores on Language Usage (grammar), variable numbers 1-19 were used and yielded an R^2 of .75.

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*These equations were derived using the Applied Multiple Linear Regression approach developed by R. A. Bottenberg and J. Ward. The Burroughs B5500 computer at the University of Virginia Computer Science Center was used in the computations.

BIBLIOGRAPHY

Books.

Bloom, Benjamin S. (ed.). Toxonomy of Educational Objectives. Handbook I. Cognitive Domain. New York: Longmans, Green and Company, 1956.

Brandwein, Paul F., Fletcher G. Watson, and Paul E. Blackwood. Teaching High School Science: A Book of Methods. Harcourt Brace and World, 1958.

Bruner, Jerome S. On Knowing. Cambridge, Massachusetts: The Belknap Press of Harvard University, 1963.

Bruner, Jerome S. The Process of Education. Cambridge, Massachusetts: Harvard University Press, 1963.

Buros, O.K. (ed.). The Fifth Mental Measurements Yearbook. Highland Park, New Jersey: The gryphon Press, 1959.

Campbell, Donald T., and Julian C. Stanley. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally and Company, 1966.

Dewey, John. How We Think. Boston: D.C. Heath and Company, 1933.

Ford, G.W., and Lawrence Pugno (ed.). The Structure of Knowledge and the Curriculum. Chicago: Rand McNally and Company, 1964, "Introduction" by B.O. Smith.

Grobman, Hulda. Evaluation Activities of Curriculum Projects. AERA Monograph Series on Curriculum Evaluation, No. 2, Chicago: Rand McNally and Company, 1968, pp. 1 - 2.

Introductory Physical Science. Englewood Cliffs, New Jersey: Prentice-Hall, Incorporated, 1967.

Lindquist, E. F. Design and Analysis of Experiments in Psychology and Education. Boston: Houghton Mifflin Company, 1956.

MacDonald, James B., Dan W. Anderson, and Frank B. May (editors). Strategies of Curriculum Development, Selected Writings of The Late Virgil E. Herrick. Columbus, Ohio: Charles E. Merrill Books, Incorporated, 1965.

National Society for the Study of Education. A Program for Teaching Science. Thirty-First Yearbook, Part I. Chicago: University of Chicago Press, 1932.

Physical Science Study Committee. Physics. Boston: D.C. Heath and Company, 1960.

Smith, Eugene R. and Ralph W. Tyler. Appraising and Recording Student Progress. Progressive Education Association Adventures in American Education. New York: McGraw-Hill Book Company, 1942.

Taba, Hilda. Curriculum Development: Theory and Practice. New York: Harcourt, Brace and World, Incorporated, 1962.

Teachers Guide to Introductory Physical Science, Prentice-Hall, Inc. 1967.

Tyler, Ralph W. Basic Principles of Curriculum and Instruction: Syllabus for Education 305. Chicago: University of Chicago Press, 1950.

Tyler, Ralph. Constructing Achievement Tests. Columbus, Ohio: The Ohio State University Press, 1934.

Wert, James E., Charles O. Neidt, and J. Stanley Ahmann. Statistical Methods in Educational and Psychological Research. New York: Appleton-Century-Crofts, Incorporated, 1954.

Articles and Periodicals.

Gagne, Robert M. and Noel E. Paradise. "Abilities and Learning Sets in Knowledge Acquisition," Psychological Monographs: General and Applied, Vol. 75 (1961).

Gagne, Robert. "Curriculum Research and the Promotion of Learning," Perspectives of Curriculum Evaluation, AERA Monograph Series on Curriculum Evaluation, No. 1, Chicago: Rand McNally and Company, 1967, p. 19.

Gavurin, E. I., and Virginia M. Donahue. "Logical Sequence and Random Sequence," Automated Teac hing Bulletin, Vol. I (1961).

Iowa Tests of Basic Skills. Manual for Administrators, Supervisors, and Counselors. Boston: Houghton Mifflin Company, 1956.

Haber-Schaim, Uri. "Introductory Physical Science Accent on Implementation," Introductory Physical Science, Physical Science II: A Progress Report, Newton, Massachusetts: Educational Development Corporation (undated).

Haber-Schaim. "Objectives and Content of The Introductory Physical Science Course," ESI Quarterly Report, Summer-Fall, 1965, Watertown, Massachusetts: ESI, 1965.

Jacobson, Milton D. "Reading Difficulty of Physics and Chemistry Textbooks," Journal of Educational and Psychological Measurement, June, 1965.

Levine, Gerald R. and Bruce L. Baker. "Item Scrambling in a Self-Instructional Program," Journal of Educational Psychology, Vol. 54 (June, 1963).

Miller, J., and S. Levine. A Study of the Effects of Different Types of Review and of "Structuring" Subtitles on the Amount Learned From a Training Film, Washington, D.C.: USAF Human Factors Research Laboratory, March, 1952. Cited by A.A. Lumsdaine. "Experimental Research on Instructional Devices and Materials," Training Research and Education, Robert Glas (ed.), University of Pittsburgh Press, 1962.

Nedelsky, Leo. "Formation of Objectives of Teaching in The Physical Sciences," American Journal of Physics, Vol. 17 (1949).

Payne, David A., David R. Krathwohl, and John Gordon. "The Effect of Sequence on Programed Instruction: American Educational Research Journal, Vol. 4 (March, 1967).

Pyatte, Jeff A. "Some Effects of Unit Structure on Achievement and Transfer," American Educational Research Journal, VI (March, 1969), pp. 241 - 260.

Roe, K. Vlachouli, H.W. Case, and A. Roe. "Scrambled Versus Ordered Sequence in Auto-instructional Programs," Journal of Educational Psychology, Vol. 53 (April, 1962).

Wuff, J.J. and L. M. Stuarlow. "The Role of Class Descriptive Cues in Paired-Associates Learning," Journal of Experimental Psychology, XLIII, (January, 1957), pp. 199 - 206.

Reports.

Bottenberg, Robert A. and Joe H. Ward. Applied Multiple Linear Regression, Technical Documentary Report PRL - TDR-63-6. Texas: 6570th Personnel Research Laboratory, Lackland Air Force Base, March, 1963.

Educational Services Incorporated. A Review of Current Programs, ESI, 1965.

ESI Quarterly Report. Summer-Fall, 1965, Watertown, Massachusetts: Educational Services Incorporated.

Ford, G.W. and Lawrence Pugno (ed.). The Structure of Knowledge and The Curriculum. Chicago: Rand McNally and Company, 1964.

Fraser, Dorothy M. Deciding What To Teach. Project on The Instructional Program of the Public Schools. Washington, D.C.: National Education Association, 1963.

Haber Schaim, Uri. "Objectives and Content of the Introductory Physical Science Course," ESI Quarterly Report. Watertown, Massachusetts: Educational Services Incorporated, Summer-Fall, 1965.

Hedges, William D. and Mary Ann MacDougall. "An Investigation of the Status of Science Education in Selected Public Elementary Schools of Virginia." Educational Research Bulletin. Charlottesville, Virginia: Division of Educational Research, University of Virginia, September, 1962.

Hedges, William D. and Mary Ann MacDougall. "A Comparison of Three Methods of Teaching Elementary School Science Involving Programmed Learning," Cooperative Research Project No. 1972. Charlottesville, Virginia: University of Virginia, 1965.

Lockhead, Ian C., Mary Ann MacDougall and William D. Hedges. "An Analysis of Test Items to Evaluate the Objectives of Science Teachers in Virginia Combined and Secondary Schools;" Educatinnal Research Bulletin. Charlottesville, Virginia: Division of Educational Research, University of Virginia, May, 1964.

Phi Delta Kappa. Education and The Structure of Knowledge. Fifth Annual Phi Delta Kappa Symposium on Educational Research. Chicago: Rand McNally and Company, 1964.

Stepwise Multiple Regression for The Burroughs B5500 Computer. Operations Research Series ORS-035. Detroit, Michigan: Burroughs Corporation, December 1, 1963.

Stokes, William Wood. "An Analysis and Evaluation of Current Efforts to Improve The Curriculum by Emphasis on Disciplinary Structure and Learning by Discovery," Dissertation Abstracts, Vol. 25, (July, 1964).

Unpublished Materials.

MacDougall, Mary Ann. "The Teaching of Upper Elementary School Science Using Programed Materials Coupled With Student Performed Experiments," USOE Cooperative Research Project 310, University of Virginia, Charlottesville, Virginia. (Report not yet published).

Pyatte, Jeff A. "An Experimental Study of the Effect of Structuring a Unit on Achievement and Transfer for Elementary School Students of High, Middle and Low Basic Ability." Unpublished Doctor's dissertation, University of Virginia, 1967.

Shaw, Robert A. "Criterion and Independent Variables and the Precision Indexes of These Variables as Used in Establishing a Formula for Predicting Reading Difficulty of Programmed Materials in Fourth Grade Science." Unpublished Doctor's dissertation, University of Virginia, 1967.